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THE POSSIBILITY OF A PIGOVIAN CRASH TAX

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Abstract

This paper explores the possibilities of using Pigovian taxes to internalize the costs of automobile crashes. Automobile crashes cause significant externalities. This would seem to provide a justification for a Pigovian tax. This paper constructs a model in which drivers calculate costs of crashes as a fraction of their ability to pay. Under this model, Pigovian taxes will not be able to influence behavior once a driver's expected costs equal everything he or she can pay.

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Introduction

The act of driving creates a number of externalities. The most notable of these are pollution, congestion, and traffic accidents.¹ This paper will focus on externalities caused by traffic accidents.² In particular, this paper will determine under what circumstances a Pigovian tax will align private and social accident costs.

Parry, Walls, and Harrington (2007) report that total costs of crashes, in quality-life years, amount to \$433 billion a year, or about 4.3 percent of annual GDP. The US Department of Transportation concludes that 16,352,041 accidents occurred in the United States in 2000.³ These crashes involved 27,551,503 vehicles and 5,309,288 injuries. Clearly, the costs of crashes are significant and widespread.

The external costs of traffic accidents are likewise quite significant. When two cars are involved in an accident, the vehicle damage to the other car and the costs of injury to the other drivers and passengers are external. Since insurance premiums are based on the expected costs of insuring a driver, an accident involving one driver will also raise premiums for other drivers uninvolved in the accident.⁴ Finally, the costs incurred by emergency personnel are collected through taxes and are not paid by the individuals involved in an accident.

Traffic accidents increase other externalities as well. By blocking travel lanes, crashes create congestion, which costs other motorists' time. Congestion, by forcing vehicles to travel

¹ Parry, Walls, and Harrington (2007) distinguish between local and global pollution. They also cite oil dependence as an additional externality caused by driving.

² Throughout this paper, the terms "accident" and "crash" are used interchangeably.

³ Blincoe et al. (2002).

⁴ Insurance companies mitigate this by classifying drivers and vehicles. Thus, a crash involving one driver will increase costs for other drivers and vehicles that exhibit similar characteristics.

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slower, reduces fuel efficiency. This creates more pollution than would exist in the absence of the congestion.⁵

A Pigovian tax is often advocated to force individuals to internalize external costs of driving. A tax on gasoline will raise the marginal private cost of driving to equal the marginal social cost at the socially optimal level. This will reduce the quantity of gasoline consumed to the socially optimal level. Parry and Small (2005), Edlin and Karaca-Mandic (2006), and Mankiw (2008) all promote this approach.

A gasoline tax, while administratively expedient, has a number of drawbacks. For one thing, higher gasoline taxes encourage people to drive smaller, more fuel-efficient cars. Smaller cars are more dangerous to their drivers than are larger vehicles, such as SUVs, vans, and pickup trucks.⁶

A gasoline tax will also fall on all drivers equally, regardless of their driving ability and whether or not they drive in high congestion areas.⁷ While a Pigovian tax on gasoline may reduce aggregate demand of driving, it is very imprecise at targeting specific externality-causing activities.

⁵See, for example, Davis and Diegel (2002).

⁶ Gayer (2004) writes, “The results strongly suggest that no matter what type of vehicle one drives, crashing into a sport-utility vehicle, van, or pickup poses a greater risk than does crashing into a car. The results also suggest that no matter what type of vehicle one crashes in to, one is at a significantly greater risk if one is in a car rather than a light truck.” However, studies such as Gayer (2004) and White (2004) conclude that heavier vehicles cause more fatalities than they avoid. Parry, Walls, and Harrington (2007) survey the literature that examines the relationship between vehicle size and weight and total highway fatalities. The literature reaches mixed conclusions, providing no clear answers as to whether smaller or larger vehicles are more dangerous.

⁷ Edlin and Karaca-Mandic (2006) note this drawback. They advocate a gasoline tax only because states already have such a tax and it is relatively easy to levy. The authors also suggest a per-mile or per-driver tax in addition to per-gallon. The authors also propose an insurance premium that is levied per-mile.

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Many economists favor congestion charges. Unlike a Pigovian tax on gasoline, congestion pricing matches the cost paid by drivers to the externality generated at any given time. Only drivers who contribute to the congestion will pay the charge. Congestion pricing has already been successfully implemented in London.⁸

While congestion pricing is a favorable alternative to the gas tax, no similar proposal exists to address the externalities caused by crashes. A gasoline tax falls on all drivers equally, rather than targeting only those individuals who cause an accident. Even a tax on insurance premiums will tax individuals based on their likelihood of getting into an accident, rather than taxing only the individuals who actually are involved in crashes.⁹

In theory, it should be possible to impose an ex post tax on drivers who cause accidents. The tax would be equal to the amount of external costs that the crash causes. No one has given this possibility serious consideration.

This paper lays out a model, consistent with standard externality models, in which a crash tax will correct the externalities of traffic accidents. The model is then modified so that drivers' costs are calculated as a fraction of what they are able to pay. In this new model, Pigovian taxes will not have any effect for any point after which drivers expect a crash to cost them everything. This paper then considers how plausible this new model is, considering existing crash data.

⁸ See Leape (2006) and Santos (2008) for a discussion of the London congestion charge.

⁹ Even assuming that insurance companies can perfectly determine a driver's level of skill, a tax on insurance premiums will not necessarily be "fair." Two drivers with the same skill level may not cause the same number of accidents. Consider two equally bad drivers. One is lucky, the other is not. The lucky driver, whose driving skills are just as bad as the other's, may go through life without causing a single crash and thus imposing no accident externalities on society. However, a tax on insurance premiums, which are based exclusively on a driver's skill, will charge both individuals equally.

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Making the Case for a Pigovian Crash Tax

Presumably, “accidents” are called such for a reason. Obviously, drivers don’t intend to get into crashes¹⁰; they happen by mistake. But just because crashes are not premeditated does not mean that a driver’s choice of behavior has no impact on the chances of being in an accident.

A National Highway Traffic Safety Administration report (2008) credits decision errors with causing 34.1% of crashes. Recognition errors, which result from distraction or inattention, account for another 40.6%. Sleep caused 3.2% of crashes. Driver performance errors, which can reasonably be assumed to be independent of a driver’s conscious decisions, accounted for only 10.3% of crashes.¹¹ Clearly, drivers make decisions—such as how fast to drive, how much attention to allocate to the roadway, or how much sleep to get the night before—that affect the chances that they will be in an accident.

For simplicity, we will aggregate all possible decisions a driver makes into one variable that measures how recklessly an individual drives. This variable captures the effects of all other variables that can influence the probability of a driver getting into an accident and the expected severity of a crash. The costs of an accident can be written as a function of the driver’s recklessness.

How does a driver decide on this level of recklessness? Like all situations involving risk, a driver examines the expected costs and benefits of reckless driving. The driver then chooses how recklessly to drive based on his or her risk preference.

¹⁰ This ignores the negligible fraction of crashes caused by individuals looking to commit suicide.

¹¹ Other factors measured in the report include “Other/unknown critical nonperformance” error and “Other/unknown driver error” Unavoidable physical impairments, such as a heart attack, account for only 2.4% of crashes.

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To be sure, drivers do not know with any precision what their expected costs are if they drive in a particular manner and become involved in an accident. Drivers do have intimate knowledge of their own driving ability, however, and through past experience they can construct a subjective probability of accidents and an expected cost given that an accident occurs.

Sitkin and Pablo (1992) describe a framework in which risk propensity and risk perception determine how an individual makes decisions in the presence of risks. For simplicity, this paper will assume that all drivers are risk neutral and their decisions are based exclusively on the expected costs and benefits of reckless behavior.

For this model, assume that a driver derives benefits from driving proportional to how recklessly he or she drives. It is easy to see why this would be the case. Driving recklessly can include driving faster or swerving in and out of traffic. This will decrease travel time and avoid the aggravation of sitting in traffic. Reckless driving can also include being more inattentive, saving the driver from the mental costs of caution. Neither time nor attention are free; both are scarce resources. Perhaps an individual simply derives utility from going fast.

In a world where there is zero crash risk (and no enforcement of traffic laws), it pays to be as reckless as possible. We can also assume that the benefits from reckless driving exhibit diminishing marginal returns.

Determining the costs of reckless driving is a far more interesting exercise. Reckless driving will lead to both a higher probability of a crash and a greater crash severity.

Consequently, the cost of accident increases as the recklessness increases.

In examining costs, an individual will first consider the probable costs of a crash, given that he or she is involved in an accident. The individual will then look at the probability of the accident occurring.

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In an accident, a driver must pay for his or her own property damage and private medical costs. Depending on the liability laws and insurance plans possessed, the at-fault driver may also have to pay for the property damage and medical costs of other individuals involved. Under compulsory insurance and no-fault liability regimes, which many states have,¹² a driver will not have to pay directly for damage to the other driver.¹³

Thus, an individual's private costs can be written in this way:

$$C_{\text{private|accident}} = PD_{\text{private}} + Med_{\text{private}} + LP_{\text{private}},$$

where $C_{\text{private|accident}}$ =total private costs given that an accident occurs at a certain level of recklessness, PD =property damage, Med =medical costs, and LP =lost productivity.

The social costs include the private costs plus all of the externalities associated with traffic accidents. These include all costs to individuals involved in the accident that are not covered by insurance (including lost productivity), congestion costs, and the costs incurred by emergency responders. Social costs can be written in this way:

$$C_{\text{social|accident}} = C_{\text{private|accident}} + C_{\text{uncovered}} + Cong + Emer,$$

where $C_{\text{social|accident}}$ =the net social costs given that an accident occurs, $C_{\text{uncovered}}$ =all costs to people involved in the accident not covered by insurance, $Cong$ =social costs of congestion, and $Emer$ =costs of emergency responders.

¹² Cohen and Dehejia (2003) compile a list of which states have compulsory insurance and/or no-fault liability laws and when those laws were enacted.

¹³ The at-fault driver's insurance should pay for the costs incurred by the victim(s). While the at-fault driver does pay for the premiums for that insurance, those payments are sunk costs at the time when he or she decides how recklessly to drive. Cohen and Dehejia (2003) find that automobile insurance produces significant moral hazard costs.

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To calculate expected private costs, an individual multiplies the private costs he or she will incur if a crash takes place by the probability of the crash occurring. Algebraically,

$$C_{\text{private}} = \text{Pr}(\text{Accident}) \times C_{\text{private}|\text{accident}}$$

where C_{private} is the net private cost.

Likewise, the expected social costs are equal to the social costs given an accident times the probability of an accident.

$$C_{\text{social}} = \text{Pr}(\text{Accident}) \times C_{\text{social}|\text{accident}}$$

where C_{social} is the net social cost.

Looking at these equations, it is obvious that the social cost will be at least equal to the private cost.¹⁴ With only an elementary understanding of Pigovian taxes, one can see that there exists an optimal tax such that the private degree of recklessness will equal the social degree (see Figure I).

From the equations constructed here, there is no reason that a “crash tax”—levied after the fact on individuals who cause accidents—will not be as effective in mitigating externalities as a congestion tax. Individuals will take the tax into account when calculating the expected costs of an accident and will adjust their driving behavior accordingly. This will result in people driving less recklessly, leading to fewer and less costly accidents.

¹⁴ I say “at least equal to the private cost” instead of “greater than the private cost” because it is possible that an accident could occur in which the at-fault party is required to pay for all damages to the other involved parties, no congestion is caused, and no one requires the services of emergency personnel. In such a situation, all terms in the social cost equation are zero except for the term C_{private} . Such a situation is possible, but rather trivial and not particularly likely.

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Modifying the Model

One glaring cost is missing from the private and social cost calculations explained above. The equations above do not factor in the fact that an individual may die in a crash. How does an individual factor in the possibility of a fatality when making a risky decision?

In its study *The Economic Impact of Motor Vehicle Crashes 2000*, the US Department of Transportation uses the Consumer Product Safety Commission's Injury Cost Model to calculate future work losses. Lifetime wage losses are calculated using a standard age-earner model described by Rice et al (1989) and Miller et al (1998).

The problem with this approach is that it only measures the economic losses resulting from a fatality. The models only calculate foregone wages discounted over an individual's expected lifetime. They do not consider that an individual may value his or her life over and above his or her expected lifetime earnings.¹⁵

Instead of calculating an absolute value of damages and foregone wages, I propose looking at accident costs as a relative value. Instead of assigning a pecuniary value to a crash, crash costs are measured as a proportion of what an individual can pay.

An individual who dies would then have a private cost equal to one. A fatal crash costs the individual everything; the driver can't possibly pay more than the value of their life.

Therefore, private costs can never exceed one.

Property damage, medical costs, and lost productivity can be calculated as a fraction of an individual's total net worth. If all of these costs added together exceed one, then an individual expects to pay more than his expected net worth. As is the case when a driver expects that an

¹⁵ Miller (1997) notes these drawbacks. He writes, "[H]uman capital costs lack comprehensiveness. They value only the monetary aspects of our lives. They fail to value the pleasure lost because a crash fatality will never again see a sunset, smell a rose, or kiss a spouse" (282). Miller goes on to describe four methods that attempt to quantify these intangible costs. All four methods attempt to derive a demand for the value of a life from some other quantifiable variable.

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accident will result in a fatality, when these costs equal or exceed one, the crash costs the driver everything.

The model can be written in this way:

$$C_{\text{private|accident}} = \text{Pr}(\text{Fatality}) + \frac{\text{PD}}{\text{TNW}} + \frac{\text{Med}}{\text{TNW}} + \frac{L_{\text{private}}}{\text{TNW}},$$

where TNW=the individual's total net worth.

We can easily modify this relative cost model to discount over an individual's expected life. The net worth will instead be written as an the net present value of the individual's expected lifetime net worth. The discount rate is subjectively decided by each driver, however, not by an exogenous interest rate. Each driver calculates their own discount rate based on their time horizons and other factors when deciding how recklessly to drive. For simplicity, this paper will assume that drivers only consider the current period.

The total potential social costs of an accident can be thought of as n, where n is the total number of people affected by an accident. Each individual can potentially pay one, so the total social cost is the vertical summation of the proportional costs borne by each individual.

$$C_{\text{social|accident}} = \sum_{i=1}^n C_{\text{private}},$$

where i goes from 1 to n.

For all individuals not directly involved in a crash, C_{private} will be equal to the time lost in congestion and the taxes paid to support emergency personnel and subsidize medical treatment. Private and social cost curves given that an accident occurs are displayed in Figure II.¹⁶

¹⁶ For simplicity, this paper assumes a quadratic cost function. This results in linear marginal cost functions.

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An ideal Pigovian tax would increase the marginal private cost so that it equals the marginal social cost, as in Figure I. However, an ex post Pigovian tax will only increase the costs if an individual gets into an accident. It will have no effect on the probability of an accident.

Because an individual expects a crash (if it occurs) to cost everything at some level of recklessness, a Pigovian tax can only increase marginal cost up to that point. We shall designate the level of recklessness at which the private costs equal one as R^* . After R^* , private costs will always equal one and marginal cost will always be zero.¹⁷ Driving more recklessly will not increase an individual's costs at all. Not only will marginal cost equal zero, but marginal cost cannot be increased. Since an individual's cost already equals one, no tax will make the individual pay any more. After point R^* , no tax will have an effect on the level of R .

Since the total cost cannot be increased after R^* , it is more accurate to write $C_{\text{private|accident}}$ as a piecewise function.

$$C_{\text{private|accident}} = \begin{cases} \text{Pr(Fatality)} + \frac{FD}{TNW} + \frac{\text{Med}}{TNW} + \frac{LP_{\text{private}}}{TNW}, & \text{from } 0 \leq R < R^* \\ 1, & \text{where } R \geq R^* \end{cases}$$

A Pigovian tax can increase the marginal private cost for all points before R^* . The effects of a Pigovian tax on $C_{\text{private|accident}}$ is shown in Figure III. Note that marginal costs must also be calculated as a proportion of what an individual can pay.¹⁸

The costs given that an accident occurs are independent of the probability of a crash. Likewise, a Pigovian tax will have no effect on the probability of an accident. An individual's

¹⁷ Since the cost function is a piece-wise function, it is not differentiable at R^* .

¹⁸ For the curves drawn in Figures II and III, $\frac{MC_{\text{private|accident}}}{TNW}$ approaches ∞ as $C_{\text{private|accident}}$ approaches R^* . However, since the marginal costs are expressed as a proportion of what an individual can pay, the $MC_{\text{private|accident}}$ curve approaches 1. $MC_{\text{private|accident}}$ cannot exceed one.

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expected cost of an accident is equal to the costs given that he or she is in an accident times the probability that an accident will occur. So,

$$C_{\text{private}} = \text{Pr}(\text{Accident}) \times C_{\text{private}|\text{accident}}$$

This is unchanged from the original model, when costs were calculated in absolute, rather than relative, terms.

Assuming that the probability of a crash increases with R , then C_{private} will continue to increase, even though $C_{\text{private}|\text{accident}}$ stops increasing at R^* . C_{private} will continue increasing until both $\text{Pr}(\text{Accident})$ and $C_{\text{private}|\text{accident}}$ equal one, or when an accident occurs with certainty and is certain to cost the driver everything. We can designate the level of recklessness at which C_{private} becomes one as R^{**} .

It is important to note that a Pigovian tax still will not affect C_{private} after R^* even though the marginal cost continues increases between R^* and R^{**} . Figure IV illustrates these effects.

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Testing the Model

To determine the possible effects of a Pigovian crash tax, one must determine whether the equilibrium R is greater than or less than R^* . Significant empirical work needs to be done to determine the level of R as well as the specific shape of an individual driver's cost curve.

Research such as Cohen and Dehejia (2003) suggests that the equilibrium R is to the left of R^* . Compulsory insurance and no-fault liability laws shift an individual driver's cost curve to the right. Rather than increase the marginal cost, as a Pigovian tax would, these laws decrease the costs a driver faces.

For all values of R greater than R^* , marginal costs are equal to zero and no tax can alter a driver's behavior. Cohen and Dehejia find that implementing compulsory insurance and no-fault liability laws increase the fatality rate. Since these policies affect drivers' behavior, they suggest that R is initially to the left of R^* .¹⁹

It is certainly true that the expected private costs of an accident do not exceed one in all situations. But it is also likely that there are many situations where the expected private costs do exceed one. To figure out when a crash tax will have an effect, it is necessary to discover what factors influence a driver's decision of R and how the level of R affects the cost and probability of a crash.

Reports such as the National Highway Traffic Safety Administration's "National Motor Vehicle Crash Causation Survey" (2008) shed significant light on which actions are associated

¹⁹ Paradoxically, when R is greater than R^* , policies that reduce a driver's marginal cost can actually lower the accident rate under the right circumstances. See Figure V for an analysis of how this would occur.

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with a higher probability of an accident.²⁰ I am aware of no studies, however, on reports that calculate the costs of an accident under given circumstances.

How much is an accident expected to cost for a driver with a given lifetime expected net worth, driving a given type of car, going a given speed, on a given road at a given time of day, and allocating a given amount of his or her attention to driving? This is not an easy question to answer by any means.

The U.S. Department of Transportation has set the value of a statistical life (VSL) at \$6.0 million when preparing economics analyses.²¹ Assuming that \$6.0 million is the correct monetary value of an individual's life,²² then R^* will occur where the total private cost curve reaches \$6.0 million. A crash tax will not fully internalize social costs if the total social cost of the accident exceeds \$6.0 million.

²⁰ The survey examines 5,471 accidents and determines their cause. The report calculates what the chances are of a certain activity being the cause of a crash, given that a crash occurs. It does not predict the probability that a driver who acts in a certain way will be in a crash. These data are much harder to come by. As Levitt and Porter (2001) write about the probability of alcohol consumption causing a crash:

Without knowing the fraction of drivers on the road who have been drinking, however, one cannot possibly draw conclusions about the relative fatal crash risk of drinking versus sober drivers, the externality associated with drinking and driving, or the appropriate policy response. For instance, if 30 percent of the drivers had been drinking, over half of all two-vehicle crashes would be expected to involve at least one drinking driver, even if drinking drivers were no more dangerous than sober drivers. (1199)

Likewise, it is impossible to know how much reckless driving actually increases the chances of being in an accident and the likely severity of that accident unless one also knows how many drivers drive recklessly. Not only that, but one would have to know precisely how recklessly each individual was driving.

²¹ The Department of Transportation adopted a recommended VSL at \$2.5 million in 1993. This value has been updated periodically, with the latest previous adjustment being in 2002, when the value was set at \$3.0 million. Recently, the value has been increased to \$5.8 million. See Szabat and Knapp (2009).

²² The DOT is certain to point out that \$5.8 million is just an estimate, not “a threshold dividing justifiable from unjustifiable actions” (Duvall and Gribbin, 2008). However, for the purposes of this paper, we can assume that \$5.8 million is a uniform VSL for all individuals in all situations. It is also important to note that DOT derives the VSL from individuals' willingness to pay for reductions in risk. It does not and cannot measure an individual's actual valuation of his or her life.

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How likely is it that a crash will cost society more than \$6.0 million? Since the VSL is \$6.0 million, any fatal crash will by definition cost at least that much. The National Highway Traffic Safety Administration reports that 0.8% of crashes result in a fatality.²³

Another 10.5% of crashes resulted in incapacitating injuries.²⁴ We can assume that incapacitating injuries cost an individual nearly \$6.0 million. It is easy to believe that property damage and external costs put the total social costs of these accidents above the threshold level. Thus, almost eleven percent of traffic crashes will be unaffected by a crash tax.

But even more crashes may be impervious to Pigovian taxation. The percentage of crashes that cost more than \$6.0 million would surely be higher when congestion and other social costs are factored in. Even though estimates of the aggregate social cost exist, far more work needs to be done to calculate the social cost generated per accident.

Blincoe et al. (2002) report that 16,352,041 accidents occurred in 2000. These cost the people involved a total of \$230.6 billion. This amounts to an average cost of only \$14,100 per accident, far below the \$6.0 million estimated VSL.²⁵ Factoring in social costs is unlikely to push the average cost above \$6.0 million.

Even though the average cost of accidents falls below the R^* value, some driving behaviors lead to higher crash costs than others. Knowing the average cost of an accident is less useful than knowing how a marginal increase in recklessness affects the expected costs of an accident. Likewise, it would be useful to learn the expected costs of an accident under certain specific conditions.

²³ National Highway Traffic Safety Administration (2008).

²⁴ Ibid.

²⁵ The VSL in 2000 was estimated to be less than \$3.0 million, however. The \$6.0 million VSL came into effect in 2009. Thus the VSL in 2000 was less than half of its 2009 value.

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Significant research is needed to determine what actions make up the aggregated variable R . In addition, more work needs to be done to discover how the R value affects the expected costs of an accident.

Results and Conclusion

More research is required to figure out how the components of the variable R are related to one another. How does a driver make decisions in risky situation with limited time to consider options? How do those decisions influence the chance of a crash and the expected costs of an accident? When does a driver reach the threshold value R^* ?

These questions will all have to be answered before a policy analyst can make recommendations about the potential for a crash tax. In spite of these unknowns, we can already make several conclusions about the model.

For one thing, it is clear that automobile crashes create significant externalities. An optimal policy will internalize these social costs. Pigovian taxes are already used to combat a number of traffic-related externalities.

In a standard external cost model, a Pigovian crash tax will be able to internalize all externalities caused by traffic accidents. Modifying the model suggests, however, that the potential of a Pigovian tax will be limited.

The model created in this paper differs from the standard external cost model in that it calculates costs as a fraction of an individual's ability to pay. The standard model calculates costs as an absolute value, ignoring how much an individual can pay. Under the modified model, there exists some threshold value at which an individual pays everything. At this point, total costs are constant and marginal costs equal zero.

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Individuals will only respond to incentives until they reach their maximum ability to pay. Once an individual pays everything, no tax can make that individual pay more. Thus, when individuals are paying everything they can, Pigovian taxes will not solve externality problems.

An example may be helpful. It is not unreasonable to assume that a crash could cost society ten million dollars. We can also assume that a driver expects their total lifetime net worth to equal only eight million dollars. Standard theory states that an appropriate tax can force an individual to act as if he would pay all ten million dollars. But in this example, the driver will never have ten million dollars. He will not internalize the remaining two million dollars that the crash causes. Even after the tax, an externality remains.

If a driver does not value the future highly, then a tax will be even less effective. Regardless of an individual's expected lifetime net worth, few people have ten million dollars to their name at any given time. A driver with a short time horizon may behave as though they only have a few million dollars at risk. This will lead to a greater level of costs that are not internalized.

Harvard's Gregory Mankiw has created an informal group that he calls the Pigou Club. This group is made up of individuals who believe that Pigovian taxes are the best way to eliminate externalities. Mankiw (2006) lists four possible reasons why individuals might be opposed to Pigovian taxes. But Mankiw never considers the possibility that, in some instances, Pigovian taxes may simply have no effect on an individual's behavior.

This paper identifies one such situation. If an individual expects a crash to cost everything if it occurs, then he or she may seek to minimize the chances of a crash. If the benefits of reckless driving are large, then an individual may still engage in the activity. If this

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happens, the driver will behave the same way regardless of whether or not an ex post Pigovian crash tax is in place.

At the very least, this model suggests that a Pigovian tax is not appropriate in all instances where externalities are present. In the case of traffic accidents, the crashes that cost society the most are precisely those that will not be affected by a tax. Other methods must be used to bring the level of recklessness on the road to the socially optimal level.²⁶

Calculating costs as a fraction of what an individual can pay substantially changes the standard external cost model. A Pigovian tax will not correct externalities when individuals face costs that exceed their total ability to pay. It remains to be seen how common this phenomenon is in real crash situations.

²⁶ More precisely, other methods must be used to bring the level of recklessness to less than R^* . For values to the left of R^* , a Pigovian tax will be effective.

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Figure I

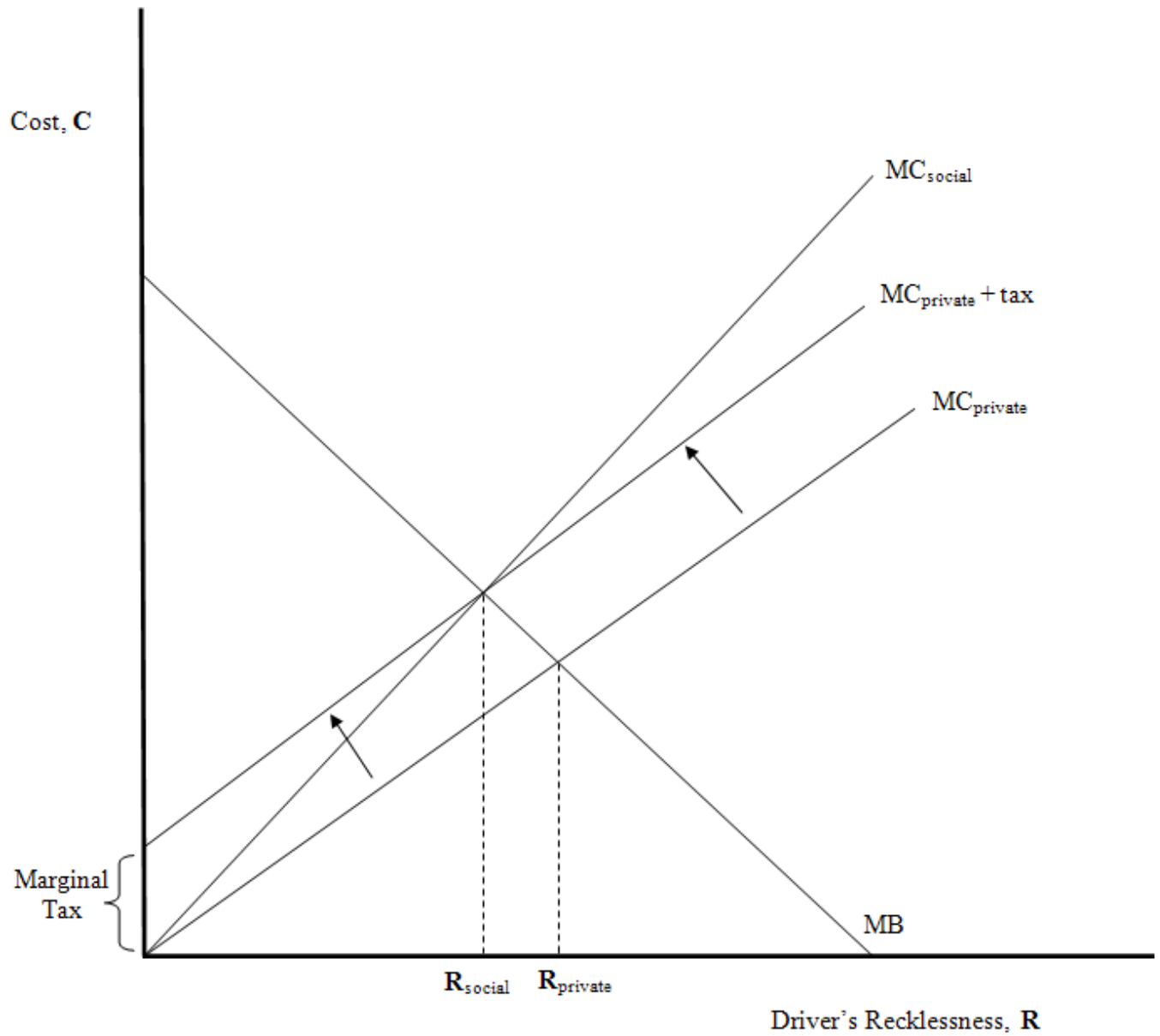
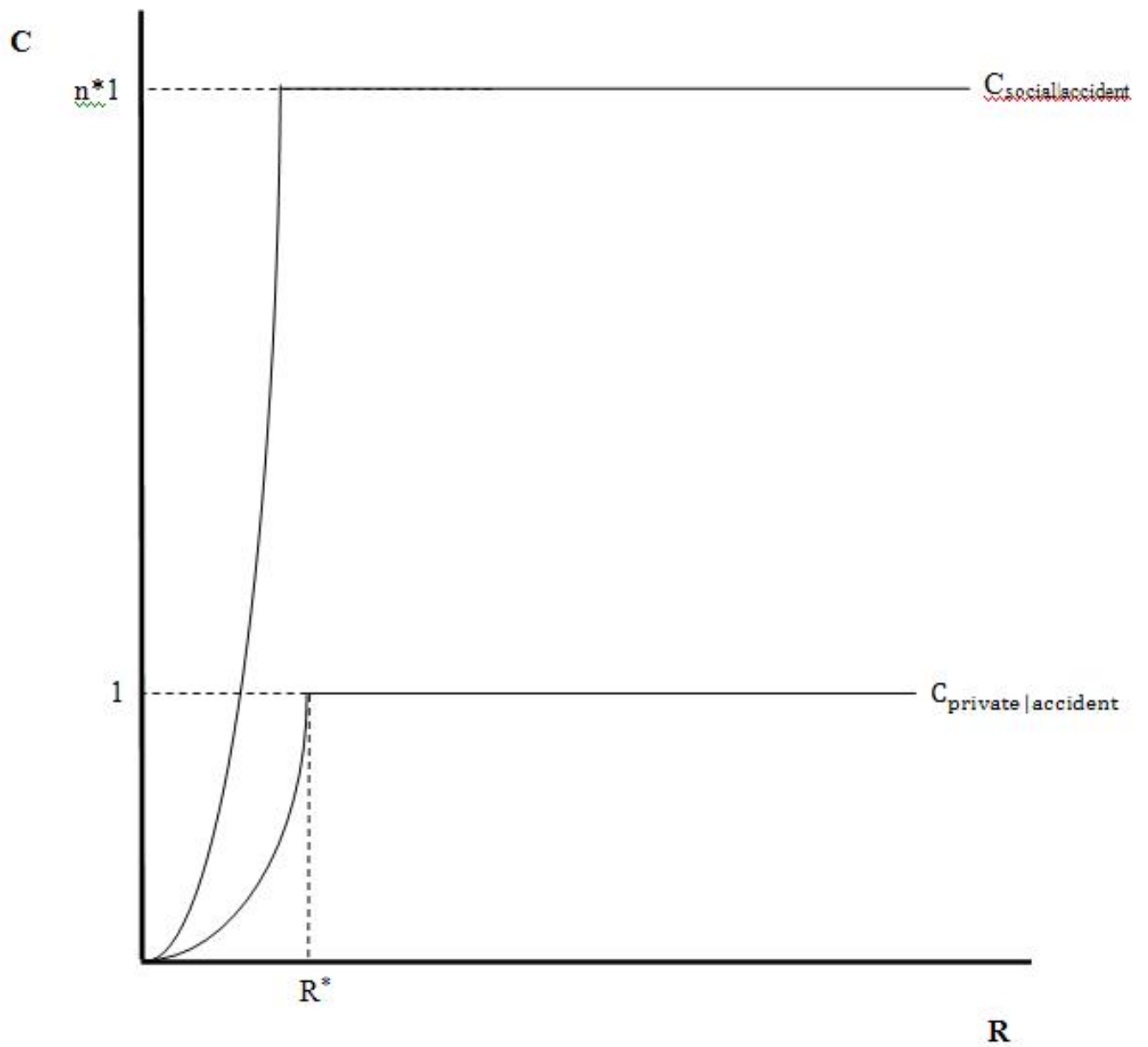


Figure I presents the standard external cost model. An optimal marginal tax can shift the marginal private cost curve so that the new R_{private} equals R_{social} at the optimal level of R .

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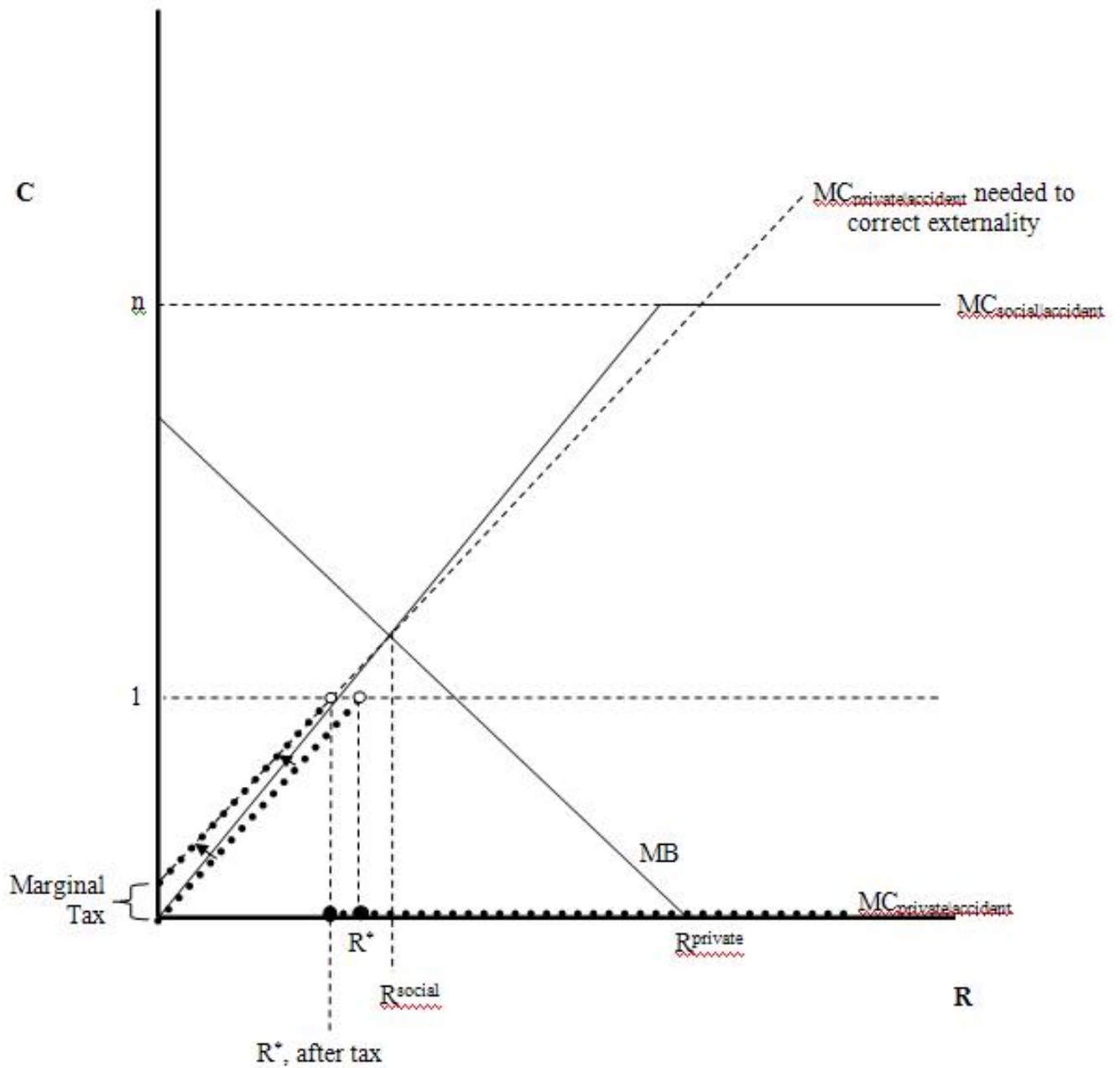
Figure II



In this graph we assume quadratic total cost curves. The private cost curve (given that an accident occurs) will increase quadratically until R^* . The social cost curve (given that an accident occurs) will increase quadratically until every driver is paying one. This occurs at n^*1 .

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Figure III



The marginal cost curves (given that an accident occurs) in this graph are derived from the total cost curves displayed in Figure II. The marginal private cost curve is shown by a dotted line. The optimal marginal tax will shift the marginal private cost curve to the left. However, when the new marginal private cost curve reaches $C=1$, it falls to 0. So a marginal tax will shift R^* to the left. Since marginal costs are 0 after R^* , the marginal benefit curve intersects the marginal private cost curve at $MC_{private}=0$.

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Figure IVa

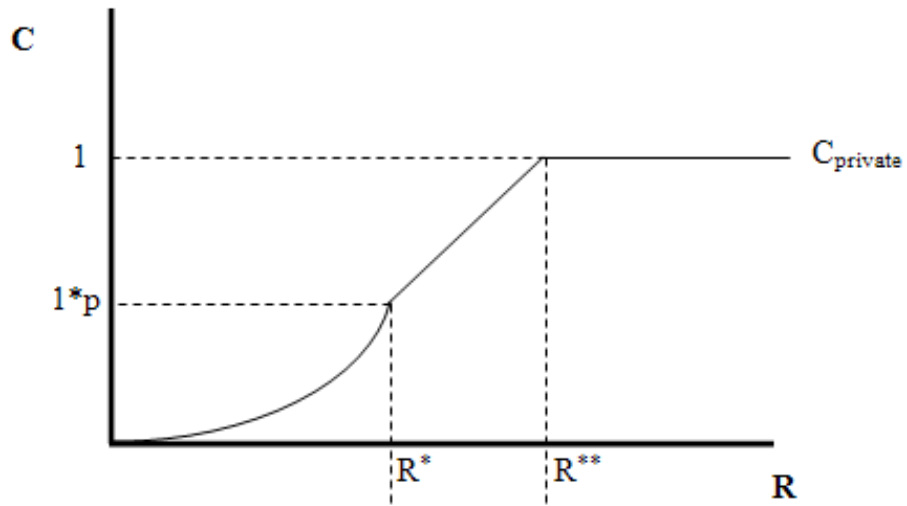
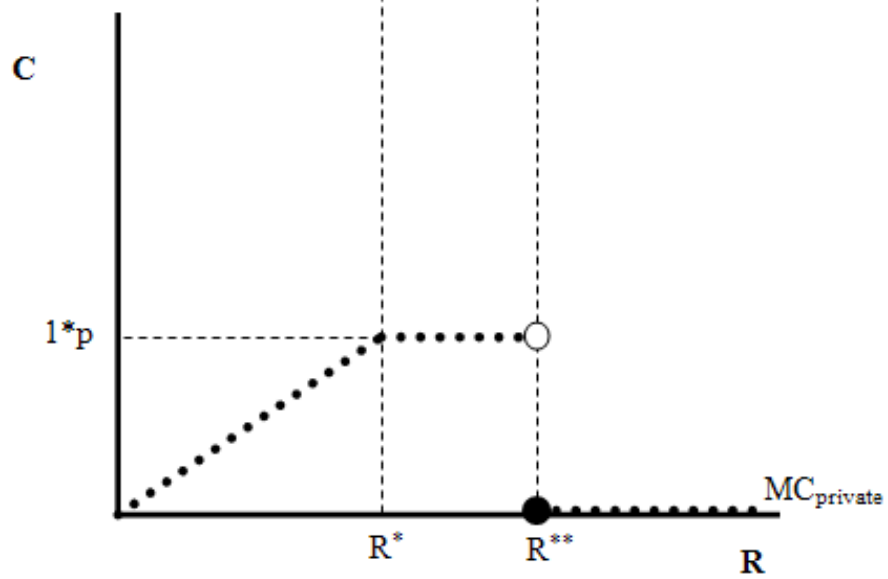


Figure IVb



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Figure

IVc

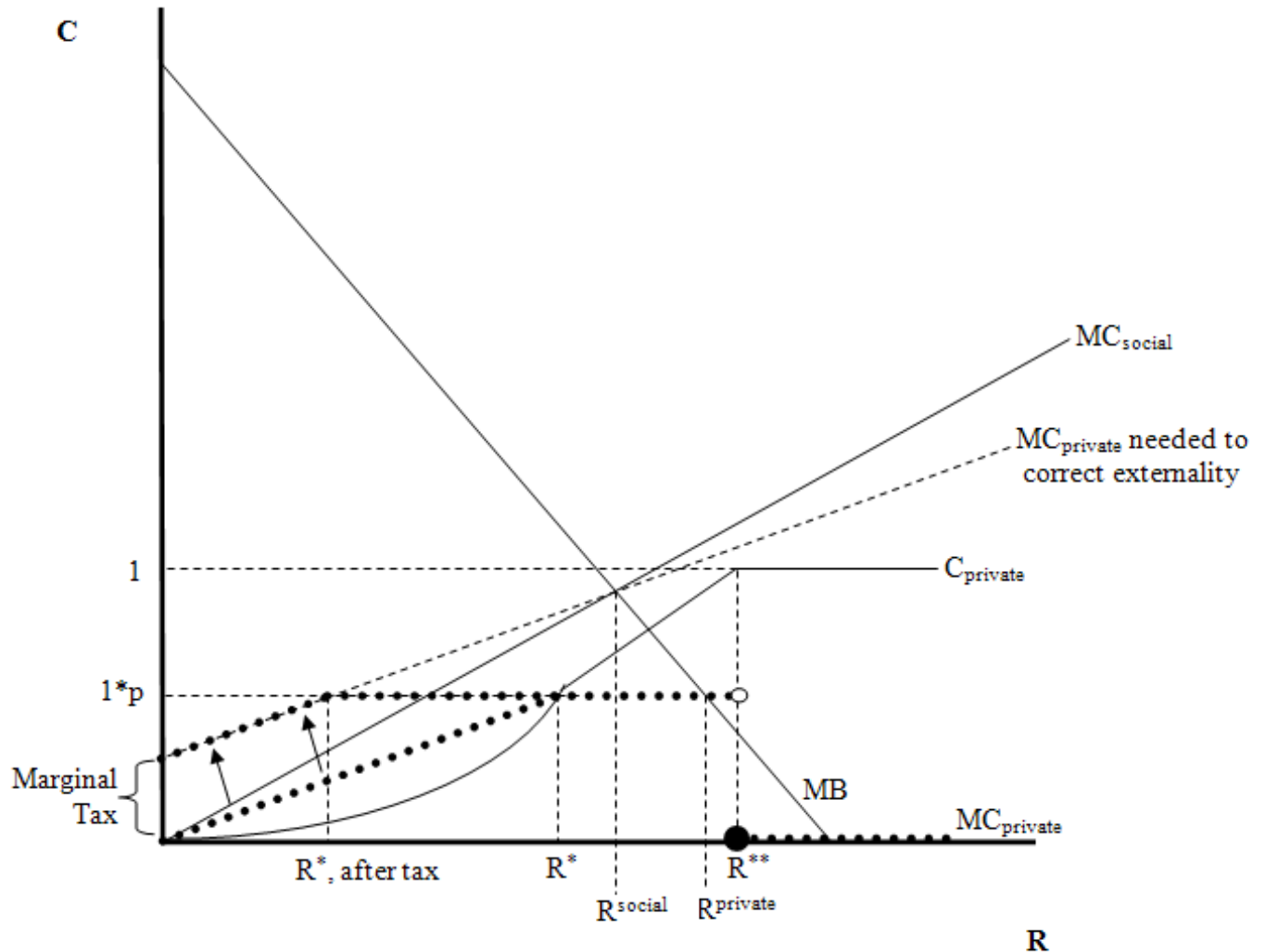
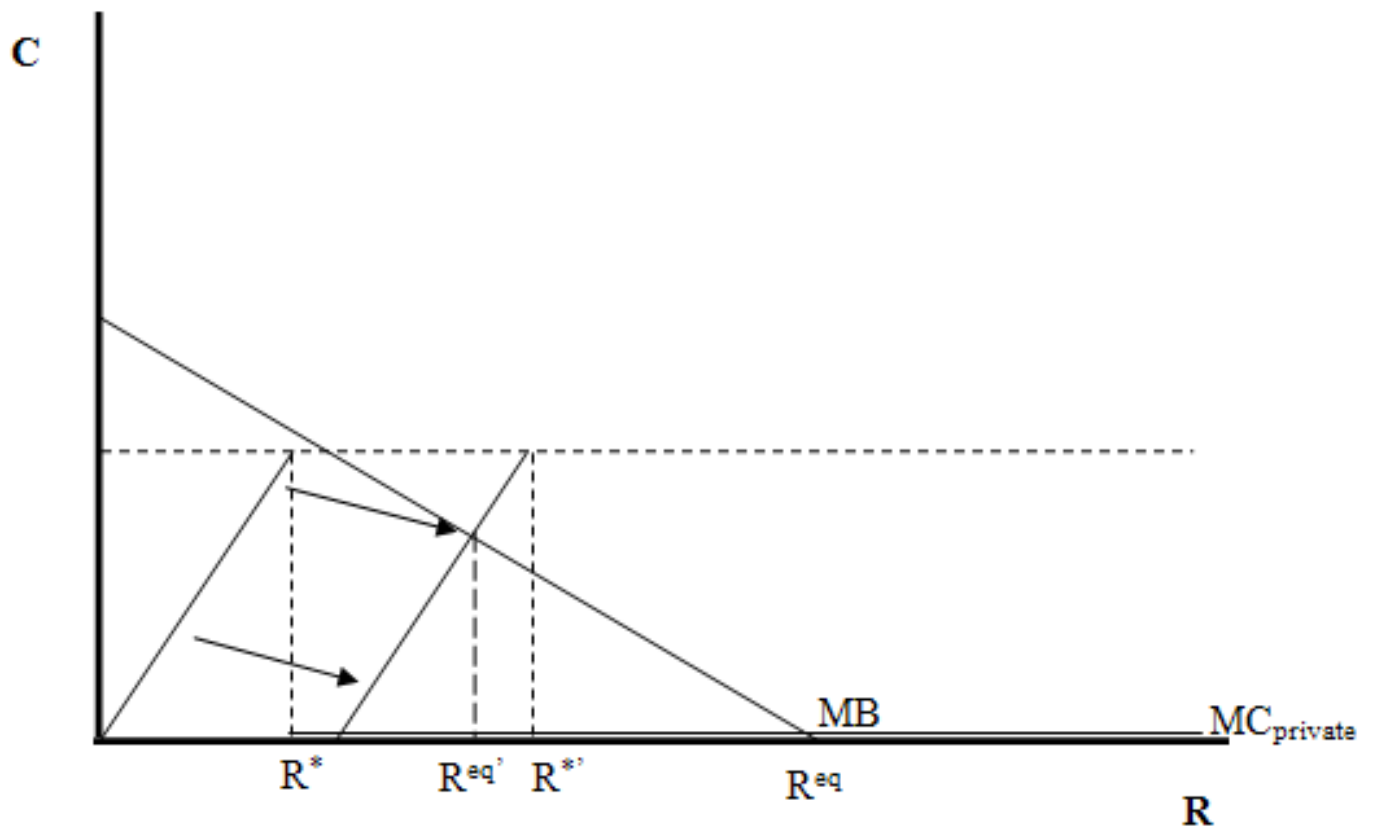


Figure IVa displays the total private cost. Note that the private cost increases quadratically from 0 to R^* . IVa increases linearly from R^* to R^{**} as the cost becomes a function solely of the probability. After R^{**} , IVa is flat. Figure IVb displays the marginal private costs. As in Figure III, marginal costs are displayed as a dotted line. Figure IVc combines Figures IVa and IVb, along with a marginal social cost curve and a marginal benefit curve. Figure IVc also displays the optimal marginal tax. As in Figure III, a marginal tax shifts R^* to the left and a marginal tax will have no effect after R^* . In this case, however, the marginal benefit curve will intersect the marginal private cost curve when $MC_{private}=1^*p$.

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Figure V



An activity that decreases an individual's marginal cost may have the paradoxical effect of reducing R^{eq} , as shown in Figure V. This result depends on the specific shape of the marginal benefits curve and the magnitude of the marginal cost reduction.