Pigou, Becker and the Regulation of Punishment-Proof Firms

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Abstract: We study the use of fines and inspections to control production activities that create external damages. The model contains a continuum of firms, differing in their compliance costs, so that only high-cost firms evade the regulations. Modifying the usual Pigou rule for taxing externalities to account for costly inspections, the external damage from the marginal evader's activities should exceed the expected fine by an amount equal to the resources expended to reduce the number of evaders a unit. According to Becker's classic work on crime and punishment, however, these resources can be minimized by raising the fines to very high levels, while reducing costly inspections. We argue that the modified Pigou rule does not hold under such a policy, because it distorts capital markets. Firms caught evading the regulation will be bankrupted by the fines, and the possibility that they will not fully repay investors lowers their expected cost of capital. Investors will lend to all firms at an interest rate above the social opportunity cost of capital, to compensate for the risks of bankruptcy. The paper investigates the optimal choice between the Becker approach of high fines and few inspections, versus keeping fines low enough to eliminate capital-market distortions, in which case the modified Pigou rule holds. High inspection costs favor the Becker approach. In some case, welfare can be improved over the Pigou optimum with an equilibrium under which some regulation-evading firms risk bankruptcy, whereas others choose capital stocks low enough to eliminate such risks.

1. Introduction

Economic agents engage in a wide variety of activities that generate external effects. For example, drivers impose congestion costs on others when they use public roads and may endanger others by driving recklessly; homeowners may anger neighbors by listening to loud music or by allowing their property to deteriorate; and firms may generate hazardous waste as part a byproduct of production or expose their workforce to unnecessary health risks by not talking sufficient care in designing their factories. Society responds to such situations by attempting to regulating behavior and by punishing those who violate the established rules. Sometimes the behavior is criminalized (it is illegal to dump hazardous waste), while in other instances attempts are made to internalize the external damages (toll roads). In the economics literature there are two classic treatments of the issues that surround such activity, due to Pigou (1920) and Becker (1968), but the analyses differ in focus, and they offer solutions that have starkly different tones. Our goal in this paper is to offer a new approach that unifies the messages of Pigou and Becker by showing that the optimal policy prescription for activities that generate external costs can take on either form, and identifying the conditions that determine which form it takes.

Pigou addressed the issue of externalities in The Economics of Welfare. An externality arises whenever the social cost of an activity differs from the private cost. Pigou's solution was to add a set of taxes to the price mechanism that would force individuals to internalize the full social costs. Thus, the Pigouvian solution is to set a tax which equals the marginal damage associated with the activity. If the external cost of the activity is low, the Pigouvian tax will be low; whereas activities that generate large external costs will be subject to large Pigouvian taxes. In this sense, the policy prescription proposed by Pigou is one in which the punishment fits the crime. Although Pigou (1954) acknowledged that there will be informational problems both in designing the optimal tax scheme and implementing it, the issue of compliance played no role in his analysis. In addition, Pigou's analysis did not emphasize the illegal nature of non-compliance.

In contrast, the illegal nature of non-compliance is at the center of Becker's (1968) analysis of such issues in "Crime and Punishment: An Economic Approach." Becker was interested in the question of how society should go about enforcing laws that criminalize activities that generate external costs. He focused on laws that are enforced by random inspection. The key policy parameters are the probability of detection, adjusted by increasing the rate of inspection, and the level of the fine imposed on those convicted of non-compliance. Becker's goal was to find the optimal policy; the one that minimizes the cost of the illegal activity.[1] He argued that because detection is costly while fines are nearly costless, the fine should be raised all the way up to the full wealth of the perpetrator. This policy enables the regulation to be enforced with a low probability and low cost of detection. It is important to note that in Becker's world, it is optimal to set the fine at a very high level, regardless of the costliness of detection and regardless of the extent of the external cost of the conundrum.[3] In contrast, the robustness of Pigou's main result is rarely questioned.[4] Extensions have tended to focus on problems with implementation or complications that arise when Pigouvian taxes co-exist with other taxes.[5]

In this paper we argue that for certain regulations, Becker's analysis is too narrow, in the sense that it does not take into account the full implications of high fines. In particular, when firms must borrow or rent capital to produce, but face regulations that are imperfectly enforced, high fines may distort their choice of inputs and create inefficiencies in factor markets. The reason for this is that high fines alter the effective cost of capital that firms face, and they also affect the willingness of investors to lend to firms that may engage in black-market activities. The costs of these distortions must then be balanced against the benefits from reduced detection costs associated with higher fines. Below we develop a model that explicitly takes these potential factor-market distortions into account and show that it is optimal to enforce some regulations with moderate fines and likely detection, while others require with severe fines. In particular, we show that when enforcement costs are low, it is optimal to adopt a "Pigouvian approach" to regulation with relatively low fines that never drive violators to bankruptcy. In contrast, when enforcement costs are high, a "Beckerian approach" is optimal, with fines that not only bankrupt some or all firms but seize some or all of the assets that are involved in the illegal activity.

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An interesting feature of our analysis is that there exists some fines and inspection rates under which the only equilibria contain ex ante identical black-market firms that make different investment decisions: some choose to be overleveraged, meaning they are bankrupted if caught evading the regulations, whereas others have sufficient assets to pay the fine. Moreover, fines and inspection rates that generate these equilibria may be optimal.

In the next section, we sketch the basic framework of our model and provide the intuition for our key results. As we explain, there are three regimes of enforcement. In the first regime, fines are below the level that would drive a violator to bankruptcy, so that regulation is similar in tone to Pigou's original design. In this regime, which is fully characterized in Section 3, firms use an efficient mix of inputs, and the price of capital for the relevant industry equals the economy-wide opportunity cost of capital. In the second regime, which has a tone consistent with Becker, the optimal fine exceeds each black-market firm's ability to pay so that the government is forced to seize some of the assets owned by investors if the firm is convicted of non-compliance. When the fine is this high, we show in Section 4 that these firms over-employ capital and that the cost of capital for the industry exceeds its efficient level. These factor market distortions are a direct result of the severity of the punishment scheme that the government uses for enforcement and they generate

up its liquidity, then the fine is paid first and any remaining assets go to investors. If investors receive less than the principal and interest owed to them, the firm is said to be "bankrupt." Black-market firms that leave themselves with more liquidity may be able to pay large fines without bankruptcy.

The firm's input decision is depicted in Figure 1 with the convex curve representing the unit isoquant. For law-abiding firms, the isocost curve is a straight-line with a slope of -*r* and, as is usual, ma slope of -*r* for ̃Ω   ̃Ω; and - ρ   “ ì for ̃Ω   ̃Ω;. Since the kink occurs at ̃Ω;ȟ it will never be optimal for the firm to use the level of capital that leaves it exactly bankrupt when fined.

Figure 1 illustrates the case where the black-market firm is indifferent between choosing low and high levels of *k*. In other words, the kinked isoquant has two tangencies with the indifference curve, one on each side of the kink. More generally, when the when the fine is low, the kink occurs at a low value for *k*, and it is optimal for the firm to operate on the steep portion of the isocost curve, at a point such as A in Figure 1. However, when the fine is high, the kink occurs at a low value of *k*, and the firm will operate along the flatter portion of the isocost curve, at a point such as B. In other words, a high enough fine raises the marginal cost of capital from *r* to ρ   “ ì, causing the firm to increase its capital from ̃Ω to ̃Ω, and insuring bankruptcy in the event of an inspection.

In designing the optimal policy, the government then faces a trade-off. If it uses low fines and frequent inspection, which we refer to as Pigouvian regulation, firms will use the proper mix of inputs; while there may be significant enforcement costs, factor markets will operate efficiently. The other option, which we refer to as Beckerian regulation, is to use severe fines with a low rate of inspection, but this will lead firms to distort their mix of inputs. This option has low enforcement costs, but this benefit must be weighed against the cost associated with inefficiency in the factor markets. Below we show that the former solution is optimal when enforcement costs are low, and the latter is optimal when these costs are high.

The other point that we wish to emphasize in this section is that when black-market firms select their inputs, they effectively decide whether to expose themselves to potential bankruptcy, and this has important implications for the industry's ability to attract investors. In particular, under a Becker regime, firms that evade the regulation and are fined will be unable to repay investors in full. In a sense, these firms are punishment proof, at least at the margin. This implies that the government will seize some of the assets owned by investors. And, since investors cannot distinguish between law-abiding and black-market firms, they will anticipate the risk of seizure and demand higher capital rents from all firms in the industry. In equilibrium, the price of capital to the industry will exceed its economy-wide opportunity cost. This is another type of production distortion that accompanies high fines: the price of capital to the industry will be inefficiently high. None of these issues arise under Pigouvian regulation.

3. Pigouvian Regulation

We are now ready to begin our formal analysis, which we divide into three parts. First, in this section, we confine our attention to situations in which the government finds it optimal to use low or modest fines, so that firms minimize costs at a point such as A in Figure 1. In the next two sections, we consider the case of severe fines, and, finally, in Sections 6 and 7 we compare the two outcomes to find the globally-optimal enforcement mechanism.

Our perfectly competitive firms face two decisions – what input mix to use and whether to abide by the law. We denote the unit cost function by *c(r)*.[7] The firms are identical in all aspects except one, the cost of compliance. We use | ꟾ to denote firm *i*'s cost of complying with the regulation and we assume that this firm-specific parameter is drawn *after the firm enters the market* from a continuous distribution function, denoted by ''0 | . Thus, the total cost of production for a law-abiding firm is ῶ ỉ | .

Alternatively, a firm may choose to operate in the black market where it saves the cost of compliance but risks detection and punishment. The probability of detection “ and the fine *F* are the same for all firms. Thus, the expected total cost of producing and operating in the black market is ῶ ỉ “''0

We assume that the government also collects revenue from consumers by imposing a sales tax of t on this good, so that the price paid by consumers for each unit is enough liquidity to repay investors fully, in which case all firms face the interest rate ì ì ᶻ. We next describe the condition that must hold for firms to carry this level of liquidity.

If black-market firms choose a relatively low level of capital (as depicted by A in Figure 1), their expected costs are ῷ ì ᶻ "῀0; whereas the higher level of capital (as depicted by B in Figure 1) results in expected costs of ῷ ρ " ì ᶻ "ἡ.[11] Note that, as described in the previous section, the higher level of capital entails a lower effective cost of capital and leads to a lower payment by the firm when caught evading the regulation (the fine bankrupts the firm, so they simply turn over all of their revenue, *p*, to the government). For the lower level of capital to be optimal for the firm, as required for a Pigou equilibrium, it must lead to lo inspections that are carried out. The government's goal is to choose "ǐ *t* and *F* to maximize social welfare (*W*), which is given by

(6) ὡ ὺ ὡ ῼ ὡ ὡ ῷ ὶ ᶻ ⊥ᶻ | Ώ0 | ή " Ύ .

We assume that lump-sum transfers are available to balance the government budget.

The government's problem is to select the policy variables "ǐ 0 and *t* to maximize (6) subject to (5) and the market equilibrium conditions. This leads to the following Lagrangian

(7) ὺ ὡ ῼ ὡ ὡ ῷ ὶ ᶻ ⊥ᶻ | Ώ0 | ή " Ύ ＿ " ή 0 ῷ ὶ ῷ ρ " ὶ ,

where ＿ is the Lagrange multiplier. This problem can be simplified by noting first that the sales tax does not enter into any of the equilibrium conditions other than (4). Thus, the government can control output directly through *t*. Maximizing (7) over *x* yields the following first-order-condition

(8) ὺ ὡ ῼ ὡ ρ 0 | ᶻ ῷ ὶ ᶻ ⊥ᶻ | Ώ0 | ή " Ύ π.

If we use (4) to substitute for ὺ ὡ , (2) to substitute for *p*, and then solve for *t*, we obtain

(9) ὸ ρ 0 | ᶻ ῼ ὡ "0 ή ".

We show below that when inspections are costly, optimal enforcement implies that ῼ ὡ "0, so that the expected fine falls short of the marginal damage created by black-market firms. Equation (9) the indicates that the government should set the sales tax to make up for this difference: since ρ 0 | ᶻ is the probability that any given unit of output is produced by a black market firm, ῼ ὡ "0 is the marginal damage not paid for by the firm, and ή " is the inspection cost per unit of output, the right-hand-side of (9) is the residual external damage per unit of output associated with the optimal enforcement mechanism imposed on firms.

We next maximize (7) over “ and “῀0, obtaining the following first-order-conditions[12]

(10) ὡἡذ ═ ἡ ἰ῎Ωة π

(11) ῍Ω ὡص ῍Ω | ᶻ ὡ| ᶻ῍Ω | ᶻ ═ ρ “ ρ ῍0 | ᶻ π

where ῍Ω | ᶻ = *G’* | ᶻ ẖ and ῎Ωة ḳ ῎Ω ρ “ ἰ denotes the cost-minimizing amount of capital used by firms when the marginal cost of capital is ρ “ ἰ (that is, at point B in Figure 1). From (10), ═ ص ط / ص ق ض ش π; which implies that the constraint in (5) always binds. Intuitively, if there is any slack in the constraint, the standard Becker argument applies – that is, the government can increase *F* and lower “ holding “῀0 constant and increase Social Welfare. With “῀0 constant, there will be no change in the market outcome, and with fewer inspections, the government will save on enforcement costs.

If we now use (10) to eliminate ═ in (11), we obtain our condition that defines the optimal expected fine under Pigouvian regulation:

(12) ῍Ω ὡص “῀0 ص ي ق ى ي ق ة Ɩᶻ / س Ɩᶻ ص ق ض ᶻش .

If enforcement is costless (ἡذ π , then the marginal compliance cost (| ᶻ “῀0 should be set equal to the marginal damage. This minimizes the social cost per unit of output. From (8), the optimal sales tax would then be zero. This policy generates the first-best allocation, which is the standard Pigouvian result.

With positive enforcement costs, the Pigouvian condition must be modified, and the first-best outcome can no longer be achieved. As the expected fine increases, black-market firms will be tempted to move into the bankruptcy region. To counteract this, the government must increase the inspection rate, but this increase is now costly. Thus, if the government wants to avoid bankrupting

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12 Alternatively, we could maximize (7) over “ and

violators, it will have to moderate the punishment. From (12), the optimal cut-off ǀ ᶻ is below marginal damage by a term that is increasing in inspection costs.

To better understand optimality condition (12), rewrite it as follows:

(13) ῙΩ ὠص ῙΩ ǀ ᶻ ǀ ᶻῙΩ ǀ ᶻ ἠذ $\frac{\text{زى}}{\text{زᒧ}^{z}}$,

where

(14) $\frac{\text{زى}}{\text{زᒧ}^{z}}$ $\frac{\text{ﭙ ﭪ ى ﭙ ﭪ ﺔ ᒧ}^{z}}{\text{ﺻ ﭪ ﺽ}^{z}\text{ﺵ}}$ πϐ

If the government increases the expected fine “῎0 by a unit, the equality between the expected fine and marginal compliance cost ǀ ᶻ implies that ǀ ᶻ must rise. The left-hand-side of (13) captures the resulting welfare gain: ῙΩ ǀ ᶻ is the measure of firms that leave the black market and ῙΩ ὠص measures the reduction in external damage that results from their compliance with the regulation. This gain comes at a cost, which is on the right-hand-side of (13): the first term is the cost of compliance for those firms that leave the black market, and the second term captures the increase in inspection costs that result from increasing the inspection rate. As we showed above, with optimal enforcement, Pigou constraint (5) must hold with equality. The derivative ῙΩ“ ῙΩ Ջ

rises with ῭Ω₊ ῭Ω₆ , causing the required increase in " to rise. Deadweight loss is positively related to the same ῭Ω₊ ῭Ω₆ .

The value of " | ᶻ is determined by the differential equation given by (18), once initial conditions are specified. We know that " π π but this alone does not determine *dπ(0)/d*| ᶻ because the numerator and denominator in (18) are both zero at | ᶻ π. Rather, we can use | ᶻ "῎0, noting that as " goes to zero, *F* converges to a value determined by the binding Pigou constraint, given by (5) with an equality, and expression for *p*, evaluating (2) at | ᶻ π:

(19) ῎0 ή ὶᶻ῭Ω₆ ή ὶᶻ῭Ω₊ Ώ ὶᶻ

use different amounts of capital to minimize their cost of production. In particular, as described in Section 2, black-market firms will choose a higher level of capital, because they realize that if they fined, the marginal capital will be costless. Maintaining the notation introduced in Section 3, we denote the amount of capital used by black-market firms as ΐΩ. Firms that operate at this point cannot pay their debts when fined, a situation we have referred to as "overleveraged." Equilibria where all black-market firms are overleveraged are referred to as "Becker equilibria."

If the Becker constraint holds with equality, then black-market firms will be indifferent between points A and B in Figure 2, and it is possible to have an equilibrium in which a fraction of black-market firms, ᾿ < 1, are overleveraged, with the remainder operating at A. We refer to such equilibria as "hybrid equilibria." In this case, only those inspected black-market firms that are overleveraged will be driven to bankruptcy by the fine. To summarize, ᾿ ρ in a Becker equilibrium, ᾿ ᴺ πᷓρ in a hybrid equilibrium, and ᾿ π in a Pigou equilibrium.

When the government inspects overleveraged black-market firms, it will now lay claim to some income owed investors in an attempt to collect the unpaid fines. These anticipated seizures will distort the capital market and lead to a higher price of capital for the regulated market. In equilibrium, the profits earned by investors from supplying capital to this industry must exactly offset losses associated with the expected seizures. The government inspects a particular firm with probability " and seizes ‴0 ή ὶΐΩ units of assets from that firm if it has not complied with the regulation. Since the fraction of firms that decide to operate in the black market is ρ ‴0 | ᶻ and ᾿ is the fraction of black-market firms that are overleveraged, it follows that expected seizures are given by "᾿ ρ ‴0 | ᶻ ‴0 ή ὶΐΩ ᷞ As for expected profits, all law-abiding firms and a fraction ρ ᾿ of all black-market firms employ ΐΩ ΐΩ ὶ units of capital, while the remainder employ ΐΩ units. Thus, since the investors pay ὶᶻ for the capital, their expected profits from supplying capital to this industry at rate *r* are given by ὶ ὶᶻ ΐΩ ὶ ‴0 | ᶻ ρ ᾿ ρ ‴0 | ᶻ ΐΩ᾿ ρ ‴0 | ᶻ in the absence of seizures. The equilibrium *r* is determined by the requirement that these expected profits equal expected seizures:

(22) ὶ ὶ῾ ῏Ω ὶ ῎Ο | ῾ ρ ῎Ο | ῾ ρ ῒ ῏Ω ὶ ῒ῏Ω὆ = “ῒ ρ ῎Ο | ῾ ῎Ο ἡ ὶ῏Ω὆ .

Since the right-hand-side of (15) is positive in a Becker or hybrid equilibrium, it must be the case that ὶ ὶ῾ in any such equilibrium. Thus, capital is paid a premium in the regulated industry.

The fact that law-abiding and overleveraged black-market firms use different amounts of capital has implications for the compliance decision. A firm with a compliance cost of | faces a total cost of | ὤ ὶ if it operates legally and an expected cost of “ἡ ὤ ρ “ ὶ if it operates in the black market and uses ῏Ω὆ units of capital. Note here that since the fine bankrupts the firm, expected costs are the same as they would be if the fine equaled *p*, so that investors were left with no interest income in the event of an inspection. The maximum fine is the firm's total assets, ἡ ῏Ω, but any rise in the fine above *p* reduces payments of principal to investors by the increase in the fine, resulting in no change in total cost. The firm with the marginal compliance cost has the same total cost in the legal and black markets:

(23) | ῾ “ἡ ὤ ὶ ὤ ρ “ ὶ .

To complete the description of equilibrium for a Becker or hybrid equilibrium, we turn to the product market. As discussed in Section 3, when firms enter the market, they must forecast that their revenue will exactly equal their expected costs for the product market to clear. The counter-part of (2) is then

(24) ἡ ὤ ὶ ῎Ο | ῾ ρ ῒ ρ ῎Ο | ῾ + “῎Ο ρ ῒ ρ ῎Ο | ῾

ὤ ρ “ ὶ “ἡ ῒ ρ ῎Ο | ῾ ⅃῾ | ῍Ω῎Ο | ῎Υ ⅍

Using (23), we can solve this expression for the market-clearing price:

(25) ή ῷ ὶ | ῾ ῒ "῍0 ρ ῒ ρ ῎0 | ᶻ ˍ ˟ ⍭ ᶻ | Ὠ῎0 | ῎Ὕ

In a hybrid equilibrium, where (21) holds with equality, (23) gives | ᶻ "῍0ῗ as in the case in a Pigou equilibrium. Finally, output and the number of firms are determined, as in the previous section, by

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(28) [illegible]

As shown, the changes in deadweight losses take place through changes in the marginal returns on capital, through changes in the share of all firms that choose the black market, and, in the case of hybrid equilibria, through changes in the share of black-market firms that choose to become overleveraged. It may be desirable to tolerate these deadweight losses if a given level of compliance can be achieved with lower inspection costs. The next two sections analyze the tradeoff in detail.

6. Is a Hybrid Equilibrium Better than the Pigou Optimum?

We now investigate the conditions under which welfare can be improved by moving from the Pigou optimum to a fine and inspection rate that cause some firms to be overleveraged; that is, the economy moves to a hybrid equilibrium. In this case, [illegible] π, [illegible] and [illegible] π initially. Moreover, a marginal increase in *r* from [illegible] has no first-order effect on deadweight loss [illegible]. Thus, (28) becomes:

(29) [illegible]

To obtain more compliance using a smaller increase in the audit rate, we must now tolerate the deadweight losses associated with some overleveraged firms. The issue is whether the overall cost of additional compliance can be lowered in this way. Assuming linear capital demand curves (so that the quadratic loss expression is an exact measure of deadweight loss), we now prove:

Proposition 1. *Starting from the Pigou optimum, a small increase in the fine and inspection rate that causes some firms to become overleveraged is desirable (undesirable) if*

(30) $\frac{1^{z}}{\text{ج}}$ ρ $\frac{\text{صي}}{\text{ض}^{z}\text{ش}}$ ρ “

equilibrium, given by (22), we obtain the marginal effect of a rise in *r* from ì ᶻ on the fraction of firms that choose to become overleveraged:

(36) ز / زض   ش / (ى ټ ة ٳ ᶻ ة ټ ص ټ شض)   ش / (ټ ة ٳ ᶻ ج),

Assuming a linear demand curve, we may re-express (35) in terms of deadweight loss ΰ ة :

overleveraged firms to higher inspection rates and fines. In particular, (38) shows that Ὠ T̸’Ω| z declines with deadweight loss ὒ. The reason is that both Ὠ T̸’Ωì and ὨìT̸’Ω| z and decline with a rise in L_B, as described by (36) and (37).

Proposition 1 also shows that it is desirable to induce some firms to become overleveraged if inspection cost p_a is sufficiently large, all else equal. The reason is that higher inspection costs increase the desirability of achieving a given co

Combined with the Proposition 1, we then find that starting from the Pigou optimum, inducing a small number of firms to become overleveraged may be welfare-reducing, while inducing all black-market firms to become overleveraged can then improve welfare. In other words, the welfare effects can be non-monotonic.

How small the deadweight losses from capital market distortions must be for a Becker equilibrium to be optimal will depend on the amount by which the marginal benefit of a higher expected fine exceeds the marginal compliance cost at the Pigou optimum, as measured by the term

$\Omega'' \quad | \; ^{z}$

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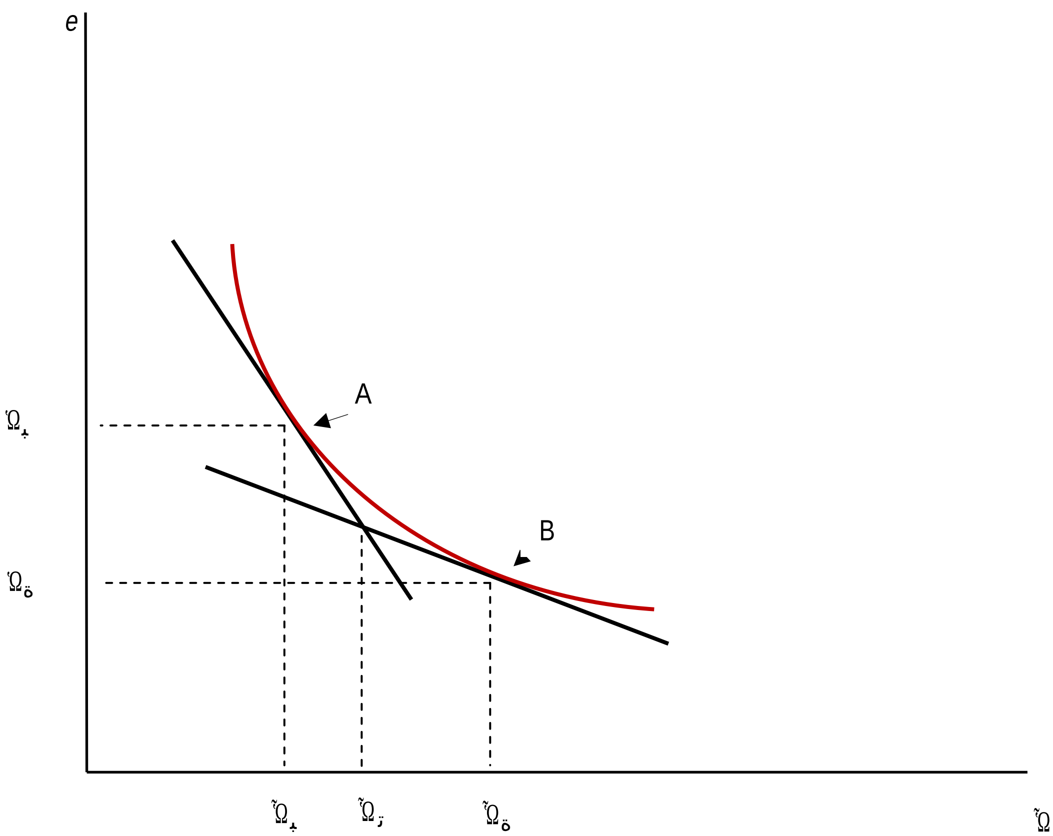


Figure 1: Choosing Inputs

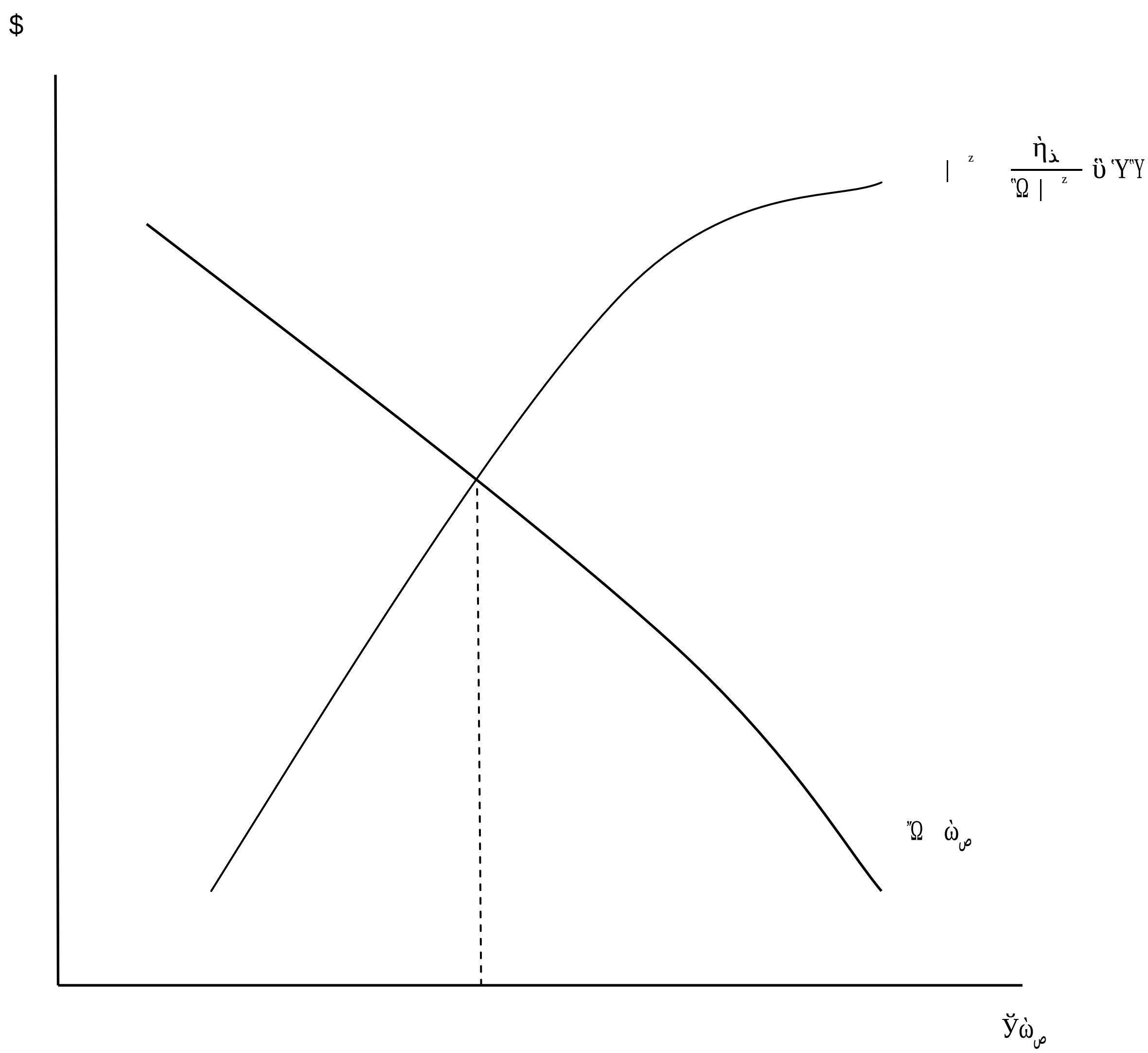
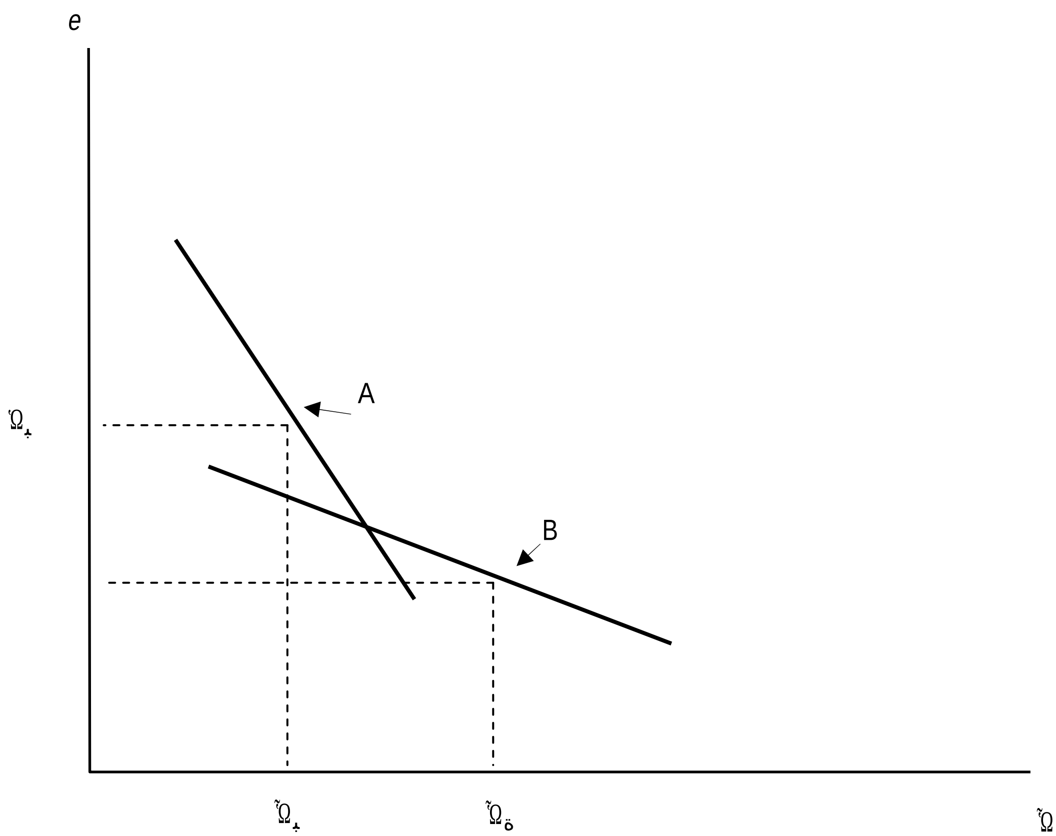


Figure 2: Optimal Pigouvian Regulation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A
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