DETERRENCE, INCOME SUPPORT AND OPTIMAL CRIME POLICY

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Abstract. Theories of crime in economics focus almost exclusively on the roles of deterrence and incapacitation in reducing criminal activity building off the Becker-Ehrlich framework, with a long history of supportive empirical work. However, a large body of recent empirical evidence has shown that income support, such as welfare, can also play a role in crime reduction. This paper extends the Becker-Ehrlich frame to incorporate transfers and the notion of economic necessity. In the absence of income support or savings and if there is a level of consumption that a person believes is necessary, then this can result in large income effect on consumption that in turn leads to a backward bending labor supply curve. This implies that if a person's main source of income is crime or some other illegitimate activity that should be reduced, then increased deterrence (a higher expected sanction) may lead to an *increase* in criminal labor supply. We embed this framework in a model where criminal and legitimate activity can be substitutes or complements, individuals have heterogeneous wages in either market, and criminal activities vary in their social cost. We then characterize optimal deterrence, transfer, and wage subsidy policies as a function of the cost of funds, social cost of crime, and individual need. We find that optimal crime policy should couple transfers and deterrence, rather than treating each of them as distinct policy options with separate goals.

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1. Introduction

The seminal works of Becker (1968) and Ehrlich (1973) model criminal (or illegitimate) activity as a market phenomena, wherein individuals commit crime[1] while weighing the benefits and the costs — the risk of being caught and punished (deterrence), as well as the opportunity cost. Furthermore, since deterrence is costly, then optimal amount of crime is generally positive. The basic predictions of this framework have been supported by many almost a half-century of empirical evidence. Yet, there is a growing body of empirical work demonstrating the importance of transfers and welfare in preventing crime—though the effects do not operate through traditional deterrence, nor via the substitution into formal labor activity. As a result, this new empirical evidence is difficult to incorporate into the existing Becker-Ehrlich framework. The goal of this paper is to introduce a model of deterrence that provides conditions under which deterrence is not effective. In those cases, optimal crime policy may entail transfer to individuals rather than an increase in deterrence.

The key feature of the Becker-Ehrlich model is that increased deterrence reduces crime. Yet, as Levitt (2004) observes, there is evidence that beyond a certain point deterrence operates mainly via incapacitation, rather than altering a person's choice to engage in criminal activity. In the standard model of crime, deterrence can be viewed as a tax that reduces the return to illegitimate activity. In such model, an increase in the tax (or deterrence) always leads to decrease in the activity, that entails a welfare lost for the individual, but provides a social benefit due to reduced crime. A common assumption of these models is that individuals have an alternative activity, and hence when deterrence increases, crime declines as the individual switches to the legitimate activity. However, suppose the individual has no alternative, and suppose that a person is facing a consumption level that is the minimum amount necessary for survival (in the mind of the individual). When this occurs the budget constraint now dominates their decision making, with the consequence that an increase in deterrence can lead to an *increase* rather than a decrease in the illegitimate activity.[2]

This point is graphically illustrated in Victor Hugo's *Les Misérables*, where the hero, Jean Valjean, is imprisoned for 19 years for stealing bread to feed his starving sister. It is unlikely that any level of deterrence would have altered Jean Valjean's choices. Accordingly, we call this the *Jean Valjean Effect.* More generally, this corresponds to a "crime of necessity",

[1]By "crime" we mean activities that are typically illegitimate (but not necessarily so), and that are socially sanctioned. Here, we follow Ehrlich (1973), and use the term "illegitimate" to mean any activity whose return to the individual is lower than the social return, where the social return is discounted by the utility of the person.

[2]In this paper, we abstract from the important effects of incarceration, in order to solely focus on deterrence effects. There is a large literature on human capital and the effects of incarceration, including Donohue III and Siegelman (1998), Lochner (2011) and Aizer and Doyle (2015). See Mungan (2021) for an interesting application of incentive theory focusing on incarceration and the use of rewards to improve quality of life outside of prison for convicts can reduce crime and duration in prison.

widely recognized in popular culture, politics, and empirical work. The New Deal attacked "the Roots of Crime" by ensuring desperate Americans could make ends meet (Fishback et al. (2010)). Drug addiction leads to street crime through "one-off 'acts of desperation" (Allen (2005)).

It is easy to see how this works technically. Suppose that a person has a minimum consumption need, say c^0 in dollar terms, and the person is engaged in crime or illegitimate activity to earn income to just meet that need. Let l be the activity level, while t is a transfer to the individual from the government or family. Finally, let w be the wage from the activity, while τ is the level of deterrence that acts as a tax on the illegitimate income. In this case the budget constraint implies that the level of illegitimate or criminal activity is given by:

$$l = \frac{c^0 - t}{w - \tau}.$$

A person is desperate when the transfer is less than their basic needs ($t < c^0$), in which case the numerator has a positive sign. As long as the deterrence is less that the return to crime ($w - \tau > 0$), then increasing the transfer t *always* reduces crime. However, an increase in deterrence, τ, reduces the value of the denominator, which in turn *increases* crime. This latter effect corresponds to the well known back-bending labor supply curve.

We incorporate this idea into a standard labor supply framework using King et al. (1988) preferences, widely used in macro-economics to capture inelastic labor supply effects. We show that with a suitable modification, these preferences provide a natural model of consumption need. When individuals have only one activity available, then whether or not deterrence is effective depends upon a person's level of transfer (which may come from savings). Thus, the model can explain when transfer or welfare programs have crime reducing effects (Tuttle (2019), Deshpande and Meuller-Smith (2021)) or no effect on crime (Watson et al. (2020)), a result that does not naturally arise in the Becker-Ehrlich framework.

The model is extended to allow for substitution with legitimate activities. This provides a convenient framework to explore how deterrence, transfers, and taxes (or subsidies) on legitimate labor affect crime. In particular, we find that the effects depend upon the nature of the criminal activity, and whether or not they are complementary with legitimate activities that raise or lower the return to illegitimate activities. For example, before containerization, theft was common in shipping because the job of being a longshoreman lowered the cost of stealing from ships. In that case, rather that raise deterrence, the industry solved this problem by reducing the complementary returns from theft with the introduction of containerization.

One of Becker (1968)'s innovations is to provide a framework for determining optimal policy. In that model, the trade off is between the benefits of increased deterrence for crime reduction against the costs of implementing a deterrence policy. The approach is able to

explain why a certain level of crime is tolerated in society due to the high cost of further deterrence. Our model is able to extend these insights to add transfer policy to the set of instruments available to manage criminal activity. We show that the optimal policy, as a function of the social cost of funds, depends primarily on the level of need, the social cost of crime, and the relative wage of a specific population. For example, we find that for low social cost crime among needy individuals, the optimal policy involves a transfer rather than deterrence. The transfer produces larger social gains from a reduction in crime than the reduction in legitimate labor, while increased deterrence will have a small extensive margin effect (individuals switching from crime to legitimate labor) offset by a larger extensive-margin increase in criminal effort among the needy.

If the population is sufficiently close to the labor-crime margin, then wage subsidies are effective without deterrence or transfers to reduce crime. As the cost of crime rises, the optimal policy involves both transfers (and subsidies) and deterrence: transfers essentially move individuals from need to (relative) affluence to ensure that deterrence is actually effective in discouraging illegitimate activity. Essentially, transfers provide individuals something to lose, making deterrence a complement to welfare rather than a substitute.

The model illustrates the point that optimal policy is a complex function of the social cost of transfer, the social costs of an activity (criminal or simply undesirable), the level of need of a population, and the degree of complementarity between illegitimate and legitimate activity. As such, it provides a framework to account for many of the results that have been reported in the recent empirical literature.

This paper builds on the theoretical models of deterrence stemming from Becker (1968) and Ehrlich (1973), which focus on the effect of deterrence (probability and size of punishment) and the attractiveness of legitimate labor as substitute for criminal activity.[3] The core elements of the Becker-Ehrlich framework are highlighted in reviews of the literature by Polinsky and Shavell (2000) and Chalfin and McCrary (2017), compiling the many theoretical modifications and empirical results in the last five decades. Labor economists have incorporated taxes (Lemieux et al. (1994)), leisure (Grogger (1998)), human capital (Williams and Sickles (2002), Lochner (2004), Deming (2011)), and networks (Calvo-Armengol et al. 2007) into models of criminal choice and deterrence, and there is broad evidence for economic conditions and wages influencing crime (Kelly (2000); **?**); Yang (2017); Agan and Makowsky (2021)). Additional advancements include incorporating extralegal consequences and social stigma (Nagin and Pogarsky (2001); Durlauf and Nagin (2011)), distinguishing

[3]Ehrlich (1973) also links income inequality to higher levels of property crime and estimates his model with data.

between the probability of arrest and the probability of punishment (Nagin (2013)), incorporating dynamics (Lee and McCrary (2017)), and incorporating the incapacitation effect of arrest (Nagin et al. (2015)).

This paper puts aside the important role of incarceration, in order to focus upon the labor supply effects of criminal deterrence. While incarceration policy is extremely important, even in the US, the relative number of individuals who have contact with the criminal justice system is larger than the number of individuals who are incapacitated in prison for a significant duration: 3% of all adults have been to prison, 8% have a felony conviction (Shannon et al. (2017)), more than 77 million people in the US have criminal histories (Fields and Emshwiller (2014)), and about 40% of white and 50% of Black men in the US experience an arrest by the age of 23 (Brame et al. (2014)). Our focus is upon the deterrence effect of sanctions, such as the probability of an arrest.

The agenda for the paper is as follows. Section 2 introduces the basic model when individuals choose a single activity level. Section 3 extends this to several activities, and shows how the insights from the one activity model naturally extend to this case. In particular, it is shown that optimal policy depends upon whether illegitimate activity is a complement or a substitute with legitimate activity. The empirical implications of the model are discussed in section (4). Section 5 uses the model to do a welfare evaluation of policy options, showing that optimal crime policy uses both deterrence and transfers as instruments. The use of deterrence is more effective for wealthier individuals, a result that is consistent with the observation in the literature on tort law that less wealthy individuals are less sensitive to tort damages.[4] The paper concludes with a discussion of the results and questions for future research.

2. Labor Supply and the Jean Valjean Effect

This section follows Becker (1968) and Ehrlich (1973) to view illegitimate activity as a labor supply problem. Our goal is to identify conditions under which transfers may be more effective than deterrence to reduce the supply of illegitimate labor. We do so by beginning with a simple model of consumption and illegitimate labor that highlights how deterrence and transfers interact to determine labor supply.

Consider an individual, i, who chooses how much time, l_i, to supply to the illegitimate labor market — in this section, "labor supply" will solely refer to illegitimate labor supply.

[4]In the tort literature this is known as the problem of judgment proof plaintiffs who cannot afford to pay damages (Shavell (1986)). In the case of civil harms, one solution is the use of enterprise liability that encourages more frequent monitoring of individuals (see Sykes (1984), Kornhauser (1982) and Arlen and MacLeod (2005)). This is consistent Chalfin and McCrary (2017)'s discussion of the deterrence literature where it is shown that deterrence is greater with more frequent monitoring. The flip side is that transfers relax the judgment proof constraint, that in turn reduces the dependence on more frequent monitoring.

Labor supply, l_i, need not only be the amount of illegitimate labor (crime), it can be also viewed as the individual's effort applied to such activity (time planning or preparing) or the severity of the activity (e.g., stealing a bag of chips vs. car-jacking).

The individual is assumed to earn w_i for illegitimate labor that corresponds to the wage after deterrence (τ_i), $w_i = w - \tau_i$, where deterrence is effectively a tax on illegitimate activity. Our formulation of deterrence as a tax is most easily seen in the form of a fine, however it can also be any increased expected sanction that reduces consumption. For example, being arrested and held in jail reduces consumption as one loses income (legitimate or criminal) while incapacitated or can damage future earnings or ability to consume.[5] In the case of drug dependency, both a fine as well as incapacitation will reduce an individual's ability to meet their minimum consumption level.

Hence, individuals i's consumption is given by:

$$c_i = w_i l_i + t_i, \tag{1}$$

where t_i is the income stream that is independent of labor supply from wealth, the state or the family. For now, we restrict our model to the case of an individual who either cannot obtain a wage from legitimate labor (or additional hours of legitimate work) or whose illegitimate wage is strictly higher than their legitimate wage at any reasonable level of deterrence. In this sense, legitimate work can be subsumed by the initial income stream (t_i). Allowing legitimate labor and wages to change will be discussed in section 5. Given the budget constraint in equation (1), the individual chooses labor supply to maximize utility that takes the following form:

$$U_i\left(c_i, l_i\right) = u_i\left(c_i\right) - V_i\left(l_i\right), \tag{2}$$

where $c_i \geq 0$ represents consumption and total labor supply is given by $l_i \geq 0$. The utility from consumption, with $c \in (c_i^0, \infty)$, is assumed to be twice differentiable, with $u' > 0$ and $u'' \leq 0$ on (c_i^0, ∞). The consumption $c_i^0 \geq 0$ represents the lower bound on a person's acceptable consumption. The cost of effort function, $V(l) \geq 0$, is assumed to be twice differentiable and strictly convex, with $V''(l) > 0$, $V'''(l) \leq 0$ for $l \geq 0$, and $V(0) = V'(0) = 0$.[6] This implies that the function is minimized when $l = 0$. The existence of well defined labor supply does not depend upon V''', but ensuring it is positive implies a unique social optimum. It can be relaxed at the cost of increasing the complexity of the analysis.[7]

[5]For example, Aneja and Avenancio-Leon (2021) find that incarceration reduces access for credit leading to increased crime.

[6]The third derivative is needed to sign the second derivative of labor demand.

[7]If $V(l) = al^v$, these conditions are satisfied for $a > 0$ and $v \geq 2$.

It is worth observing that the functional form in (2) is not only consistent with King et al. (1988) preferences used in macro-economics, but is also the ubiquitous functional form used in agency theory (Hart and Holmström (1987)). In our context, this functional form results in a clean set of conditions that allow us to separate the case where labor supply is upward sloping, or when it is downward sloping. In labor economics, the standard approach supposes that leisure is a consumption good, with the consequence one does not obtain clean conditions that distinguish under which labor supply is backward bending.[8]

The fixed transfer t_i can be income from wealth, but it is also a potential policy instrument that can be changed by the government through lump sum transfers or taxes. Given a wage w_i and transfer t_i the individual chooses labor supply. In order for this to be a well defined problem it must be feasible in the sense that total income is sufficient to pay the minimum consumption need c_i^0. This can be captured in a utility framework with the following definition:

Definition 1. A person has a consumption need c_i^0 if:

$$\lim_{c_i \downarrow c_i^0} u(c_i) = -\infty.$$

We have defined need by a minimal consumption level, and when $c_i > c_i^0$ then the person has sufficient resources to survive, and hence utility is finite. It is natural to think about a need as one for which utility become unbounded from below as $c_i \to c_i^0$. Accordingly, we define a person's *need* or *neediness* by $n_i = c_i^0 - t_i$, the amount by which a transfer (and non-illegitimate income) falls below minimum consumption. Let $n_i^0 = c_i^0$ denote a person's need in the absence of a government transfer.[9] When a person is needy, then (illegitimate) labor income is needed to ensure that they have sufficient consumption to cover their basic needs. This parameter plays a key role in the subsequent development.

Given that utility is increasing in consumption, then consumption is equal to labor income plus transfers, and hence the optimal labor supply is the solution to

$$\max_{l \geq 0} U_i(l), \tag{3}$$

where

$$U_i(l) = u_i(w_i l + t_i) - V_i(l). \tag{4}$$

The assumptions regarding the utility from consumption and cost of labor imply:

[8]See Keane (2011) for a recent review of the literature on labor supply elasticities. The focus has been on obtaining elasticity measures that control for endogeneity bias. Empirical estimates of Mashallian elasticities vary from -0.2 to 0.89 (table 7). The focus of that literature is using labor supply elasticities to evaluate income tax policy.

[9]This is done for convenience. If a person has their own income stream then we simply let $c_i^0 = c_i^{TrueNeed} - t_i^0$.

Proposition 2. *There is a well defined labor supply function, $l_i^*(w_i)$ solving (3) for $w_i > 0$.*

We begin by characterizing preferences that are wage inelastic– meaning labor supply does not change with the wage. It turns out that these preferences have a simple structure that allow a simple characterization of cases with either upward (increasing with wage) or downward (decreasing with wage) labor supply curves.

Proposition 3. *Labor supply is wage inelastic on an open set of wages not containing the zero wage if and only if it has the form:*

$$u_i(c) = log(c - t_i). \tag{5}$$

The details of the proof are found in the appendix. One can verify the sufficient condition. When $t_i = 0$, the utility of the individual is given by:

$$U(l_i) = log(w_i l_i) - V(l_i).$$

The optimal labor supply with no transfers, l_i^0, solves $U'(l_i^0) = 0$, and it is the unique solution to:

$$\frac{1}{l_i} = V_i'\left(l_i^0\right) > 0. \tag{6}$$

Since this solution is independent of the wage, then labor supply is wage inelastic. These preferences are widely used in macro-economics, and they are known as the King-Plosser-Rebelo preferences (King et al. (1988)).[10] This result motivates the following specification that allows one to provide a clean condition under which labor supply is either upward or backward bending:

Definition 4. The preference of individual i with need c_i^0 is given by:

$$u_i(c) = \log\left(c - c_i^0\right).$$

This satisfies the criteria of need since $lim_{c \to c_i^0} u_i(c) = -\infty$. With these preferences and given $n_i = c_i^0 - t_i$, or $t_i = c_i^0 + n_i$, then labor demand is inelastic if and only if need satisfies $n_i = 0$. A person is said to be needy if and if $n_i > 0$. What is nice about this specification is that whether or not labor supply is upward sloping is completely determined by the level need. When a person is needy, we show presently that decreasing the wage *increases* labor supply, and hence the Marshallian elasticity is negative. Conversely, we say a person is affluent if $n_i < 0$, in which case decreasing the wage, *decreases* labor supply.

[10] When $c_i^0 = 0$. Kimball and Shapiro (2008) provide an alternative axiomatization of this preferences via an assumption they call *scale symmetry*. Their concern it with inter-temporal labor supply, while our focus is upon deterrence and inequality within the period.

More precisely, give a wage $w > 0$, and transfer t_i, and a binding budget constraint, the person's utility as a function of labor supply l_i is given by:

$$\begin{aligned} U_i\left(l_i|w,t_i\right) &= \log\left(wl_i + t_i - c_i^0\right) - V\left(l_i\right), \\ &= \log\left(wl_i - n_i\right) - V\left(l_i\right), \end{aligned}$$

where $n_i = c_i^0 - t_i$ is the person's need.

However, at the individual level we know there is quite a deal of variation in the elasticity in labor supply. What is nice about this specification is that a single parameter, the level of need n_i, determines the effectiveness of deterrence. The analysis of the labor supply problem can be simplified if we derive labor supply as a function of *affluence:*

$$A_i = -\frac{n_i}{w_i} = \frac{t_i - c_i^0}{w_i}.$$

When a person is needy ($n_i > 0$), then $A_i < 0$, and A_i is the amount of labor hours needed to meet basic needs. When a person is not needy, then $A_i \geq 0$, and it measures in labor hours how far above one's consumption need (c_i^0) the endowment places the individual. In particular, notice that as the wage approaches zero, a needy individual becomes increasingly desperate because the amount labor required to meet needs becomes infinite ($\lim_{w_i \to +0} \frac{n_i}{w_i} = \infty$). These effects are captured by the labor supply function:

Proposition 5. *Given a wage $w_i > 0$, labor supply can be written as a function of affluence:*

$$l_i\left(w_i\right) = l\left(A_i\right),$$

where $A_i = -\frac{n_i}{w_i}$, and the function $l\left(A_i\right) > 0$ is the unique, decreasing solution to:

$$A_i = \frac{1}{V_i'\left(l\left(A_i\right)\right)} - l\left(A_i\right). \tag{7}$$

The details of the proof are in the appendix (section). The individual's optimal labor supply is found by differentiating (3) with respect to the wage, w_i, and rearranging to get (7). The nice feature of this result is that the shape of labor supply is a fixed function of the level of affluence. This relationship is illustrated in figure (1). Given that the marginal cost of effort is zero with zero effort, this implies that for any positive wage there is some labor supply. When a person is not needy ($A_i \leq 0$), then increasing the wage (w_i) increases affluence ($A_i = \frac{-n_i}{w_i}$) and labor supply increases.

Conversely, if the person is needy ($n_i = c_i^0 - t_i > 0$), then as the wage decreases and approaches zero the person becomes less affluent ($A_i = -\frac{n_i}{w_i} \to -\infty$), and labor supply increases without bound. Labor supply is inelastic when $n_i = 0$, since $A_i = 0$, and independent of the wage. In this case labor supply, $\bar{l}_i$, is the unique solution to $\bar{l}_i = 1/V'\left(\bar{l}_i\right)$.

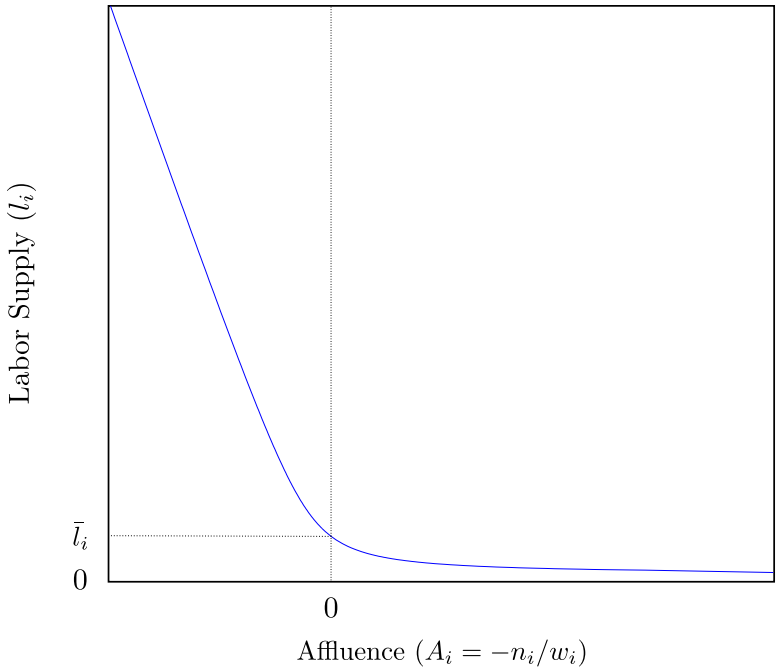


FIGURE 1. Labor Supply as a Function of Affluence

When viewed as a function of affluence, labor supply is a smooth continuous function. This is not the case for labor supply curve as a function of the wage. This is illustrated in figure (2). When need is zero, then labor supply is inelastic and fixed at $\bar{l}_i$. When a person is affluent, the labor supply is given by the lower curve. In this case, the elasticity of labor supply is positive, and it becomes increasingly inelastic as the wage rises. Labor supply increases with the wage and asymptotically approaches $\bar{l}_i$, the maximum labor supply. This is because as the wage increases, $w_i \to \infty$, then affluence approaches zero, $A_i \to 0$, and hence labor supply approaches $\bar{l}_i$. This relationship is intuitive, and it is the most commonly considered case: as wages rise, individuals work more to afford more consumption, as substitution effect drives them away from non-labor.

Conversely, for a needy person, labor supply has a negative elasticity, which we call the Jean Valjean effect. As the wage falls, the needy person must work more to cover their basic needs, and hence labor supply becomes unbounded when the wage approaches zero. This produces a backward bending labor supply curve (as the wages rise, then labor supply falls). In this case the income effect is larger than the substitution effect.

2.1. **Discussion.** This section provides a very simple extension of the Becker-Ehrlich view of criminal activity as a labor market decision. Namely, by introducing standard preference assumptions and target level of minimum consumption (c^0), we show that the sensitivity of individuals to changes in the 'wage' from criminal labor varies significantly particularly with

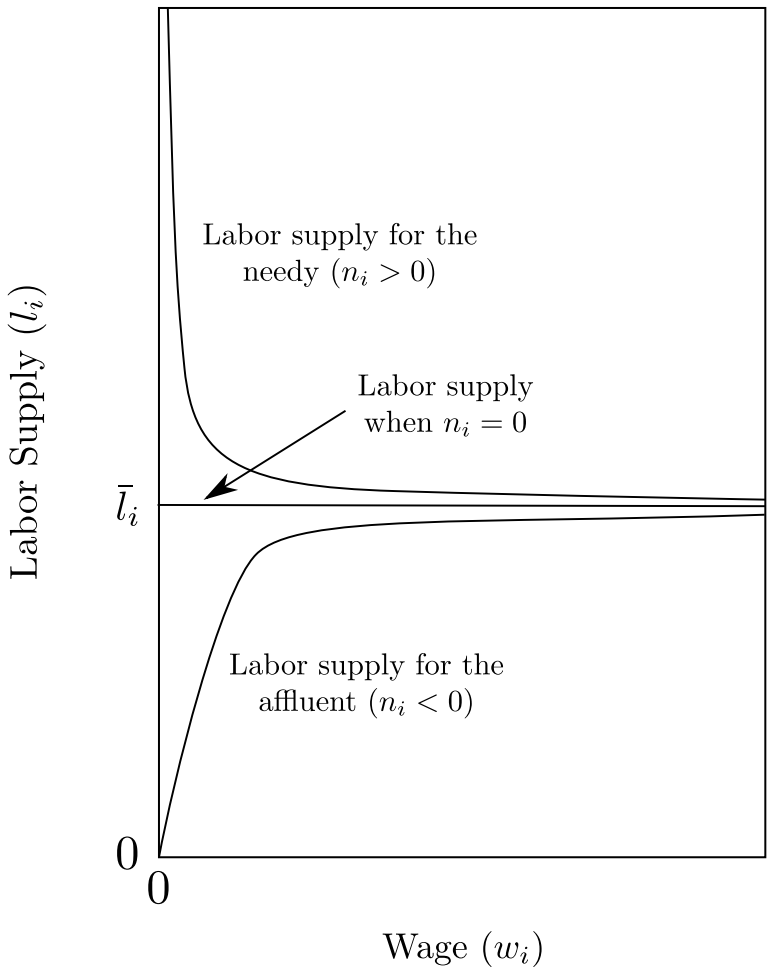


FIGURE 2. Labor Supply

the respect to the individual's level of need: the difference between their base wealth and their target consumption. We model deterrence as a method of reducing the criminal wage, or a tax on crime, meaning that increasing deterrence can increase criminal activity among needy individuals and decrease it among affluent ones – just as a tax on legitimate labor can increase labor supply as needy individuals work more to meet their consumption needs. Note that an increase in l_i need not be an increase in observed crime, but rather effort applied to criminal activity. This effect on the needy, the Jean Valjean effect, is generally lacking in deterrence theory, which predicts increasing deterrence decreases crime.[11]

Much of the literature follows Becker's original model to suppose that criminal activity affects the probability of detection. When detected, the individual faces a penalty P. In appendix section (A.2) we show that one can use a standard agency model as in Shapiro and

[11]Such a gap is familiar in the development literature around social insurance. As discussed in Chetty (2006), social insurance prevents low-income individuals from reducing investments in human capital, for example, in the goal of smoothing consumption.

Stiglitz (Shapiro and Stiglitz), to model activity over time. One can show that the model with a probability of detection is equivalent to a labor supply choice in continuous time, with a Poisson arrival rate of punishments, where the punishment takes the form of a tax on labor supply.

The research on the effect of transfers on crime and the deterrence literature are largely separate due to transfers not being easily incorporated in the Becker-Ehrlich model of deterrence. As such, this simple model provides a unification of these disjoint but directly related literature, as well as the ability to estimate how elasticities with respect to deterrence and transfers change across the distribution of individual need. We postpone a detailed discussion of the empirical implications of the approach to section (4). One of the reasons that deterrence always effect in the Becker-Erlich model is the implicit assumption that individuals always have available to them alternative legitimate employment opportunities. The next section extends the one activity model to allow for substitution between legitimate and illegitimate work.

3. Intensive vs Extensive Margin: The Substitution Effect

Low unemployment, high wages, and good economic conditions are consistently found to be crime-reducing, and legitimate labor is often viewed as a substitute for crime (Ehrlich (1973)). In this section, we show that the level of illegitimate activity not only depends on the payoff from both legitimate and illegitimate labor, but, importantly, the complementarities between legitimate and illegitimate labor.

Let L_i denote a legitimate activity, and let l_i continue to represent the level of the illegitimate activity or crime. While traditionally viewed as substitutes (one either chooses employment or crime), a feature of illegitimate activities is that they may be complementary with the legitimate activity, as with the example of longshoremen discussed in the introduction. Let W_i be the wage for the legitimate activity, and $w_i = w - \tau_i$ continues to be the wage from illegitimate activity, while t_i^0 is a person's endowment in flow terms, and t_i is any public transfer. Preferences are given by:

$$u_i\left(\vec{w}_i, \vec{l_i}\right) = \log\left(W_i \times L_i + w_i \times l_i + t_i + t_i^0 - c_i^0\right) - V_i\left(\left(L_i^\theta + l_i^\theta\right)^{1/\theta}\right), \tag{8}$$

where $\vec{w}_i = \{W_i, w_i\} = \{W_i, w - \tau_i\}$ $\vec{l_i} = \{L_i, l_i\}$. Let:

$$f_\theta\left(\vec{l}\right) = \left(L^\theta + l^\theta\right)^{1/\theta},$$

be a CES production function, where $\theta \geq 1$ measures the degree of substitution between activities given by $\sigma = \frac{1}{1-\theta}$. We study in detail the cases where the activities are perfect

substitutes ($\theta \to 1$) or perfect complements ($\theta \to \infty$).[12] If $\theta = 1$ then $f_1\left(\vec{l}\right) = L + l$ and the model is linear. In that case it is optimal for the individual to allocate all effort to the activity, with the highest wage (perfect substitutes). This An increase in θ increases the return to spreading labor between the two activities. When $\theta \to \infty$ this results in the Leontief preferences $f_{\theta=\infty}\left(\vec{l}\right) = \max\{L, l\}$. In that case the individual allocates effort equally between the two activities, regardless of the relative wages (perfect complements).

In addition to capturing the full range of substitution possibilities between legitimate and illegitimate activities, the CES production function allows us to aggregate activity levels and wages into a single index. The aggregate measures allow us to distinguish the effect of policy on over all economic activity, separate from the allocation between legitimate and illegitimate activities.

The labor supply, $\vec{l}^*$,that maximizes utility (8) satisfies (see appendix section (A.3) for details of the computations):

$$\left(\frac{l_i^*}{L_i^*}\right) = \left(\frac{w_i}{W_i}\right)^{1/(\theta-1)}. \tag{9}$$

Thus, the ratio of legitimate to illegitimate activity does not depend upon the shape of the cost of labor function, V_i. For this specification we can define an aggregate measure of "activity", denoted by $\hat{l}_i$, and a corresponding wage index $\hat{w}_i$ by:

$$\hat{l}_i = f_\theta\left(\vec{l}\right) = \left(L_i^\theta + l_i^\theta\right)^{1/\theta}, \tag{10}$$

$$\hat{w}_i = \hat{w}\left(\vec{w}\right) = \frac{W^{\sigma+1} + w^{\sigma+1}}{f_\theta\left(W^\sigma, w^\sigma\right)} = f_{\theta\sigma}\left(W, w\right)^{-1}. \tag{11}$$

where $\sigma = \frac{\theta}{\theta-1}$. This allows us to view the choice as a two step procedure. In the first step the individual chooses how to allocate labor between two activities, with a bound on aggregate activity to solve:

$$\max_{\vec{l}_i \geq \vec{0}} \log\left(W_i \times L_i + w_i \times l_i + \hat{w}_i A_i\right)$$

subject to:

$$f_\theta\left(\vec{l}_i\right) \leq \hat{l}_i.$$

[12]Notice that this is a bit different from Arrow et al. (1961), where the CES is used for production. In their case $\theta < 1$. The difference is that labor is a cost in the CES function and an element of productivity in the Arrow et al. (1961).

In the appendix we show that the solution is:

$$L_i = \gamma\left(\frac{W_i}{w_i}\right)\hat{l}_i, \tag{12}$$

$$l_i = \gamma\left(\frac{w_i}{W_i}\right)\hat{l}_i, \tag{13}$$

where $\gamma(r) = \left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}}$. This function plays an important role in the subsequent analysis. Notice that $\gamma(r)$ is increasing in r since $\sigma > 1$, with:

$$\lim_{r\to 0}\gamma(r) = 0,$$
$$\lim_{r\to\infty}\gamma(r) = 1.$$

See appendix section (A.3.1) for additional results. Notice that $\theta = \sigma$ if and only if $\theta = \sigma = 2$. It turns out that this forms an economically meaningful cutoff. When $\theta > 2$ then labor supply to legitimate and illegitimate labor are complements, and when $\theta \in (1, 2)$, they are substitutes.

With this function, we get that aggregate wage satisfies:

$$\hat{w}(\vec{w}) \equiv W \times \gamma\left(\frac{W}{w}\right) + w \times \gamma\left(\frac{w}{W}\right), \tag{14}$$

In particular, given the activity level, $\hat{l}_i$, the allocation between legitimate and illegitimate labor depends only upon the ratio of returns. Moreover, with these definitions the following identities hold:

$$W_i \times L_i + w_i \times l_i = \hat{w}_i\hat{l}_i,$$
$$f_\theta\left(\vec{l}_i\right) = \hat{l}_i.$$

In other words, at an optimal allocation, $\hat{w}_i$ is the return in dollars from engaging in an aggregate activity level given by $\hat{l}_i$. This implies that the optimal activity level can be modeled as a one dimension labor supply problem, as studied in section (2). Thus, the optimal activity level, $\hat{l}_i^*$, is the solution to:

$$\hat{l}^*(\hat{w}_i) = \arg\max_{\hat{l}_i \geq 0} \log\left(\hat{w}_i \times \hat{l}_i + t_i + t_i^0 - c_i^0\right) - V_i\left(\hat{l}_i\right).$$

This is formally identical to the one activity problem solved in the previous section. As before, we can define *aggregate* affluence as $\hat{A}_i = \frac{-n_i}{\hat{w}_i} = \frac{-c_i^0 + t_i^0 + t_i}{\hat{w}_i}$, and thus we have:

$$\hat{l}^*(\hat{w}_i) = l\left(\hat{A}_i\right) = l\left(\frac{-n_i}{\hat{w}_i}\right). \tag{15}$$

Equations (12-13) imply that, holding total activity fixed, increasing deterrence reduces the relative return of the illegitimate activity and hence decreases the relative allocation of time to that activity. However, this is only a partial effect. Increasing deterrence also affects total activity. As we can see from (15), when a person is needy, then the Jean Valjean effect implies that decreasing the aggregate wage, $\hat{w}_i$, *increases* total activity. Thus, for needy persons more deterrence increases the ratio of legitimate to illegitimate labor via (9). The net effect upon crime or illegitimate activity depends upon the relative size of the substitution effect versus the effect on over all activity. Thus, for needy individuals the net effect of deterrence is indeterminate.

From (15) we can see that the effect of a transfer on aggregate activity is the same as in the single activity case, hence for affluent individuals an increase in deterrence always decreases illegitimate activities. When substitution is imperfect, $\theta \in (1, \infty)$ and wages strictly positive, then effect of an increase in deterrence on illegitimate activity is:

$$\frac{\partial l_i}{\partial \tau_i} = \frac{\partial \hat{l}_i \gamma\left(\frac{w_i}{W_i}\right)}{\partial \tau_i}. \tag{16}$$

$$= -l'\left(\hat{A}_I\right)\gamma\left(\frac{w_i}{W_i}\right)\frac{\hat{A}_i}{\hat{w}_i}\frac{\partial \hat{w}_i}{\partial \tau_i} - l\left(\hat{A}_I\right)\frac{\gamma'\left(\frac{w_i}{W_i}\right)}{W_i} \tag{17}$$

In the appendix we show that $\gamma' \in (0, 1)$, and hence the second term is negative. What a person is affluent, then an increase in deterrence always reduces the activity level, and hence the first terms is also negative, Thus, for affluent individuals, increased deterrence always reduces the level of illegitimate activity. However, when a person is needy the sign of $\frac{\partial \hat{l}_i}{\partial \tau_i}$ is indeterminate. In the appendix it is shown that $\lim_{r\to\infty} r\gamma'(r) = 0$, from which it follows that as $W_i \to 0$ then the second term on the right of (16) approaches zero. The first term converges to the labor supply for the one activity level, which implies that deterrence reduces illegitimate activity if and only if the person is affluent.

Suppose now we take wages as fixed and consider the consequence of substitution for deterrence. In the case of perfect substitutes ($\theta = 1$), then the individual will simply choose the activity with the highest return. This immediately implies that:

$$l_i(\vec{w}) = \begin{cases} 0, & \tau_i \geq w - W_i, \\ l\left(\frac{t_i^0 + t_i - c_i^0}{w - \tau_i}\right), & \tau_i < w - W_i. \end{cases}$$

In other words with perfect substitutes the individual will specialize in legitimate or illegitimate work. If deterrence is greater the then difference between the illegitimate wage and legitimate wage then illegitimate activity or crime will be driven to zero. If not, illegitimate or criminal activity will vary as in the case of the one activity model above.

In the case of perfect complements, it is always optimal to to set $l_i = L_i$, and hence the level of crime is identical to the measure of aggregate activity with a wage $\hat{w} = f_\sigma(w - \tau_i, W_i)$:

$$l_i(\vec{w}) = \hat{l}_i = l\left(\frac{t_i^0 + t_i - c_i^0}{\hat{w}_i}\right).$$

Hence, the effect of deterrence is given by:

$$\frac{\partial l_i}{\partial \tau_i} = l'\left(\hat{A}_i\right)\hat{A}_i$$

4. Empirical Implications

This simple one activity model makes a number of predictions that are in line with in line with existing empirical research. As Chalfin and McCrary (2017) observed, there is great deal of variation in the estimate elasticity of response of crime to deterrence, and it is often small or insignificant. In particular, the elasticities reported in the literature are the average effects, and hence mask underlying variation.

Second, this model highlights the potentially significant effect of transfers to needy individuals in reducing their criminal activity. Property crimes and other 'income generating' crime are often described as crimes of desperation. As discussed in Allen (2005), drug addiction leads to street crime through "one-off 'acts of desperation'". Programs which target needy individuals, such as SNAP (Tuttle (2019)) and SSI (Deshpande and Meuller-Smith (2021)), have been shown to have large impacts on income generating crime in particular, while cash transfers to the relatively affluent have no such effect (Watson et al. (2020)). The use of transfers to reduce crime is inline with shifting the focus of public safety policy toward less punitive (deterrence-focused) solutions (Bell (2021)), as the externalities associated with policing-centered alternatives have proven to be sizable (Ang (2021)).

Third, our model predicts negative labor supply elasticities for desperate individuals. Coca eradication is a perfect example of this. The policy of coca eradication (government actions to destroy large swaths of coca farms in South American countries such as Colombia to reduce cocaine supply) is largely considered a failure (ICG (2021)). The policy destroyed farmers' income without a corresponding alternative income stream or transfer It simply drove them into desperation and increased the ability of cartels to pressure them. As predicted by the model, needy coca farmers when faced with increased deterrence (destruction of their illegal crops) exhibit negative labor supply: Reyes (2014) finds that coca eradication increased coca cultivation with an elasticity close to 1; Mejia et al. (2017) shows eradication via arial spraying to be highly destructive but have a relatively small effect on cultivation and massive costs relative to benefits.[13]

[13]While desperation is most easily linked to property crimes, there is evidence for increased deterrence actually increasing violence, despite its goal of reducing serious crime. A growing literature focusing on

Extending the model to allow for substitution between legitimate and illegitimate activities provides an addition set of implications within a standard labor supply model. First, when employment and illegitimate activity are substitutes, then an increase unemployment that reduces the return to legitimate labor increases crime; however if more employment is available, individuals will choose employment and legitimate activity over unemployment and illegitimate activity which bears the deterrence tax. Similarly, a wage subsidy that increases W_i, the return to legitimate activity, results in substitution away from crime. This underscores the well known result in the deterrence and labor literature that improved economic conditions decrease crime, particularly property crime (Grogger (1998); Kelly (2000); **?**); Yang (2017); Rose (2018); Dell et al. (2019); Rege et al. (2019); Agan and Makowsky (2021)).[14]

Furthermore, some employment and illegitimate activity can be complements instead of substitutes. Our model predicts that these jobs will be more likely to employ individuals with criminal records since individuals with criminal histories will have more criminal capital, and thus higher wages from illegitimate activity, so they will be attracted to occupations where these skills are complementary with legitimate activities.[15]

Financial advisor misconduct is a prime example of complementarities between legitimate and illegitimate work. Egan et al. (2019) provides a highly relevant analysis of the industry. First, they show that over 7% of financial advisors have at least one reported disclosure of misconduct. Second they provide evidence consistent with advisors who commit misconduct being fired but re-hired by other firms, and some firms specializing in misconduct– where complementarities between legitimate and illegitimate labor are high.

Another profession that has complementarities with illegitimate activity is law enforcement. Given the powers (a monopoly on violence, frequent contact with criminal elements, etc.) and discretion of police officers, committing illegitimate acts as a police officer is very

Mexico and Brazil has found heavy-handed and aggressive anti-crime initiatives to actually increase violent crime (Calderón et al. (2015); Flores-Macías (2018)) or increase support for criminal organizations (Magaloni et al. (2020)). Bullock (2021), for example, suggests that a reduction in police raids in Brazil reduced violent crime because unpredictable and highly violent raids forced criminals to be more violent and on-edge for self-protection.

[14]This was the logic behind New Deal policies providing work-relief programs: Fishback et al. (2010) finds that New Deal work relief programs during the Great Depression reduced property crime, and calls for more study of the effects of social insurance on crime. **?** introduces crime into a search model which connects wages, crime, and unemployment.

[15]Schnepel (2018), for example, finds that employment opportunities in higher wage industries like construction and manufacturing significantly reduce recidivism, while opportunities for lower wage jobs (retail and food service) and high qualification jobs do not. This is consistent with the observation that retail jobs suffer from on the job theft, and that such businesses are often points of contact for illegal activity. Additionally, Davis and Heller (2020) show that some youth summer employment increases future property crime, which the authors ascribe to employment increasing opportunities for some forms of criminal activity, and hence employment and crime are complements.

attractive and potentially lucrative. The frequency of corruption and major misconduct scandals in US policing over the last half-century are evidence of this complementarity. This issue is a focus of Becker and Stigler (1974), who design an optimal compensation structure for law enforcement agencies in order to discourage malfeasance.

On an aggregate level, the degree of substitution between legitimate activities and crime has implications for policy. If a legitimate industry is complementary with one that is illegitimate, then deterrence will reduce overall activity. For example, Russo (2014) shows that increases in legitimate shipping without increased enforcement or inspections led to an increase in cocaine smuggling, as the activities are complementary. Increasing inspections would deter smuggling but would also raise costs for the legitimate activity, thereby reducing shipping. Furthermore, transfers would decrease the legal and illegal shipping activity– though transfers to suppliers may reduce supply (as discussed above with respect to cocoa eradication). Figure (3) illustrates this complementarity, displaying the negative relationship between the price of cocaine in cocaine importing country's and the country's ratio of imports to GDP.

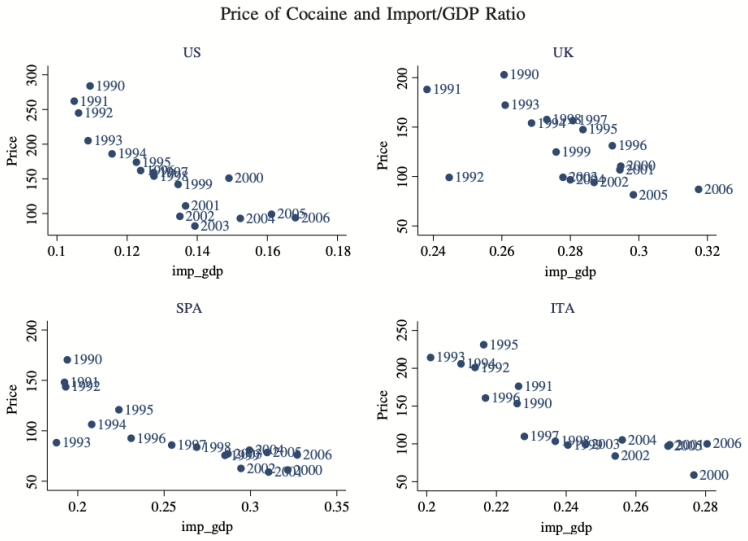


FIGURE 3. Price of Cocaine and Import/GDP Ratio
Source: Russo (2014)

The case of the Netherlands perfectly illustrates the need to consider these complementarities when constructing crime policy. While many believe that 'soft drugs' such as marijuana and hashish are legal in the Netherlands, they are actually technically illegal. However, consumption and sale of such drugs is tolerated, effectively decriminalizing these activities through a policy of tolerance known as "gedoogbeleid". In principal, this half-way policy seems like a tolerant and enlightened approach to drugs with little social and individual

harm.[16] However, it introduces perverse results due to complementarities. Because the 'coffee shops', which sell soft drugs, are legal but obtaining the drugs is illegal (i.e., production, transportation, etc.), this means that the policy induces strong complementarities between the legitimate activity (demand) and the illegitimate activity (supply). As a result, all supply is performed by criminal enterprise, who then invest in criminal production and shipping networks and violence to protect territory and influence critics and officials.[17] This has led to the Netherlands being a hub for cocaine production and shipment for international drug trafficking and the site of increasingly dire situation with powerful drug gangs — who have assassinated lawyers, informants, and in 2021 caused the prime minister to be put under special guard.[18] Either making consumption illegal or supply legal would significantly damage these criminal enterprise as they would remove the complementarity between criminal enterprise and legitimate activity.[19]

Finally, one can use this framework to understand the introduction of legitimate activities which are substitutes for illegitimate ones. For example, Cunningham and Shah (2017) show that decriminalizing indoor sex work actually reduces sex crimes and STIs among sex workers, while the total market expanded. Similarly, Ciacci and Sviatschi (2021) show that opening of adult entertainment establishments in New York reduce sex crimes. This research illustrates that the creation of a less socially costly alternative activity that is a substitute for a socially costly and illegitimate one can reduce crime and improve social outcomes.

5. Deterrence and Optimal Policy

In this section, we provide a model of optimal crime policy which combines the models in the previous sections to show that optimal crime policy operates through three main instruments: transfers to individuals, deterrence, and wage subsidies. We begin by outlining the general case, and then focus upon the conditions for optimal policy when a person is needy and has few legitimate employment opportunities. We then consider the cases of pure substitutes and pure complements to illustrate the role they play in determining optimal policy. The optimal policies and exogenous parameters for this model are summarized as follows:

- There is a private return, w, and public cost, w^c, to labor supply l_i. The assumption that $w^c > w$ makes the labor illegitimate because the social cost is great than the private benefit. It is a *crime* when there is a penalty associated with the activity,

[16] https://www.politico.eu/article/the-dark-dangerous-side-of-dutch-tolerance/

[17] See https://www.france24.com/en/europe/20211002-dutch-pm-under-protection-as-the-mocro-mafia-drug-cartel-sows-fear-in-the-netherlands and https://youtu.be/Ig5uP2R_9bg

[18] https://www.nytimes.com/2021/09/30/world/europe/netherlands-prime-minister-threats.html

[19] Notably, legal and illegal drugs have been shown to be substitutes, not complements, among juveniles based on alcohol usage studies (**?**).

that is modeled by the level of deterrence faced by individual i: $\tau_i \in [0, w]$. The social cost associated with this activity is given by:

$$sc_i^{\tau} = w^c l_i + c_{\tau}\left(\tau_i / w\right),$$

where $c^{\tau}(\cdot) \geq 0$ is the cost of enforcing deterrence τ_i, with $c_{\tau}(0) = c'_{\tau}(0) = 0$, $c''_{\tau} > 0$, and $\lim_{x \to 1} c_{\tau}(x) = \infty$. This latter assumption implies that perfect deterrence relative to the gain from criminal activity is always too costly.

- The private returns, W, to the legitimate labor supply, L_i, and the public subsidy s_i to this activity, result in a social cost:

$$sc_i^{s} = (1 + \rho) L_i s_i,$$

where $\rho > 0$ is the marginal cost of public transfers to individuals, and $1 + \rho$ is the total cost. The fact that total transfers to the individual have positive welfare is incorporated into the social cost of transfers considered next.

- A person's endowed transfer is t_i^0 and minimum consumption need is $c_i^0 > 0$. The social cost of a lump sum transfer, t_i, to the individual it given by:

$$sc_i^{t} = \rho t_i - \hat{w}_i \hat{l}_i,$$

where $\rho > 0$ is the marginal social cost of funds, $\hat{w}_i$ is the aggregate wage index, and $\hat{l}_i$ is the aggregate labor supply index.[20]

Given these parameters, the individual chooses illegitimate and legitimate labor supply, as given by proposition (5). Thus, we can let the policy choices be given by:

$$\vec{pol} = \{\tau_i, s_i, t_i\} \in P,$$

where the set of policy choices is given by:

$$P = [0, w] \times \Re_+^2.$$

The total social cost is the sum of the individual cost components. The total cost is a continuous and differentiable function of policy and hence we have:

Proposition 6. *Given the degree of substitution $\theta > 1$, then there is exists an optimal policy, $\vec{pol}^*$:*

$$\vec{pol}^* = \arg \min_{\vec{pol} \in P} sc_i\left(\vec{pol}\right),$$

[20]The $\hat{w}_i \hat{l}_i$ is included since policy changes should include the welfare impact that is measured in terms of income. Given that the person's endowment, t_i^0 , does not vary with the policy choices we do not need to include it in this cost function. We follow a standard approach in public economics, and suppose utility is transferable and measured in income terms. Thus the utility function is used to describe behavior, rather than welfare. This can be viewed as a "conservative" measure of well-being that under estimates the benefits of transfers or the cost of deterrence.

where:

$$sc_i\left(\vec{pol}\right) = sc_i^{\tau} + sc_i^{s} + sc_i^{t},$$
$$= \rho t_i + c_{\tau}\left(\tau_i/w\right) + MC\left(\tau_i, s_i\right) \times l\left(\hat{A}_i\right),$$

$\hat{A}_i = -\frac{n_i}{\hat{w}_i} = \frac{t_i + t_i^0 - c_i^0}{\hat{w}_i}$ *is affluence, and the marginal cost of activity as a function of policy is:*

$$MC\left(\tau_i, s_i\right) = w^c \gamma\left(\frac{w_i}{W_i}\right) - \hat{w}_i + (1+\rho)\,\gamma\left(\frac{W_i}{w_i}\right) s_i,$$

where $w_i = w - \tau_i$ *and* $W_i = W + s_i$.

Proof of this results follows from the fact that the social cost is bounded above and continuous. This in turn can be used to bound the policy space, and hence there exists an optimal policy. A necessary condition for intervention is that illegitimate activities impose a social cost in the absence of intervention (and hence are deemed crimes) is that $MC > 0$. This is satisfied when the cost of the illegitimate activity, w^c, is sufficiently high. In general, optimal policy may consist of a combination of the three instruments.

Existence here depends upon the continuity of costs, that in turn requires imperfect substitution and the impossibility of perfect deterrence. Those are cases that we consider separately below. In those extreme cases, one can obtain some interesting and stark results.

5.1. **Deterrence versus Transfers?** This section derives the formula for optimal policy in the case of a single, illegitimate activity. The purpose is to illustrate the fact that under some conditions, it may be optimal to use a transfer of resource to the individual rather than increase deterrence. In our case, the deterrence we are referring to an increase in the marginal cost of illegitimate activity. The analysis can be extended to deal with incarceration, though they we would have to address the issue of incapacitation, which is not the focus of this paper.[21]

To provide a unified analysis, suppose that $t_i^0 = 0$, and hence all transfers are provided by the government. We can address the general case by supposing that the transfer $t_i \geq 0$ is given. We then address two questions. First, given this transfer, what is the optimal level of deterrence. Second, given the cost of funds λ_g, should this transfer be increased or decreased? If the level of deterrence is set at the optimal level, then we can use the envelope principle to derive simple first order conditions to characterize the optimal transfer.

[21]In this model deterrence can be viewed as a tax on crime. As is the public economics literature, optimal taxes are a function of labor supply elasticities (Saez (2001)).

Given a transfer to individual i of t_i, the first order condition for optimal deterrence, $\tau^*(t_i)$, is:

$$\frac{dsc_i}{d\tau_i} = c'_\tau(\tau_i/w)/w + MC\frac{\partial l(A_i)}{\partial \tau_i} + \frac{\partial MC}{\partial \tau_i} l(A_i) \tag{18}$$

$$= c'_\tau(\tau_i/w)/w + (w^c - w + \tau_i) l'(A_i) \frac{t_i - c_i^0}{(w-\tau_i)^2} + l(A_i) \tag{19}$$

The first order condition for optimal deterrence is $\frac{dsc_i}{d\tau_i} = 0$. Notice that when a person is needy then $t_i - c_i^0$ and the expression of the right is strictly position, and hence it is impossible to satisfy the first order condition. Thus a necessary condition for deterrence to be optimal is that a person be affluent, namely $t_i > c_i^0$.

The extent to which deterrence is effective depends upon the extend to which a person's activity level is responsive to variation in the return to that activity. As we show in section 2, increasing the transfer reduces labor supply. The maximum extent to which this is possible can be measured by the elasticity of labor supply relative to affluence, defined by:

$$e_A(t,w) = \frac{l'\left(\frac{t-c_i^0}{w}\right)}{l\left(\frac{t-c_i^0}{w}\right)} \frac{t-c_i^0}{w}. \tag{20}$$

When $t > c_i^0$ this is negative, in which case increasing deterrence reduces illegitimate activity. The greatest sensitivity to deterrence is defined by:

$$e_A^{max}(w) = \inf_{t \geq 0} e_A(t,w).$$

From this we have the following proposition:

Proposition 7. *When there is no legitimate work ($W = 0$), then it is efficient to deter illegitimate activity ($\tau_i > 0$) for some transfer t if and only if:*

$$\frac{(w^c - w)}{w} e_A^{max}(w) < -1. \tag{21}$$

When this condition holds, then optimal deterrence, $\tau^*(t)$ satisfies:

(1) *There is no deterrence ($\tau^*(t) = 0$) whenever*

$$\frac{(w^c - w)}{w} e_A(t,w) \geq -1, \tag{22}$$

(2) *When this condition does not hold then the optimal level of deterrence, $\tau^*(t) > 0$, satisfies:*

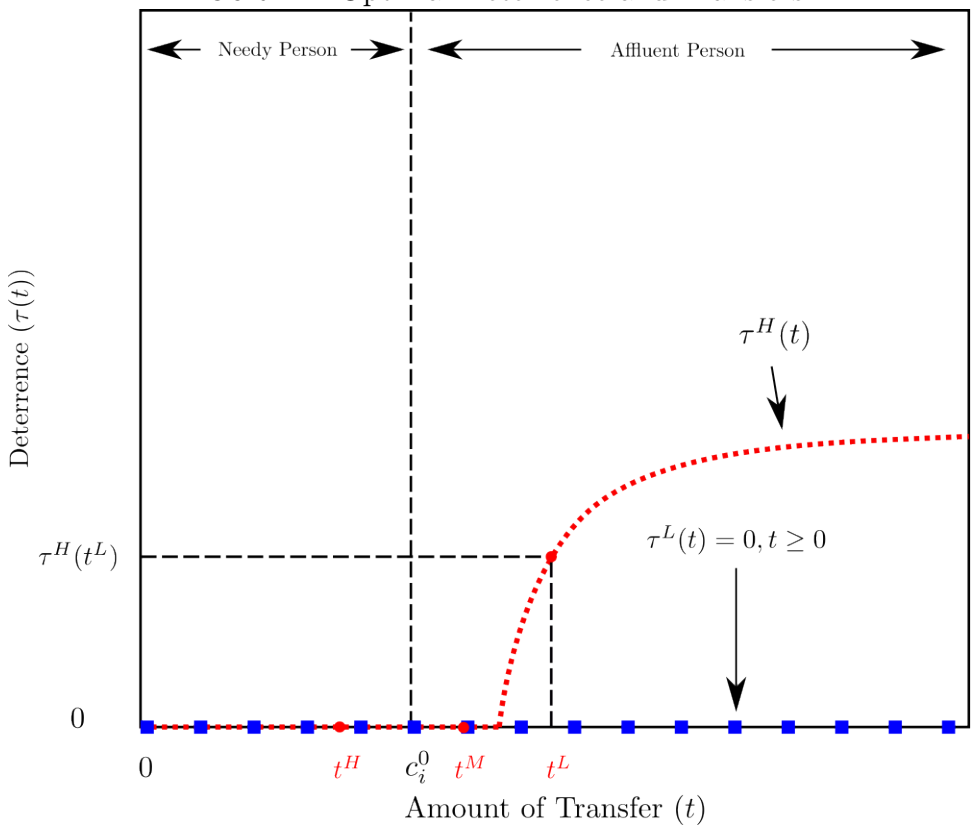
$$c'(\tau^*/w) = wl^* \times \left(\frac{(w^c - w^*(t))}{w^*(t)} e_A(t, w^*(t)) - 1 \right), \tag{23}$$

where $w^*(t) = w - \tau^*(t)$ *is the net wage for illegitimate labor supply given by* $l^* = l\left(\frac{t-c_i^0}{w^*(t)}\right)$.

This result derives the optimal level of deterrence as a function of the total transfer to an individual, t. If w^c is sufficiently close to the illegitimate wage w then condition (21) implies that it is never optimal to deter, regardless of the transfer sized. When the cost of illegitimate labor is sufficiently high this condition holds and for affluent individuals whose labor supply is sufficiently elastic (condition (22) holds) then it is efficient to have some deterrence.

This result is illustrated in figure (4). The small (red) dotted line illustrates the optimal deterrence rule as a function of affluence when illegitimate activity has a high social cost, w^{cH}, relative to an activity with a low social cost, $w^{cL} < w^{cH}$. Notice that deterrence is not optimal until the person is sufficiently affluent. In addition, the optimal level of deterrence rises with the affluence of the individual. If the social cost of the activity is sufficiently low, then no deterrence is optimal regardless of a person's affluence, as illustrated by the blue line with large dashes. For example, in New York city jaywalking is not enforced, even though it is technically a crime, Thus, it is an illegitimate activity, but it is not sanctioned in practice.

FIGURE 4. Optimal Deterrence and Transfers



In this figure we have illustrated the optimal deterrence for three different levels of affluence. When the transfer is t^H (H refers to high social cost of funds, w^{cH}, that we discuss presently) then the individual is needy, and it is never optimal to impose deterrence. Given there is a fixed cost associated with initiating deterrence, then even when a person is affluent, as given by transfer t^M deterrence may still not be optimal. However, when sufficiently affluent, as indicated by t^L, then it is optimal to have some deterrence when the social cost of illegitimate activity is high (w^{cH}).

This curve illustrates the optimal deterrence *conditional* upon the level of transfer. The next question is whether the public should fund a transfer out of public funds? As we discussed in the empirical section, there is a growing body of evidence illustrating the result that increases in transfers to individuals can reduce crime. Whether or not such transfers are efficient depends upon the marginal costs of public funds. Suppose that we have in place an efficient deterrence level conditional upon the transfer t, given by $\tau^*(t)$. Exploiting the envelope theorem, we can then ask whether or not it is efficient to use transfers in addition to deterrence as part of optimal crime policy, under the hypothesis that a person has no income endowment ($t_i^0 = 0$) . The first order condition for an optimal transfer of funds is given by:

$$\frac{dsc\left(t,\tau^*(t)\right)}{dt} = \frac{\partial sc\left(t,\tau^*(t)\right)}{\partial t} = \rho + \frac{w^c - w^*(t)}{w^*(t)} l'\left(\frac{t-c^0}{w^*(t)}\right),$$

where $w^*(t) = w - \tau^*(t)$, w is the return to crime, as in proposition (7). It is assumed that the cost of crime is greater than the private return ($w^c > w$), then regardless of the level of transfer, since $l' < 0$, if the cost of funds is sufficiently low it is always efficient to increase the transfer. Accordingly, we can define the marginal value of a transfer t by:

$$\nu(t) = -\frac{w^c - w^*(t)}{w^*(t)} l'\left(\frac{t-c^0}{w^*(t)}\right) > 0. \tag{24}$$

Given this valuation, it is optimal to transfer funds up to the point that $\rho = \nu_i(t^*)$. The form of marginal cost function is illustrated in figure (5) assuming efficient deterrence. The curves illustrate the marginal benefit of a transfer to an individuals , $\nu(t)$, for high cost $\left(w^{cH}\right)$ and low cost $\left(w^{cL}\right)$ illegitimate activities, as function of the transfer t. Three levels for the marginal costs of funds are illustrated, $\rho \in \left\{\rho^L, \rho^M, \rho^H\right\}$. In all three cases transfers are not efficient for the low social cost activity. However, for the high social cost activity a transfer is efficient. In particular, if a person already has an endowment of t_i^0, then for the high social cost person $\left(w^{cH}\right)$, the efficient transfer for case $g \in \{L, M, H\}$ are:

$$t_i^{*g} = max\left\{0, t^g - t_i^0\right\}, g] \in \{L, M, H\}.$$

Under the assumption of a cost marginal costs of public funds, this rule tops up a person fixed income to the level that results in an optimal level of illegitimate activity with efficient

deterrence in place. Like Becker (1968), the model does not predict perfect deterrence, but illustrates that transfers, addition to deterrence, are part of an optimal crime policy.

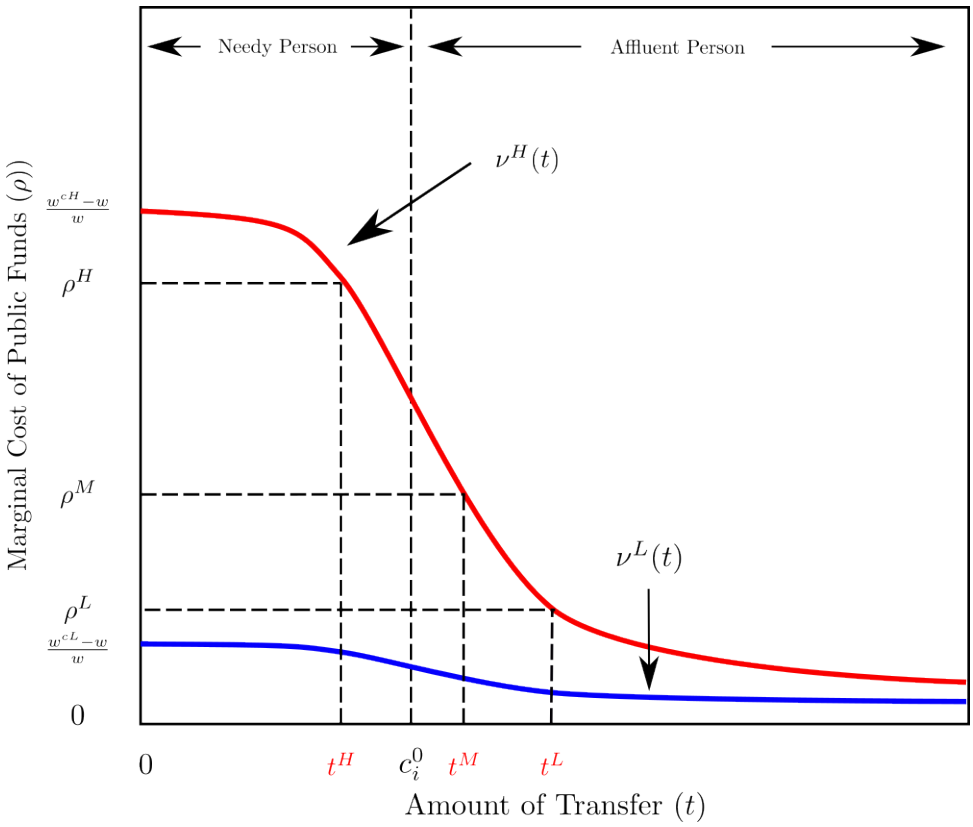


FIGURE 5. Marginal Benefit of Transfer

5.2. **When are make-work projects optimal?** When there is no easily available legitimate work, another solution that has often by used by governments is to provide make-work projects. Let us suppose that initially there is no legitimate work (say due to wide-spread unemployment among young people), and the government decides to sponsor a make-work project at a wage $W = s$ that is a substitute for illegitimate work ($\theta > 1$). This program can divert labor from illegitimate activity, hence, it is potentially welfare enhancing. To keep matters simple it is assumed that the only value of the legitimate work is to provide income for the individual, though many make-work programs in practice also provide useful services as well (at public parks across the United States we still see today roads and bridges built by youth employment programs from the 1930s)[22].

Let us suppose that deterrence and transfers are set at the optimal levels. In that case, we can ask if there is a gain to adding a make work project with $s > 0$. Again, appealing to the

[22]See `https://en.wikipedia.org/wiki/National_Youth_Administration`.

envelope theorem It turns out that at the optimal deterrence and transfer $\left.\frac{\partial sc_i}{\partial s_i}\right|_{s_i=0} = 0$. This could be a local minimum or maximum. We can address this by taking the second derivative. This tedious calculation is discussed in the appendix. In the case of complements, the second derivative is positive and hence no subsidy is a local minimum. For substitutes, it is zero, which suggests that any potential gains are small. However, this is only a local result. In the case of perfect substitutes, that we discuss next, make work projects may enhance social welfare. The fact that the effects are small in this model is possibly consistent with the observation that they are not widely used in practice as solution to the crime problem, though there are many policies that encourage legitimate work as a matter of policies that directly address inequality.

5.3. **The case of perfect substitutes.** Suppose that $\theta = 1$, in which case the individual's utility is given by:

$$u_i\left(\vec{w}_i, \vec{l}, T\right) = \log\left(W_i \times L_i + w_i \times l_i - \hat{w}_i A_i\right) - V_i\left(L_i + l_i\right).$$

Clearly, it is optimal for the individual to devote all effort to the activity with the highest return. Letting $\hat{l}_i$ be the aggregate return, then the optimal supply to each activity is given by:

$$\gamma_i^l\left(\vec{w}_i\right) = \begin{cases} 1, & \text{if } w_i > W_i, \\ [0,1], & \text{if } w_i = W_i, \\ 0, & \text{if } w_i < W_i. \end{cases}$$

Thus, when the return to legitimate labor is greater than illegitimate labor ($W_i > w_i$), then there is no illegitimate or criminal labor supply. For the current discussion, suppose that the person is needy with no income beyond wage labor, and that illegitimate work is preferred to legitimate work ($w > W$). Hence the individual specializes in illegitimate labor. In the absence of any intervention the social cost is:

$$\bar{sc}_i = \left(w^c - w\right)\bar{l},$$

where $\bar{l} = l\left(-\frac{c_i^0}{w}\right)$ is labor supply at wage w. Since legitimate and illegitimate labor are perfect substitutes, if deterrence is set $\tau^d = w - W$ then the individual will allocate all labor to the legitimate activity, resulting is social cost:

$$sc_i^\tau = c\left(\frac{w - W}{w}\right) + \left(w\bar{l} - Wl^\tau\right),$$

where $l^\tau = l\left(-\frac{c_i^0}{W}\right)$. In this case, the social cost is the cost of deterrence plus the lost income to the individual.

The next strategy is to subsidize legitimate labor by the amount $s_i = w - W$. In this case labor supply does not change, but now social cost is given by the cost of the subsidy:

$$sc_i^s = \rho\,(w - W)\,\bar{l}.$$

Notice that if the legitimate wage, W, is close to the illegitimate wage, w, then in the case of perfect substitutes it would always be efficient to shutdown the illegitimate activity completely. Whether this is achieved with deterrence or a subsidy depends upon the relative sizes of sc_i^τ and sc_i^s. This result highlights the importance of the degree of substitution for optimal policy, and that deterrence or wage subsidies can both be effective tools in this case. Notice that a transfer simply results in a smooth fall in illegitimate activity, and would not in general be as effective as deterrence or wage subsidies. This is not the case for perfect complements.

5.4. **The case of perfect complements.** There are many types of occupations where legitimate and illegitimate activities are complements. For example: before containerization, many dockworkers engaged in theft from ships; accountants who maintain the books for an enterprise may be tempted to siphon off some of the income from the business; mobsters may engage in a legitimate garbage collection business, and use their business to dispose of the evidence from their crimes; cash-heavy businesses, such as used car dealerships and laundromats, are used as fronts for money laundering purposes. Here we derive optimal deterrence for perfect complements. Observe that when $L > l$ then:

$$\begin{aligned}\lim_{\theta\to\infty} f_\theta\,(L,l) &= \lim_{\theta\to\infty} \left(L^\theta + l^\theta\right)^{1/\theta}, \\ &= \lim_{\theta\to\infty} L\left(1 + \left(\frac{l}{L}\right)^\theta\right)^{1/\theta} \\ &= L.\end{aligned}$$

Hence:

$$\lim_{\theta\to\infty} f_\theta\,(L,l) = \max\{L,l\}.$$

This implies that the optimal labor supply for $\vec{w} > \vec{0}$ is to set $L = l = \hat{l}$. When $\theta \to \infty$ then the aggregate wage is:

$$\hat{w} = w + W,$$

What is interesting about this case is that deterrence and wage subsidies have no allocative role to play in determining the trade-off between the two activities. For example, the legitimate activity might be the operation of a night club, while the illegitimate activity may be the sale of drugs. In that case it might be that $W + w > w^c > w$, and hence the activity is tolerated. On the other hand, the legitimate activity might be the sale of alcohol, while

the illegitimate activity is drunk driving or violent crime. In that case, we have the cost of the joint activities is greater than their benefit, $w^c > W + w$. So, if policymakers believe that the illegitimate and legitimate activity cannot be effectively distinguished, both will be illegal (e.g. 'dry counties').

In either case, when there are strong complements, this can be viewed as a single activity case, with a wage $\bar{w} = W + w$ and labor supply $l\left(\frac{t-c_i^0}{\bar{w}}\right)$. In this case there is no deterrence nor a wage subsidy, hence $\tau_i = s_i = 0$, and the social cost is given by:

$$\begin{aligned} sc_i &= sc_i^t \\ &= \rho t - (w^c - \bar{w})\, l\left(A_i\right). \end{aligned}$$

From which we get the following result.

Proposition 8. *Suppose activities are pure complements, aggregate labor supply satisfies $l'' < 0$, then if $-\frac{(w^c-\bar{w})}{\bar{w}} l'\left(\frac{-c_i^0}{\bar{w}}\right) > \rho$ the optimal transfer, t^*, is the unique solution to:*

$$\rho = \frac{(w^c - \bar{w})}{\bar{w}} l'\left(\frac{t^* - c_i^0}{\bar{w}}\right).$$

This result is a straightforward implication of the convexity of the aggregate labor supply ($l'' < 0$). It implies that an increase in the social cost of the activity, w^c or a decrease in the marginal cost of public funds, ρ, results in an higher transfer and a lower level of illegitimate activity. In particular, it highlights the point that whether one uses transfers, deterrence or subsidies to manage illegitimate activity is sensitive to the degree of substitution between legitimate and illegitimate labor.

6. Final Discussion

It is well recognized that both deterrence and social policy have a role is optimal crime policy. This paper makes two contributions. First, it shows within a simple labor supply model that holds fixed a person's preferences over consumption, there can be large variation in how a person responds to deterrence. In particular, there are natural conditions under which increases deterrence may lead to an increase rather than a decrease in crime, an phenomena we call the *Jean Valjean effect.* In those cases, it may be cost effect to have transfers to the individuals. Despite the simplicity, the model is able to captures many of the observed features of the evidence on criminal deterrence. We conclude with a discussion of the normative implications of the analysis. The central takeaway is that depending on social cost of the activity in question, optimal policy changes significantly. For the lowest cost activities, the optimal policy is to do nothing: increasing deterrence or transfers is inefficient as the social cost is sufficiently low. This is defacto policy for multiple crimes such as jaywalking or low-level speeding, where even tickets are infrequent. For example, based

on surveys in the US, 89% of Americans speed with 40% report going 20 miles per hour over,[23] For example, 78% of Americans admit to jaywalking (with 40% saying it should be illegal),[24] 52.5% report eating while driving and 36% admit to using phone while driving.[25]

Furthermore, given that the activity is only 'illegitimate' and not necessarily a crime, this also applies to things like the use of 'soft drugs'. Caffeine, alcohol, tobacco and, more recently, marijuana (in legal states) have no associated transfers and very low deterrence against use as the social cost is deemed to be sufficiently low for adults. (Note that this discussion does not take into account the well documented racial disparities enforcement of low-cost crimes.) This case can also apply to crimes that are low-friction transfers between individuals– in which case the social cost near equal to the benefit to the perpetrator. For example, in Spain, petty thefts (less than a few hundred euros) are not prosecuted and criminals are quickly released from custody after paying a fine (Burgen (2018)).[26]

Crime type	All Violent Crime	Impaired Driving	All Non-Violent Crime
Medical	58801	7011	0
Mental Health	40149	814	0
Productivity	85980	32086	3954
Property Loss	3534	14793	136488
Public Services	56145	181	24968
Adjudication and Sanctioning	77210	6316	39431
Perpetrator Work Loss	17162	619	11890
Total Tangible Costs (subtotal)	338981	61820	216731
Quality of Life	1858401	100747	0
Total	2197382	162567	216731
Quality-adjusted life year	10321125	559525	0

TABLE 1. Total Cost of Crime in the US (2017) in Millions of Dollars

Source: Table 6 of Miller et al. (2021).

Only a subset of crimes have low social costs. Indeed, crimes are often actions which have high social costs, and thus it is efficient to reduce their occurrence. While the Becker-Ehrlich framework suggests that crime policy should be measured using the degree of deterrence (e.g., size of fine, probability of detection) for activities deemed crimes or that increased wages will reduce crime, our model demonstrates the existence of a middle area in which optimal policy solely entails transfers to needy individuals which will have an intensive margin effect for those whose criminal wage is significantly higher than their legitimate one. Table 1

[23]https://www.prnewswire.com/news-releases/new-allstate-survey-shows-americans-think-they-are-great-drivers---habits-tell-a-different-story-126563103.html

[24]https://today.yougov.com/topics/lifestyle/articles-reports/2014/09/25/almost-everyone-jaywalks

[25]https://www.thezebra.com/resources/research/distracted-driving-statistics/

[26]Despite large amounts of petty theft, Spain ranks as one of the lowest crime countries in the world, similar to China or Singapore. See https://worldpopulationreview.com/country-rankings/crime-rate-by-country .

displays the large costs of crime in the US from Miller et al. (2021). In 2017, the total tangible cost of non-violent crime was $200 billion, with the majority of that cost coming from property loss ($136 billion) and an addition $40 billion in adjudication and sanctioning costs. Often, these are considered 'financially motivated' or 'income-generating' crimes or 'crimes of desperation', and their motivations can be directly addressed by transfers (Foley (2011); Carr and Packham (2019)). [27] On the other hand, punitive solutions, such as incarceration, are associated with food insecurity (Cox and Wallace (2016)), likely increasing individuals' desperation.

Transfers can also come in the form of healthcare. Jácome (2020) finds that access to mental healthcare reduces criminal activity. Men who lose access to Medicaid coverage are more likely to be arrested, and expanding Medicaid eligibility is cost-effective at reducing crime relative to increasing sanctions. Similarly, He and Barkowski (2020) find that the ACA medicare expansion was associated with crime reductions. Transfers cover individuals' minimum consumption which they cannot do through legitimate means due to (mental) health difficulties. Overall, this literature indicates that transfers prevent crime by providing for people who are below their minimum consumption levels and thus preventing crime, and our model is consistent with this.

For individuals whose legitimate wage is close to their illegitimate wage, the optimal policy is to increase legitimate wage which will have an extensive margin effect of shifting them to legitimate labor from crime– with no effect on those whose wage gap (difference between legitimate and illegitimate wage) is large. Naturally, a transfer to low wage-gap individuals will decrease total activity while decreasing crime among high wage-gap individuals, meaning there is a trade off at play in designing social policy, which has significant empirical support. For example, removing individuals from welfare causes their earnings to increase (Deshpande and Meuller-Smith (2021)), however, as predicted in our model, this effect only applies to a portion of those on welfare. In fact, the total effect of SSI removal is negative: Deshpande and Meuller-Smith (2021) show that removal from welfare causes a large increase in crime among recipients, particularly income generating crimes. In a cost-benefit analysis, they show that removing individuals from SSI is actually costly, largely due to the increase in victim costs of crime. Similarly, removal from SNAP has been shown to increase financially motivated crimes and recidivism (Tuttle (2019)), but work-requirements for SNAP both

[27]For example, Foley (2011) shows that financially motivated crimes increase over the course of the month, as time since last welfare transfer increases, and Carr and Packham (2019) finds that staggering SNAP benefits decreases theft at grocery stores significantly. Hastings and Washington (2010) finds that households could save money by purchasing food later in the month. However, Carr and Packham (2021) finds that shifting the timing of SNAP benefits away from the first of the month, when other government transfers occur, increases domestic violence and child abuse possibly due to this creating more opportunities for internal struggles over scarce resources in the family. Importantly, physical cash transfers increase criminal opportunities, as shown in Wright et al. (2017), using electronic benefit transfers reduces crimes.

decrease participation among participants while having almost no effect on labor market participation (Gray et al. (2021)). Unsurprisingly, wage subsidies, such as the minimum wage or EITC, have been shown to reduce recidivism largely by reducing income generating crimes (Agan and Makowsky (2021)) and reduce reports of child neglect (Raissian and Bullinger (2017)). Similarly, Lochner (2004) find large crime reduction externalities resulting from increased education.

Such income generating crimes, which are often attributed to desperation, are the focus of many social services, and a natural question is whether government should spend more on deterrence (police) or transfers (social services). As shown in Figure (6) from Owens and Ba (2021), growth policing employment and salaries have significantly more than that of public welfare or housing in absolute terms between 1993 and 2016. Salaries in education (which increases legitimate wages) have actually decreased by a small amount over the same time period, while salaries for police have increased by over 10% in real terms.

Finally, for crimes with sufficiently high social costs, such as violent crimes, the socially optimal policy involves a combination of deterrence, wage subsidies, and transfers. Table 1 shows that violent crime costs $2.2 trillion in 2017, with the vast majority of the cost ($1.9 trillion) coming from quality of life loss. In our model, for high social cost crimes, the optimal strategy is to use transfers as a complement to deterrence, as transfers make individuals sensitive to deterrence. This is similar to the logic of the Shapiro and Stiglitz (Shapiro and Stiglitz) where higher wages are used as 'something to lose' in unemployment. In the development literature, this dual instrument approach has some empirical support. For example, Blattman et al. (2017) finds that therapy alone only caused short-run reductions in antisocial behavior in men (reducing the 'wage' of antisocial behavior). However, they find that cash transfers in combination with therapy allowed for longer lasting and more significant effects.

A broader implication of this model is the relationship between inequality and crime. This model links the deterrence and crime literature with public finance and the economics of inequality (Chetty et al. (2014)). The relationship between inequality, desperation, and crime is rarely studied in economics (İmrohoroğlu et al. (2000); Barone and Mocetti (2016)), despite the strong evidence for poverty and deprivation leading to reduced cognitive abilities and economic decision making (Mani et al. (2013); Haushofer and Fehr (2014)), the existence of poverty traps (Balboni et al. (2021)), the importance of early investments in breaking cycles of poverty (Johnson and Jackson (2019)), and the strong racial component in inequality (Derenoncourt and Montialoux (2021)). Related work includes Haushofer and Shapiro (2016), who find that unconditional cash transfers are effective at increasing income and improving psychological well being.

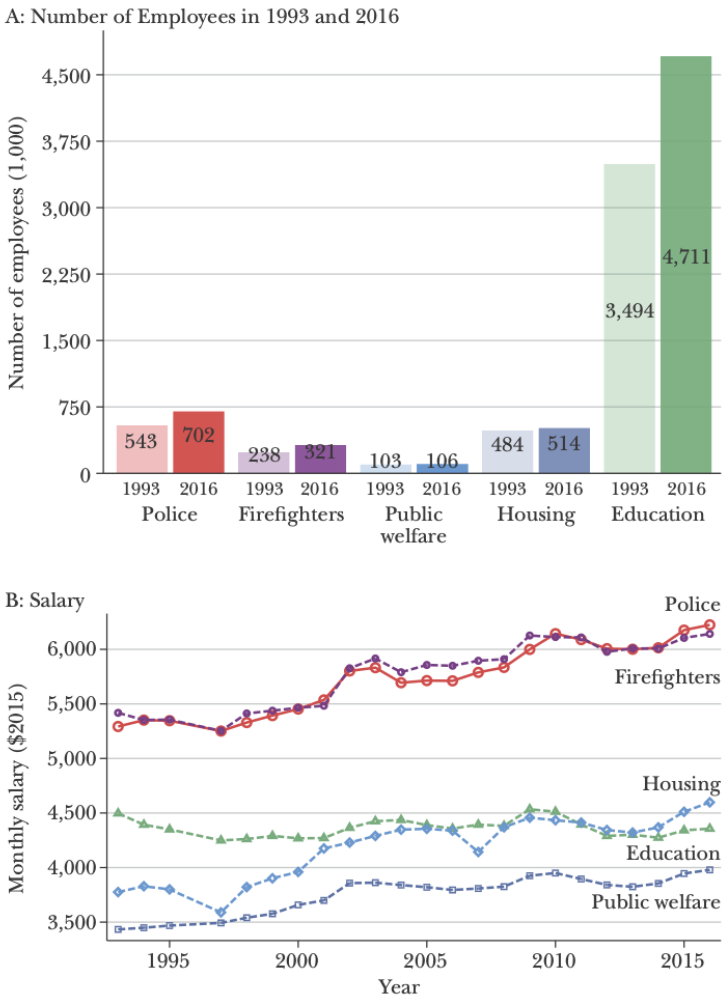


FIGURE 6. Public Employment from 1993 to 2016
Source: ?

Finally, our model connects both the literature on the effects of deterrence and transfers on crime with the literature on public finance and sufficient statistics. While computing elasticities of crime with respect to policy changes, such as police manpower (Chalfin and McCrary (2018)), assignments (Ba et al. (2021)), or arrests (Cho et al. (2021)) are common in the crime literature, while computing elasticities of crime with respect to welfare programs is not as common.

In summary, model and the evidence we discuss highlights that deterrence is an effective policy in two situations:

(1) Individuals are affluent, and hence the threat of punishment leads to a decline in wealth, which in turn leads to a reduction in illegitimate activities.

(2) Individuals have desirable alternatives to crime, then increasing deterrence leads to a reallocation of labor to these desirable alternatives.

There are situations where these conditions are not satisfied. If an individuals does not have alternative remunerative activities and must work to meet basic needs, then an increase in deterrence may lead to more, rather than less, crime. A second case occurs when legitimate activities are complementary with criminal activities. In that case, if a person is not affluent, then an increase in deterrence can lead to an increase in both legitimate and criminal activity. For affluent individuals, an increase in deterrence simply results in less of both activities. In that case, it may not be optimal to have perfect deterrence, and tolerate a level of crime due to the benefits of the legitimate activity. Thus, we allow for the possibility of illegitimate and legitimate activity to be complements or substitutes, and characterize optimal policy in such cases. We discuss how the case of labor and crime being complementarities has large and significant public policy implications including international trade and Dutch tolerance for soft drugs.

The central message of our results relating to optimal policy is that crime reduction must focus on the different characteristics of the individual. At a first glance, this would seem to be inline with the significant amount of discretion police have in choosing which laws to enforce against which individuals. Yet, in practice, a large body of evidence shows that officers exercise discretion in racially disparate ways (Hoekstra and Sloan (2020); Goncalves and Mello (2021); Ba et al. (2021); Feigenberg and Miller (2022)) and aggressiveness of enforcement of low-level crimes depends on local regime preferences and racial heterogeneity (Feigenberg and Miller (2021)). These facts further emphasize the importance in researching how to reduce socially costly activity while avoiding excessive reliance on punitive policies which may only exasperate racial disparities and the desperate circumstances which lead to crime in the first place. In future work we plan to extend this framework to incorporate human capital, incarceration, and racial disparities in application of deterrence and transfers.

Appendix A. Propositions, Proofs and Derivations Model of Jean Valjean Effect

A.1. **Derivations for Section 2: Labor Supply and the Jean Valjean Effect.**

Proposition. *There is a well defined labor supply function, $l_i^*(w_i)$. solving (3) for $w_i > 0$.*

Proof. Let $\bar{l}$ be any labor supply choice resulting in feasible consumption $c = w_i\bar{l} + t_i > c_i^0$. Next, define the set of labor supply choice providing utility at least as great as at l:

$$G_i\left(\vec{x}_i, \bar{l}\right) = \left\{\hat{l} | U_i\left(\hat{l}\right) \geq U_i\left(\bar{l}\right)\right\},$$

where:

$$U_i(l) = u_i(w_i l + t_i) - V_i(l).$$

The fact that V_i is unbounded and continuous, while u_i is strictly concave, implies that $G(\vec{x}_i, \bar{l})$ is a compact set. Hence, there the optimal labor supply is given by:

$$l_i^*(w_i, t_i) = \arg \max_{l \in G_i(\vec{x}_i, l)} U_i(l).$$

If it happens that $\bar{l} = l_i^*(w_i, t_i)$, then the strict concavity of U_i implies that G_i is a single point. In that case the fact that the set of feasible allocations is open, means that one can find a new $\bar{l}$ in the neighborhood of the old choice, resulting in a set G_i such that $l_i^*(w_i, t_i)$ is in the interior for G_i. The hypothesis that $V(\cdot) \geq 0$, $V(0) = 0$ and $V''(\cdot) > 0$ implies that $V'(0) = 0$ and hence $l_i^* \neq 0$ for $w_i \neq 0$. From this and an inspection of the first order conditions for the optimum implies that labor supply is a continuous function of the wage. If $t_i = 0$, then $l_i = l_i^0$ is the optimal solution as defined by (6). □

The next proposition is a formal statement and proof of the necessary conditions for proposition (3).

Proposition. *Let W be an open subset of $\Re_{++}$ Suppose the labor supply function is inelastic ($\frac{dl_i^*(w)}{dw} = 0$) on this set then the preference for consumption is represented by:*

$$u_i(c) = log(c - t_i). \tag{25}$$

Proof. The first derivative of (4) with respect to the wage implies that for $w \in W$ labor supply satisfies:

$$u_i'(w l_i^*(w) + t_i) w_i - V'(l_i^*(w)) = 0.$$

The assumption that labor supply is wage inelastic implies we can take the derivative of the first order condition to get:

$$0 = u_i'(w l_i^*(w) + t_i) + u_i''(w l_i^*(w) + t_i) l_i^*(w) w.$$

Letting $c = l_i^*(w) w$, and then we have:

$$u_i''(c + t_i) c + u_i'(c + t_i) = 0,$$

and thus:

$$\frac{d \log(u_i'(c + t_i))}{dc} = -\frac{1}{c}.$$

The solution to this implies for some constant α':

$$\log(u_i'(c + t_i)) = -\log(c) + \alpha' = \log\left(\frac{1}{c}\right) + \alpha'.$$

Take this expression to the power e and let $\alpha = \exp(\alpha') > 0$:

$$u_i'(c + t_i) = \frac{\alpha}{c}.$$

Let $\tilde{c} = c + t_i$ and hence:

$$u_i'(\tilde{c}) = \frac{\alpha}{\tilde{c} - t_i},$$

and for some $\beta \in \Re$ then:

$$u_i(\tilde{c}) = \alpha \log(\tilde{c} - t_i) + \beta.$$

However, von Neumann-Morgenstern preferences are invariant under positive affine transformations, and this this is equivalent to:

$$u_i(\tilde{c}) = \log(\tilde{c} - t_i).$$

□

The next proposition is a general version of proposition (5) where $l^+(w_i)$ corresponds to solution for (5).

Proposition 9. *Labor supply can be written in the form:*

$$l_i(w_i) = l(A_i),$$

where $A_i = -\frac{n_i}{w_i}$*, and the function* $l(A_i) > 0$ *is the unique, decreasing solution to:*

$$A_i = \frac{1}{V_i'(l(A_i))} - l(A_i).$$

Proof. The first order condition for labor supply satisfies:

$$\frac{1}{(w_i l_i - n_i)} w_i - V'(l_i) = 0. \tag{26}$$

$$\frac{n_i}{w_i} = l_i - \frac{1}{V'(l_i)} \equiv g(l_i). \tag{27}$$

Since $V'(0) = 0$ then we have $\lim_{l \to 0+} g(l) = -\infty$ For $l_i > 0$ the strict concavity of V_i implies that $g' > 0$, while $lim_{l_i \to \infty} g(l_i) = \infty$. This ensures that g is invertible for $l_i > 0$ and hence $l(A_i)$ is well defined for $A_i \in \Re$ and strictly decreasing. □

A.2. **Deterrence as a Tax.** The purpose of this section is to show that the penalty in the standard deterrence model is equivalent to a tax on the market wage. In the Becker model of deterrence, if an individual chooses to offend, then she faces a probability p of a punishment f (see footnote 16 of Becker (1968)). We can translate this into a flow of offenses using the Shapiro and Stiglitz (Shapiro and Stiglitz) model.

Suppose that the individual has a single illegitimate activity, and that effort in that activity is given by l_i per unit of time, resulting in illegitimate income of $w \times l_i$ per unit of time.

Time is divided into small intervals of length $\Delta > 0$. During a period Δ, we can suppose that the probability of detection is given by γl_i. This is a Poisson parameter, so with an higher level of activity the individual faces a higher probability of detection. When caught, a penalty P is paid. Let us suppose that the individual's discount rate is r, and that the process is stationary, and thus utility solves the following dynamic program:

$$U_t = \Delta\left(\gamma l_i u\left(wl_i - P - n_i\right) + \left(1 - \gamma l_i\right) u\left(wl_i - n_i\right)\right) + e^{\Delta r} U_{t+\Delta}. \tag{28}$$

The stationary process assumption implies $U_{t+\Delta} = U_t$, and we have:

$$\begin{aligned}
\frac{1 - e^{-\Delta r}}{\Delta} U_t &= u\left(wl_i - n_i\right) + \gamma l_i \left(u\left(wl_i - P - n_i\right) - u\left(wl_i - n_i\right)\right), \\
&\cong u\left(wl_i - n_i\right) - \gamma l_i P \frac{du\left(wl_i - n_i\right)}{dc}, \\
&\cong u\left(wl_i - \gamma l_i P - n_i\right) \\
&= u\left(w_i l_i - n_i\right),
\end{aligned}$$

where $w_i = w - \gamma P = w - \tau_i$ is the net return from illegitimate effort, $\tau_i = \gamma P$ is the level of deterrence, or the tax on illegitimate activity. If we let $\Delta \to 0$ then we get:

$$rU_t = u\left(w_i l_i - n_i\right) - V_i\left(l_i\right).$$

[28] Since multiplying utility by a constant does not change preferences, which expression corresponds to the static model given by equation (4).

A.3. **Derivations for Section 3: Intensive vs Extensive Margin.** Preferences are given by:

$$u\left(\vec{w}_i, \vec{l}_i, T_i\right) = log\left(W_i \times L_i + w_i \times l_i + T_i - c_i^0\right) - V\left(f_\theta\left(\vec{l}_i\right)\right). \tag{29}$$

where $f_\theta\left(\vec{l}\right) = \left(L^\theta + l^\theta\right)^{1/\theta}, \theta \geq 1$. Notice that this is a bit different from the standard CES function from Arrow et al. (1961) that normally requires $\theta \leq 1$. The reason for the difference is that we are aggregating costly effort, rather than output. When $\theta \to \infty$ then the cost of effort is $V\left(\max\left(L, l\right)\right)$, and hence the individual can increase the lower effort at no cost, and which in general increases utility. Hence, at the optimal it will always be the case that $L_i = l_i$ for the CES production function when $\theta \to \infty$.

For the rest of the discussion the index i is dropped to reduce notational clutter.

[28] See Chalfin and McCrary (2017) for a review of the literature on deterrence relating to both the probability of detection and size of the sanctions. The framework extends quite naturally to deal with incarceration, though we put that issue aside for this paper.

The first order condition for the level of illegitimate work, $u_l = 0$, is given by:

$$\begin{aligned}\frac{du}{dl} &= \frac{1}{\left(W \times L + w \times l + T - c^0\right)} w_i - V'\left(f_\theta\left(\vec{l}\right)\right) \frac{df_\theta}{dl}, \\ &= \frac{1}{\left(W \times L + w \times l + T - c^0\right)} w_i - V'\left(f_\theta\left(\vec{l}\right)\right) f_\theta\left(\vec{l}\right)^{1-\theta} l^{\theta-1} \\ &= 0.\end{aligned}$$

Hence:

$$w = \left(W \times L + w \times l + T - c^0\right) \times V'\left(f_\theta\left(\vec{l}\right)\right) f_\theta\left(\vec{l}\right)^{1-\theta} l^{\theta-1}$$

With a similar expressions for L_i, we have at an optimal allocation of labor supply:

$$\begin{aligned}\frac{W}{w} &= \left(\frac{L}{l}\right)^{(\theta-1)}, \\ \left(\frac{L}{l}\right) &= \left(\frac{W}{w}\right)^{1/(\theta-1)} = \left(\frac{W}{w}\right)^{\sigma}, \end{aligned} \tag{30}$$

where $\sigma = \frac{1}{\theta-1}$ is the elasticity of substitution for the CES production function. This implies that the ratio of labor allocated to each activity is constant regardless of the scale. Let $\hat{l}$ define the scale of activity and set:and using the fact that f_θ is homogeneous of degree 1, and the property $f_\theta\left(L, l\right) = \hat{l} f_\theta\left(\gamma^L\left(\vec{w}\right), \gamma^l\left(\vec{w}\right)\right) = \hat{l}$, to conclude:

$$f_\theta\left(\gamma^L\left(\vec{w}\right), \gamma^l\left(\vec{w}\right)\right) = 1 \tag{31}$$

for all $\vec{w}$. Combine this with the ratio condition (30) we get:

$$\gamma^L\left(\vec{w}\right) = \frac{W^\sigma}{f_\theta\left(W^\sigma, w^\sigma\right)}, \tag{32}$$

$$\gamma^l\left(\vec{w}\right) = \frac{w^\sigma}{f_\theta\left(W^\sigma, w^\sigma\right)}. \tag{33}$$

Finally, we would like to aggregate wages so that solution can be viewed as two step problem. In step one determine the aggregate activity, $\hat{l}$ as a function of a an aggregate wage $\hat{w}$. This is fixed by the budget constraint:

$$\begin{aligned}\hat{w}\hat{l} &= W \times L + w \times l, \\ &= W \times \gamma^L\left(\vec{w}\right) \times \hat{l} + w \times \gamma^l\left(\vec{w}\right) \times \hat{l}.\end{aligned}$$

Thus, we construct an aggregate wage index that ensures the budget constraint is always satisfied for all wages at the optimal allocation between tasks:

$$\hat{w}\left(\vec{w}\right) \equiv W \times \gamma^{L}\left(\vec{w}\right) + w \times \gamma^{l}\left(\vec{w}\right), \tag{34}$$

$$= \frac{W^{\sigma+1} + w^{\sigma+1}}{f_{\theta}\left(W^{\sigma}, w^{\sigma}\right)} \tag{35}$$

$$= f_{\theta\sigma}\left(W, w\right)^{-1}. \tag{36}$$

We can simplify the expressions a bit. Observe that from (32) we get:

$$\gamma^{L}\left(\vec{w}\right) = \frac{1}{f_{\theta}\left(1, \left(\frac{w}{W}\right)^{\sigma}\right)}$$

$$= \left[1 + \left(\frac{w}{W}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}} = \gamma\left(\frac{W}{w}\right),$$

where $\gamma\left(r\right) = \left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}}$. Thus, the fraction of the aggregate activity allocated to legitimate labor depends only upon the ration of legitimate to illegitimate labor. Similarly, we have:

$$\gamma^{l}\left(\vec{w}\right) = \left[\left(\frac{W}{w}\right)^{\frac{\theta}{\theta-1}} + 1\right]^{-\frac{1}{\theta}} = \gamma\left(\frac{w}{W}\right) \tag{37}$$

From this we get 14. With these definitions we can view labor supply as a two step procedure. In the first step, the aggregate wage $\hat{w}\left(\vec{w}\right)$ given by (35) is the dollar value measurement of activity level, and the payoff of the individual can be written in the following form:

$$u = log\left(\hat{w}\hat{l} + T - c^{0}\right) - V\left(\hat{l}\right)$$

Given the activity level $\hat{l}$, the expressions (12-13) determine the optimal allocation of labor between the two activities given the wages $\vec{w}$. The optimal level of activity is can be found by applying the results of section 2 to this context. Thus the equilibrium activity level when $\hat{w} > 0$ is given by:

$$\hat{l}^{*}\left(\hat{w}, T\right) = l\left(\frac{T - c^{0}}{\hat{w}}\right),$$

$$= l\left(\hat{A}\right)$$

and $\hat{A} \equiv \frac{T-c^{0}}{\hat{w}}$ is the level of affluence in terms of the aggregate wage $\hat{w}$.

Once the optimal activity level,$\hat{l}^{*}$, has been determined, then labor supply can be derived from (12-13) and we have:

Proposition. *Given preferences (8) with substitution parameter $\theta < 1$ and strictly positive wages, then the labor supplied to legitimate (at wage W_i) and illegitimate (at wage w_i) activities by individual i is given by*

$$L_i^* = \hat{l}_i^* \gamma\left(\frac{W_i}{w_i}\right),$$
$$l_i^* = \hat{l}_i^* \gamma\left(\frac{w_i}{W}\right),$$

as defined by (32) and (37). The optimal aggregate activity level, $\hat{l}_i^* = l\left(\frac{t_i - c_i^0}{\hat{w}_i}\right) \geq 0$, solves:

$$\max_{\hat{l}_i \geq 0} log\left(\hat{w}_i \hat{l}_i + t_i - c_i^0\right) - V_i\left(\hat{l}_i\right),$$

where $w_i = \hat{w}\left(\vec{w}_i\right) \equiv W_i \times \gamma\left(\frac{W_i}{w_i}\right) + w_i \times \gamma\left(\frac{w_i}{W_i}\right)$.

A.3.1. *Some Additional Results on $\gamma(\cdot)$.* The fraction of aggregate labor allocated legitimate or illegitimate activity is determined by the function $\gamma(r) = \left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}}$. Its properties determine which type of policy is most effective. Note that for $\theta > 1$ then $\lim_{r\to 0} \gamma(r) = 0$ and $\lim_{r\to\infty} \gamma(r) = 1$. We also have:

$$\begin{aligned}
\gamma'(r) &= \frac{d\left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}}}{dr} \\
&= -\frac{1}{\theta}\left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1}{\theta}-1} \frac{\theta}{1-\theta} r^{\frac{\theta}{1-\theta}-1}, \\
&= \frac{1}{\theta-1}\left[1 + \left(\frac{1}{r}\right)^{\frac{\theta}{\theta-1}}\right]^{-\frac{1+\theta}{\theta}} r^{\frac{2\theta-1}{1-\theta}} \\
&> 0
\end{aligned}$$

providing a direct proof that $\gamma(\cdot)$ is an increasing function.

For small $r \to 0$ we have

$$\begin{aligned}
\gamma'(r) &= O\left(r^{-\frac{\theta}{\theta-1}\times -\frac{1+\theta}{\theta} + \frac{2\theta-1}{1-\theta}}\right) \\
&= O\left(r^{\frac{(1+\theta)-2\theta+1}{\theta-1}}\right) \\
&= O\left(r^{\frac{2-\theta}{\theta-1}}\right).
\end{aligned}$$

This implies that

$$\lim_{r\to 0} \gamma'(r) = \begin{cases} 0, & \theta \in (1,2), \\ \infty, & \theta > 2. \end{cases}$$

When $\theta \in (1,2)$ this corresponds to the case of substitutes, while $\theta > 2$ corresponds to complements, and hence the corresponding differences in the limits.

For large r we have $\gamma'(r) = O\left(r^{\frac{2\theta-1}{1-\theta}}\right) = O\left(\left(\frac{1}{r}\right)^{\frac{2\theta-1}{\theta-1}}\right)$ and hence converges to zero for large r for $\theta > 1$. Moreover, we have:

$$r^2\gamma'(r) = O\left(r^{\frac{1}{1-\theta}}\right), \tag{38}$$

and hence $\lim_{r\to\infty} r^2\gamma'(r) = 0$.

A.4. **Derivations for Section 4: Deterrence and Optimal Policy.**

A.4.1. *When are make-work projects optimal?* Suppose that deterrence and transfers are chosen at their optimal levels. The question we ask is whether it is efficient to subsidize legitimate work. It is assumed that $\theta > 1$ and hence as the subsidy rises, there is substitution between legitimate and illegitimate work. We ask if increasing the subsidy from zero lowers social costs. Suppose that there is not legitimate work, thus all legitimate work is provided by the public purse, and we can set $W = s$. In this case the social cost is:

$$\begin{aligned}
sc &= \rho t + c\left(\frac{\tau^*}{w^*}\right) + \left\{w^c\gamma\left(\frac{w^*}{s}\right) - \hat{w}^* + (1+\rho)\,\gamma\left(\frac{s}{w^*}\right)s\right\} l\left(\hat{A}_i\right) \\
&= \rho t + c\left(\frac{\tau^*}{w^*}\right) + \left\{w^c\gamma\left(\frac{w^*}{W}\right) - \left(w\gamma\left(\frac{w^*}{s}\right) + s\gamma\left(\frac{s}{w^*}\right)\right) + (1+\rho)\,\gamma\left(\frac{s}{w^*}\right)s\right\} l\left(\hat{A}_i\right) \\
&= \rho t + c\left(\frac{\tau^*}{w}\right) + \left\{(w^c - w^*)\,\gamma\left(\frac{w^*}{s}\right) + \rho \times s \times \gamma\left(\frac{s}{w_i}\right)\right\} l\left(\hat{A}_i\right) \\
&= \rho t + c\left(\frac{\tau^*}{w}\right) + MC \times l\left(\hat{A}_i\right).
\end{aligned}$$

Increasing the subsidy reduces the share of activity allocated to illegitimate labor. It is assumed that deterrence and transfers are set at the optimal level, and then we ask whether it is efficient to also provide make work labor by setting s_i above zero. The first order condition for the wage subsidy is:

$$\begin{aligned}
\frac{\partial sc}{\partial s} = &\left\{-(w^c - w^*)\,\gamma'\left(\frac{w^*}{s}\right)\frac{w^*}{s^2} + \rho\gamma'\left(\frac{s_i}{w^*}\right)\frac{s_i}{w^*} + \rho\gamma\left(\frac{s}{w}\right)\right\} l\left(\hat{A}_i^*\right) \\
&- MC \times l'\left(\hat{A}_i^*\right) \times \frac{t^* - c^0}{\hat{w}^{*2}} \times \frac{\partial \hat{w}^*}{\partial s}.
\end{aligned} \tag{39}$$

We can compute the partial derivative of aggregate wage using (14) to get:

$$\frac{\partial \hat{w}^*}{\partial s} = \gamma\left(\frac{s}{w^*}\right) + \frac{s}{w^*}\gamma'\left(\frac{s}{w^*}\right) + \frac{w^{*2}}{s^2}\gamma'\left(\frac{w^*}{s}\right).$$

Using (38) it follows that $\lim_{s\to 0}\frac{\partial sc}{\partial s} = 0$. Hence, whether or not a subsidy is optimal depends upon the second order condition at $s = 0$. If $\left.\frac{\partial^2 sc}{\partial s^2}\right|_{s=0} > 0$ then we are at a local

minimum, and implementing workfare is welfare increasing. If this is negative, we are at a local maximum, and hence small increases in workfare cannot increase welfare. When s is small we can drop terms that have small variation with respect to s_i. Notice that marginal cost, $MC^0 = (w^c - w^*)$, and affluence $A^0 = \frac{-n}{w^*}$when $s = 0$. Let e_A we the elasticity of illegitimate activity with respect to affluence as defined about. Then we can use the following approximation to social cost:

$$\frac{w^*}{l(A^0)}\frac{\partial sc}{\partial s} \simeq -MC^0\left(\gamma'\left(\frac{w^*}{s}\right)\frac{w^{*2}}{s^2} + e_A \times \frac{\partial \hat{w}^*}{\partial s}\right), \tag{40}$$

and hence

$$\left.\frac{w^*}{l(A^0)}\frac{\partial^2 sc}{\partial s^2}\right| = -MC^0 \times A, \tag{41}$$

where A is defined by:

$$A = d\left(\gamma'\left(\frac{w^*}{s}\right)\frac{w^{*2}}{s^2}(1+e_A) + e^A \times \left(\gamma\left(\frac{s}{w^*}\right) + \frac{s}{w^*}\gamma'\left(\frac{s}{w^*}\right)\right)\right)/ds \tag{42}$$

$$= -\gamma''\left(\frac{w^*}{s}\right)\frac{w^{*3}}{s^4}(1+e_A) \tag{43}$$

$$-2\gamma'\left(\frac{w^*}{s}\right)\frac{w^{*2}}{s^3}(1+e_A) \tag{44}$$

$$\left(2\gamma'\left(\frac{s}{w^*}\right) + \frac{s}{w^*}\gamma''\left(\frac{s}{w^*}\right)\right)\frac{e_a}{w^*} \tag{45}$$

For $\theta > 2$, one is in the case of complements, then $-\gamma''\left(\frac{w^*}{s}\right)\frac{w^{*3}}{s^4}$ and $-2\gamma'\left(\frac{w^*}{s}\right)\frac{w^{*2}}{s^3}$ approach $-\infty$ as $s \to 0$, while $2\gamma'\left(\frac{s}{w^*}\right) + \frac{s}{w^*}\gamma''\left(\frac{s}{w^*}\right) \to \infty$. For affluent persons $e_A < 0$ and hence workfare is not optimal since the second derivative of social cost given by (41) would be positive. For the case of positive elasticities, notice that terms (43-44) dominate the corresponding terms in (45), and hence again workfare is not optimal.

Next, suppose that Thus, if $(1 + e_A) > 0$, then this implies that $\frac{\partial^2 sc}{\partial s^2} > 0$ and hence increasing workfare is welfare reducing.This is because of the complementarities between legitimate and illegitimate work - workfare increases illegitimate work. If elasticity $e_A$is less than -1 then we get the opposite result.

Next consider the case $\theta \in (1, 2)$. In this case, legitimate and illegitimate activities are substitutes. It turns out that the second derivative is still zero, and hence while there may be gains to workfare, they are likey to be small. In the case of perfect substitutes illustrates an extreme case where workfare may be effective, though the argument relies upon a non-differentiable supply function.

A.4.2. *The Case of Perfect Substitutes.* With pure substitutes the individual solves:

$$\max_{l_i \geq 0, L_i \geq 0} \log\left(W_i \times L_i + w_i \times l_i + T_i - c_i^0\right) - V_i\left(L_i + l_i\right).$$

The first order conditions for l_i are as follows. If $l_i^* > 0$ then:

$$w_i = \frac{V^{'}\left(L_i^* + l_i^*\right)}{\log\left(W_i \times L_i^* + w_i \times l_i^* + T_i - c_i^0\right)}.$$

However, if $l_i^* = 0$ then $L_i^* > 0$ and:

$$w_i \leq \frac{V^{'}\left(L_i^*\right)}{\log\left(W_i \times L_i^* + T_i - c_i^0\right)}$$

If the return from crime is much greater than the return for legitimate work, as would be the case if there is no legitimate work available, then the case of pure substitutes corresponds to the one activity case of section (2).

A.4.3. *The Case of Perfect Complements.* With pure complements the individual solves:

$$\max_{l_i \geq 0, L_i \geq 0} \log\left(W_i \times L_i + w_i \times l_i + T_i - c_i^0\right) - V_i\left(\max\left\{L_i, l_i\right\}\right).$$

Clearly, $L_i < l_i$ or $l_i < L_i$ cannot be optimal when wages are strictly positive, thus we can let $L_i = l_i = \hat{l}_i$. The first order conditions for $\hat{l}$ is:

$$\hat{w}_i \equiv W_i + w_i = \frac{V^{'}\left(\hat{l}_i^*\right)}{\log\left(\left(W_i + w_i\right) \times \hat{l}_i^* + T_i - c_i^0\right)}.$$

Thus, the case of pure complements reduces to the one activity case with wage $\hat{w}_i$ and $L_i = l_i = \hat{l}_i$. When the wage for one activity is less than or equal to zero and the other activity has a positive wage, then the negative wage activity can be set to zero. In that case $\hat{l}_i = max\left\{L_i, l_i\right\}$ and $\hat{w}_i = \max\left\{w_i, W_i\right\}$. If both activities have a negative wage, then $\hat{l}_i = L_i = l_i$ and $\hat{w}_i = W_i + w_i$, and we are again back into the one dimension case.

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