

# Crime and Drugs: An Economic Approach<sup>□</sup>

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April 1997

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<sup>□</sup> We should like to thank Henry Chiu, John Fender, Katy Graddy, David Kelsey, Paul Madden, Gareth Myles, Jonathan Thomas and seminar participants at the Universities of Birmingham, Bristol, Manchester, Warwick, and the IFS/Warwick Public Economics Weekend for helpful comments on earlier versions of this paper. Needless to say all errors are ours. Address for correspondence: London Business School, Sussex Place, Regent's Park, London, NW1 4SA. Email: [cdoyle@lbs.lon.ac.uk](mailto:cdoyle@lbs.lon.ac.uk).

We present a model which ties together rational drug consumption, taxation, crime and other drug-related externalities. Drug control policy is addressed using an optimal tax framework. Consumption, possession and production of a drug may be prohibited, legalized or decriminalized. In all regimes illicit production of a drug may take place and drug-related crime occurs. We show that illicit drug production, the price elasticity of demand for a drug, the addictive nature of a drug, the effectiveness of drug enforcement strategies, and income distribution all influence optimal (second best) policy. Prohibition is contrasted with decriminalization and legalization, and where legalization yields a higher welfare than prohibition we show that this can be associated with greater drug-related crime and more drug addiction. The model is discussed in the context of US National Drug Control Strategy.

#### Abstract

Keywords: Crime, decriminalization, drugs, externalities, legalization, optimal tax, prohibition.

JEL classifications: D62, H23, H50, K42

## 1. Introduction

Drug consumption, crime and other drug-related externalities embrace at least three areas of economics: consumer theory (rational addiction), the economics of crime, and public economics (taxation and externalities).<sup>1</sup> As the addictive property of drugs can lead to dependency, this distinguishes them from other commodities (see Becker and Murphy (1988), Becker et al. (1991) and Chaloupka (1991)). The tendency for some drug addicts to engage in acquisitive crime and the presence of illicit production of drugs raise questions related to enforcement, deterrence and punishment. Work on crime has been influenced considerably by Becker (1968) and Shavell (1993). More generally, the prevalence of drug-related externalities provides a role for corrective Pigouvian taxes, for example see Diamond (1973). The aforementioned areas of economics surface in the literature on drugs, for example see Lee (1993), Moore (1990) and Reuter and Kleiman (1986). However, to date research has yet to embed all these issues within a unifying framework. In this paper we achieve this by combining optimal deterrence strategies, rational addiction and optimal taxation. Thus, for the first time drug control policy is addressed using an optimal tax framework, allowing for a richer analysis of the issues.

In recent years concerns expressed about the prevalence of drug consumption have resulted in the implementation of a National Drug Control Strategy (NDCS) directed towards deterring consumption of all drugs.<sup>2</sup> According to data from the 1993 Substance Abuse and Mental Health Administration National Household Survey on Drug Abuse 77 million Americans aged 12 or older (37% of the population) reported use of an illicit drug at least once in a lifetime, 12% reported

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<sup>1</sup>For the purposes of this article a drug is defined as having an addictive property which can lead to dependency. Alcohol, cocaine, heroin, marijuana, methamphetamine, tobacco, etc. satisfy this criterion. Illicit drugs include heroin and cocaine; while tobacco and alcohol are legal for adults, they may not be consumed legally by young people in most countries.

<sup>2</sup>The Controlled Substances Act, Title II of the Comprehensive Drug Abuse Prevention and Control Act of 1970 is the legal foundation of the government's fight against abuse of drugs and other substances. The federal Anti-Drug Abuse Act of 1988 established as a policy goal the creation of a drug free America. A key provision of that act was the establishment of the Office of National Drug Control Policy (ONDCP) which is responsible for the NDCS. See ONDCP (1997) and web site: <http://www.ncjrs.org>.

use of a drug within the past year and an estimated 12.8 million, about 6% of the population aged twelve and older, reported use of an illicit drug on a current basis (within the past month).<sup>3</sup> Anxieties about drug consumption have focussed in particular on externalities which according to Rice et al. (1990) impose a \$66.9 billion burden on the US economy each year in social, health, and criminal costs and foregone production. This estimate is a little over 1% of GDP or nearly \$1,000 per capita. The enormity of these externalities has prompted President Clinton to request, in the 1997 NDCS, that \$16 billion should be deployed by federal agencies to combat drugs in the fiscal year 1998. This represents an increase of nearly 19% over the drug control budget in 1996 and an increase in nominal terms of nearly 500% over the 1985 budget. Of the proposed \$16 billion, 66% will be directed towards supply reduction strategies (eg. interdiction) and the remainder on demand reduction strategies (eg. media campaigns, community policing, etc.).

A drug-related externality that attracts considerable attention is crime. DiIulio (1996) has suggested that further help is needed from economists to guide public policy on crime, and drug-related crime is no exception. A recent survey has shown that the majority of US citizens believe drug abuse and drug-related crime to be among the most pressing of society's problems and 9% of citizens in January 1994 stated drug abuse to be the most serious problem in America.<sup>4</sup> The relationship between drug consumption and crime is well documented, for example see Boyum and Kleiman (1995), Lana and Gfroerer (1992) and Tonry and Wilson (eds.) (1990) *inter alia*.<sup>5</sup> BJS (1994,p.8) shows that in 1989 some 13% of all convicted jail inmates said they committed their offense to obtain money for drugs, and in 1991 some 17% of state prison inmates and 10% of federal prison inmates said they committed their offense to obtain money for drugs. Of all US inmates in 1991 convicted for burglary, around 30% stated that the crime was undertaken to facilitate drug consumption. Johnston et al. (1985) have shown in a survey of male heroin addicts that for irregular, regular and daily users they ob-

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<sup>3</sup>See Bureau of Justice Statistics (BJS) (1994,p.30). Drug abuse problems occur in many countries. For example "drug misuse is a major and growing problem in England" and "in any one year at least 6% of the population take an illegal drug", see para. 2.4 and Annex A.3 in *Tackling Drugs Together* (1994). A survey in France showed that 4% of those aged between 18 and 75 used illicit drugs during 1992, see Baudier et al. (1994).

<sup>4</sup>The Gallup Organization Consult with America: A Look at How Americans View the Country's Drug Problem, Summary Report, Rockville, MD: March 1996 and BJS (1994,p.32).

<sup>5</sup>See also 'Fact Sheet: Drug-Related Crime', NCJ-149286, September 1994, Drugs & Crime Data Center & Clearinghouse, NCJRS, Rockville, MD.

tained 19%, 30% and 32% of their total income from acquisitive crime. Deschenes et al. (1991) in a survey of Chicano/white male heroin addicts show that 48% of total income was derived from acquisitive crime. Although there seems to be little doubt about the magnitude of drug-related crime, caution should be exercised in attributing causality. Chaiken and Chaiken (1990) argue that the temporal sequence from drug abuse to predatory criminality is not typical. Nevertheless, they remark that the intensity of criminal behavior escalates as criminals become increasingly dependent on drugs.

In this paper we examine drug control policy and crime using an optimal commodity taxation framework along the lines set out in the seminal work of Diamond and Mirrlees (1971). In our analysis, society chooses a regime (legalization, decriminalization or prohibition) and selects instruments to affect the price of a drug and hence, indirectly, expected utility. We show that optimal (in a second best sense) policy in all regimes involves the setting of individual expenditures (analogous to the setting of taxes) which accord to Ramsey-like elasticity rules. At the optimum, in each regime, expenditures are directed towards those areas which result in the least burden on society. In this setting we can provide a deeper analysis of the welfare implications of demand and supply drug control strategies and the merits or otherwise of prohibition, decriminalization and legalization. Within this framework we show that drug control policy results in an optimal (implicit or explicit) price for a drug.<sup>6</sup>

The paper is organized as follows. In section 2 we present an overview and outline the key findings of the paper. In section 3 we characterize individual consumption decisions and in section 4 describe the market equilibrium. Section 5 constructs the second best policy for society given prohibition. Here an optimal tax problem is solved taking into account the behavior of consumers, illicit drug production, and the drug-related externalities. In this section we also address the issue of decriminalization. In section 6 we consider the effect of legalization and show conditions where society is no worse off compared to prohibition. Section 7 concludes the paper by summarizing the findings and suggesting further research. An appendix contains various mathematical derivations and algebra.

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<sup>6</sup>Some researchers have argued that drug control policy is not about the establishment of optimal prices. For example, in the context of cocaine Wilson (1990,p.525) has stated "There is no such thing as an optimal price of cocaine because there is no such thing as an optimal mix of two radically opposed goals — to reduce drug use and to prevent drug-related crime." In this paper we show this is misleading and argue that in general drug control policy is about the setting of optimal prices for drugs.

## 2. Overview

In our model, drug consumption, crime and related externalities are characterized by the following assumptions:

1. A drug has an addictive property: any individual consuming a drug enters (probabilistically) one of two states (i) casual consumption or (ii) addiction (dependency).<sup>7</sup> In the casual state, consumption of a drug does not generate any externalities. In the addiction state there are two forms of consumption externalities.
2. An individual in the addiction state may resort to crime to fund consumption.<sup>8</sup> This is likely to involve relatively less well off drug users. The scale of drug-related crime depends on the price of the drug, the addictive property of a drug, the distribution of income, inter alia and we denote it the crime externality.
3. Individuals in the addiction state adversely affect the well-being of those who do not consume the drug.<sup>9</sup> We claim that this externality is likely to be influenced to a considerable degree by the quantity of the drug needed in the addiction state, hence we term this the quantity externality.

Clearly different drugs have different addictive properties and in practice the probability of entering the state of addiction is influenced by a myriad of factors. For some drugs like crack cocaine and heroin dependency is more likely to arise than for other drugs like alcohol and marijuana. Our model is sufficiently robust to cope with the many different types of drugs available. In the model we differentiate consumers according to their preferences and endowments. A fraction of the

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<sup>7</sup>Throughout addiction is equivalent to dependency. This distinguishes drugs from other goods which may be addictive but do not lead to physical dependency, such as the playing of computer games or gambling.

<sup>8</sup>Chaiken and Chaiken (1990) and Moore (1990) show that it is addicts who tend to commit most of the economic drug-related crime. See also the discussion above.

<sup>9</sup>In practice this is largely through effects involving medical care, diseases, other health problems, and abuse burdens in the workplace. Chapter II in the 1997 NDCS cites research which shows that among drug users absenteeism is 66% higher versus non-users, disciplinary actions are 90% higher and turnover significantly greater. According to the 1997 NDCS an estimated 5.4 million full time workers and 1.9 million part-time workers in the US are illicit drug users. These data suggest considerable foregone production due to drug use.

population, drug users, hold preferences having a positive marginal utility of drug consumption. The majority, however, hold preferences where drug consumption yields zero utility and it is these non-drug consumers who constitute 'society' and determine policy. We suppose initially that, for whatever reason, society prohibits drug use and therefore all drug production is illicit. Under prohibition society's choice of policy is similar in spirit to a public-sector pricing problem: society determines the optimal supply and demand side strategies to maximize welfare subject to a budget constraint. Policy is therefore equivalent to choosing a price for the drug.

Having addressed the problem assuming prohibition, we then consider whether decriminalization (where consumption and possession are not penalized but production remains prohibited) and legalization (like decriminalization, except production can be legal but illicit production may take place) can yield welfare outcomes which leave society no worse off. Under legalization, because the drug is legitimized, society can use indirect taxation to affect both crime and quantity externalities and generate revenue to contribute to other demand and supply strategies. In practice this typically holds for alcohol and tobacco.<sup>10</sup> We show that illicit drug production, the price elasticity of demand, the addictive nature of a drug, the relative responsiveness of the quantity and crime externalities to policy variables, and the distribution of income all crucially determine whether society is no worse off under legalization.

Our main insights are as follows. Prohibition is desirable where the quantity and crime externalities rise rapidly following legalization. Although legalization enables society to raise tax revenue through sales of a drug, legitimization encourages greater consumption leading to adverse changes in externalities. Society can offset these by increasing the price of a drug via taxation, but the presence of illicit production makes this costly. This is because a higher price for a drug means more resources need to be devoted to combating illicit supply. The addictive nature of a drug also plays a role. In the case of drugs where the probability of addiction varies little in consumption a higher price serves to exacerbate the crime externality, although in the case where the probability of addiction changes markedly in consumption the crime externality is inversely related to price. Whether crime increases or decreases in the price of a drug also depends on the distribution of

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<sup>10</sup>For example, in 1988 the state of California passed Proposition 99, the California Tobacco Tax and Health Promotion Act in which 20% of tax revenues raised from the sale of tobacco should be channelled towards educational programmes to reduce tobacco use.

endowments.

We show that decriminalization is unlikely to yield welfare levels above that associated with prohibition as it promotes greater consumption (possession is not punished) and hence increases the crime and quantity externalities. It is more costly under decriminalization to reduce the cost of externalities because one instrument, penalizing possession, is unavailable. However, in some circumstances decriminalization may yield a higher welfare level than prohibition, particularly when it is costly to enforce possession laws or where a drug is not very addictive. However, if decriminalization can lead to higher welfare than prohibition it always makes sense to legalize the drug due to tax revenue advantages.<sup>11</sup>

Where legalization results in higher welfare than prohibition it is clearly optimal. Legalization is likely to be optimal for reasons which are diametrically opposed to those supporting the optimality of prohibition. For example where the quantity externality slowly increases in aggregate consumption and the addictive properties of the drug are low. If legalization is optimal, it is possible to have higher crime and greater addiction. This is because at the margin tax revenues may offset adverse changes in crime and quantity externalities.

### 3. Characterizing the consumers' problems

We consider an economy in which there is a continuum of risk neutral consumers, normalized at unity. Each consumer has an endowment of a consumption good  $y \in [0; \bar{y}]$ ; and there is a twice continuously differentiable distribution function  $G : [0; \bar{y}] \rightarrow [0; 1]$  across endowments. The endowment good  $y$  can be exchanged for a drug  $d$  and we assume  $y$  is the numeraire. The price of  $d$  is denoted  $p$ ; and we assume for analytical tractability that the drug is produced according to a linear cost function having zero fixed costs and a marginal cost  $k > 0$ .

The population comprises two types of consumers. A proportion  $\alpha \in (0; \frac{1}{2})$  of the population is assumed to have preferences  $u(y; d)$ ; discussed in detail shortly. The other  $1 - \alpha$  part of the population, which we denote 'society', only derives satisfaction from consuming the endowment good and holds preferences  $v(y)$ ; where

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<sup>11</sup>Marijuana usually attracts the greatest attention in the legalization vs. prohibition debate. The National Opinion Research Center (NORC) Poll has asked adults about the legalization of marijuana since 1973 and in 1993 22% believed it should be legalized, see BJS (1994, p.33). The relatively high support for the legalization of marijuana possibly reflects a view that the quantity externality in this case is relatively low.

$v(0) = 0; v'(0) > 0; v''(y) < 0$  and  $v'''(y) > 0$ : All consumers maximize expected utility.

Let  $\tau \in [0, 1]$  be a uniform proportionate tax rate applied to all individuals' endowments by society. An individual's net endowment is  $(1 - \tau)y = \pm y$ ; where  $\pm = (1 - \tau)$ : For the moment the tax rate, other policy instruments and the motives of society are assumed to be exogenous, and all tax revenues collected are equal to expenditures. To avoid additional complications raised by asymmetric information we assume that the size of each individual's endowment is known by society.

The consumption problem for those individuals who do not derive any utility from the drug is straightforward — they seek to consume their own endowment net of taxation. The problem confronting drug taking consumers is described next.

### Drug users

We assume that there are two states describing drug consumption: one state characterizes the casual consumer of drugs and the other the addictive consumer of drugs. In the addiction state a consumer only derives positive utility by consuming some 'large' quantity (made precise below)  $d_a > 0$  of the drug. If a consumer enters the addiction state but has insufficient income to purchase the amount  $d_a$  of the drug, then he or she is assumed to resort to theft as a way of funding consumption.

A consumer enters the addiction state with a probability as follows

$$\text{Addiction state probability} = \begin{cases} 0 & \text{for } d = 0; \\ \tau & \text{for } 0 < d < d_a; \\ 1 & \text{for } d = d_a; \end{cases}$$

where the function  $\tau(d)$  is such that  $\lim_{d \rightarrow 0} \tau(d) = \tau \in (0, 1)$ ;  $\tau(d_a) = 0$ ;  $\tau'(d) > 0$ ;  $\tau''(d) < 0$  and  $\tau'''(d) > 0$ . Hence the probability of drug addiction is non-decreasing in drug consumption.

We suppose that policy, which is given, penalizes possession and consumption of the drug.<sup>12</sup> Each drug user purchasing a positive quantity of the drug faces a probability  $\tau$  of being found in 'possession' of the drug by a policing authority. If caught in possession the individual faces a penalty such that the drug is confiscated

<sup>12</sup>These rules may not be optimal for society and in sections 5 and 6 below we address the optimality of policy design.

— thus barring consumption — and in addition the individual is endowed an amount  $f^p \geq 0$ :

### Rich drug users

A rich drug user is an individual with an endowment such that  $d_a$  of the drug can be purchased without recourse to theft. Rich drug users are those holding net endowments  $\pm y \geq pd_a$ ; hence the critical endowment level which denotes the boundary of rich drug users is

$$\hat{y} = pd_a \quad (3.1)$$

For simplicity we suppose that a drug user's utility function is separable across the goods and the states. Thus in the casual state we define utility as  $u(y; d) = v(y) + c(d)$ ; where  $c(0) = 0$ ;  $c'(0) > 0$ ;  $c''(d) < 0$  and in the addiction state utility is  $u(y; d) = v(y) + a(d_a)$  for  $d \geq d_a$  and zero for  $d < d_a$ : For notational clarity assume  $a(d_a) = c(d_a)$ .

Drug consumption is optimal if the following inequality is satisfied for any  $d > 0$

$$(1 - \frac{1}{2}) (\beta(d)[v(\pm y - pd) + c(d)] + (1 - \beta(d))[v(\pm y - pd_a) + c(d_a)]) + \frac{1}{2} v(\pm y - \beta(d)pd) - (1 - \beta(d))pd_a - f^p \geq v(\pm y) \quad (3.2)$$

The expression in (3.2) is akin to a participation constraint. Risk neutrality and the assumption that non-drug takers set policy means that it is optimal to set insurance rates. However, we assume that the maximum amount any individual expects to pay cannot be greater than the amount of endowment net of drug expenditure. As insurance rates are at least as large as  $\hat{y}$ ; the term pre-multiplied by  $\frac{1}{2}$  in (3.2) is equal to zero. Whether (3.2) holds depends critically on the values of  $\beta$ ;  $a(d_a)$  and  $\beta$ ; but throughout we assume that the inequality does hold. The optimization problem facing a rich drug user with an endowment  $y$  is to choose a consumption level of the drug that maximizes the following

$$(1 - \frac{1}{2}) (\beta(d)[v(\pm y - pd) + c(d)] + (1 - \beta(d))[v(\pm y - pd_a) + c(d_a)]) \quad (3.3)$$

The problem in (3.3) has a first order condition which implies a standard efficiency condition where the marginal utility of endowment consumption is equal to the

marginal utility of drug consumption

$$-(c^0_i; v^0p)_i -^0 ([v(\pm y_i; pd_a) + c(d_a)]_i [v(\pm y_i; pd) + c(d)]) = 0: \quad (3.4)$$

Let the optimal consumption bundle be  $(y^a; d^a)$  and the value of expected utility be  $u(d^a(z; y))$ , where  $z = f_{\pm}; d_a; pg$ :

In (3.4) at the margin an individual's consumption decision is independent of the possession probability. Expression (3.4) also implies that an individual's optimal drug consumption declines in the price of the drug and increases in the endowment level, see (A.3) and (A.4) in the appendix. The effect of an increase in the income tax  $\zeta$  on individual drug demand is qualitatively identical to a reduction in endowment income. Finally, to ensure that the addiction level of the drug  $d_a$  is always greater than the casual consumption level of any rich drug user, we assume that  $d^a(z; \hat{y}) < d_a$  at  $\pm = 1$  and  $p = k$ :

### Poor drug users

A poor drug user has an (net) endowment level  $\pm y < \hat{y}$ : If a poor drug user enters the addiction state, there is a need to steal to finance consumption of the drug. For analytical tractability we suppose that theft only affects the non-drug takers.<sup>13</sup> If a poor drug user with endowment  $y$  enters the addiction state, the amount stolen is given by

$$r(z; y) = pd_a \pm y: \quad (3.5)$$

We assume that if an individual steals there is a probability  $\cdot$  of being apprehended for theft which carries a fine  $f^r \pm \hat{y}$ . A drug taker committing a theft selects a victim(s) at random from the non-drug users. Hence drug users are imperfectly informed about income levels among non-drug users.

These individuals face the same decision as the rich types, except that if the addiction state is entered they know ex ante theft will occur. As fines for theft and possession are very high, drug consumption is optimal if the following participation constraint holds

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<sup>13</sup>In the model society only cares about the crime itself suffers, hence this assumption is consistent with the motivation for anti-crime policy.

$$(1 - \frac{1}{2}) f^{-}(d)[v(\pm y - pd) + c(d)] + (1 - i^{-}(d))[(1 - i^{-})c(d_a) + \cdot c(d)]g_{\pm} v(\pm y): \quad (3.6)$$

Assuming that (3.6) is satisfied for some  $d > 0$ ; poor drug users choose a drug consumption level to maximize the following

$$^{-}(d)[v(\pm y - pd) + c(d)] + (1 - i^{-}(d))[(1 - i^{-})[v(\hat{y} - pd_a) + c(d_a)] + \cdot c(d)]: \quad (3.7)$$

For poor drug users the first order condition of expected utility maximization includes the probability of apprehension, see (A.2). It is possible that the optimal consumption bundle for individuals on very low incomes is a corner solution, where consumption consists entirely of the drug. The details are shown in the appendix.

#### 4. Market equilibrium

We suppose that drugs are supplied illicitly under Bertrand competition with a fixed number of firms  $n \geq 2$ : We assume only a fraction  $\hat{A} \in (0, 1)$  of each firm's total production reaches its intended market because of society's policy (eg. interdiction). Aggregate demand for the drug can be written as  $q(p; t)$  :

$$q(p; t) = d_a \cdot (1 - \frac{1}{2}) \int_0^{\hat{y}} (1 - i^{-}) g(y) dy + \int_0^{\hat{y}} (1 - i^{-}) g(y) dy + \int_0^{\hat{y}} (1 - i^{-}) d^a g(y) dy + \int_0^{\hat{y}} (1 - i^{-}) d^a g(y) dy + \int_0^{\hat{y}} d^a g(y) dy + \int_0^{\hat{y}} d^a g(y) dy ; \quad (4.1)$$

where  $t = \{f; \hat{A}; \hat{y}; \cdot; d_a\}$ : Demand in (4.1) has four components; the first shows the demand from those addicted who consume  $d_a$ , the second is the demand from addicted poor users apprehended for burglary, the third gives the demand from casual drug consumers not caught in possession and the final term is the casual demand by those who are caught in possession of the drug. Clearly individuals caught in possession are unable to become addicted. Individual demand for every

drug user is inversely related to price and positively related to income net of tax (see the appendix), hence  $\partial q/\partial p < 0$  and  $\partial q/\partial \pi > 0$ . It is also the case  $\partial q/\partial \lambda < 0$ ; which can be seen by letting  $\lambda = 1$  (in the limit) and observing that demand would be  $\lambda d^a$ : As  $\lambda$  falls below one an increasing fraction of drug users become addicts, a proportion of whom buy  $d_a$ :

Competition implies profits are driven to zero and each firm expects the following profit in equilibrium

$$[\lambda p - k]q(p; \pi) = 0; \quad (4.2)$$

and the equilibrium price under competition is given by

$$p^c = k/\lambda; \quad (4.3)$$

Substituting (4.3) into (4.1) gives the equilibrium quantity and as supply is perfectly elastic, the equilibrium price (quantity) in (4.3) increases (decreases) in marginal cost  $k$  and decreases (increases) in the probability  $\lambda$ : Those factors influencing the demand side of the market only affect the level of equilibrium output  $q^c$ .

## 5. Optimal second best policy under prohibition

Suppose that the majority of non-drug consumers for whatever reason prohibit consumption, possession and production of the drug. We assume in this instance that society — the non-drug users — aims to solve a problem which maximizes the welfare of the population presuming that all individuals should be non-drug consumers. Nevertheless it is recognized that a fraction  $\lambda < 1/2$  of the population hold preferences favoring consumption of the drug. Although welfare is couched in terms of presuming a population of non-drug consumers, policy is designed taking into account the existence of drug users. We suppose that the problem is solved in a second best sense as lump-sum redistributions of the endowment good are ignored. Society chooses policy to influence the values of  $\lambda$ ;  $\lambda$ ;  $\lambda$ ; and  $\lambda$ : The probability of addiction  $\lambda$  and the potency of the drug  $d_a$  are not considered to be influenced by society.<sup>14</sup>

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<sup>14</sup>This assumption should not be taken to mean that society is incapable of influencing such variables in practice. Society may be able to pass rules which influence potency. For example,

### Crime externality (cost of drug-related crime)

Theft is only committed by poor drug users in the addiction state and the expected value of the crime externality is

$$T^a = (1 - \frac{1}{2}) \int_0^z [1 - (d^a(z^a; y))] r(z^a; y) g(y) dy \quad (5.1)$$

Differentiating (5.1) with respect to  $p^a$  gives

$$\frac{\partial T^a}{\partial p^a} = (1 - \frac{1}{2}) \left[ \frac{\partial \mu}{\partial p^a} \int_0^z [1 - (d^a(z^a; y))] g(y) dy + \int_0^z \left[ -\frac{\partial d^a}{\partial p^a} r(z^a; y) g(y) \right] dy \right] \quad (5.2)$$

The first term in (5.2) shows how crime increases in price for a given  $\mu$ : For a higher price a poor drug user in the addiction state steals more. The second term in (5.2) reflects the effect of a changing price on the proportion of addicts feeding through a change in  $\mu$ : Although a lower price for a drug means that a poor drug user in the addiction state need steal less, it stimulates greater consumption by each individual and increases the probability of addiction. (This is analogous to a Slutsky effect.) If the increase in the proportion of poor drug users in the addiction state is sufficiently large because  $\mu$  declines rapidly in consumption, this can result in an inverse relationship between crime and the price of a drug. This is more likely if the probability of addiction is very sensitive to changes in the level of consumption, that is  $-\frac{\partial d^a}{\partial p^a}$  is relatively large in absolute terms. From (5.2) the sign of  $\int_0^z [1 - (d^a(z^a; y)) - \frac{\partial d^a}{\partial p^a} r(z^a; y)] g(y) dy$  determines the sign of the derivative. The term within square brackets is crucial and it is more likely to be negative at low values of  $y$ : Hence, the more positively skewed the distribution of endowments, the more likely there is an inverse relationship between crime and the price of the drug.

In our discussion of policy the response of crime to changes in the possession probability is examined. Noting that  $\frac{\partial p^a}{\partial \frac{1}{2}} = 0$ ; then:

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it could determine the maximum permitted alcoholic strength of a beverage. However, this sort of policy is not considered here.

$$\frac{\partial T^a}{\partial \frac{1}{2}} = \int_0^z (1 - i^{-d^a(z^a; y)}) r(z^a; y) g(y) dy < 0: \quad (5.3)$$

Hence the value of drug-related crime falls as the probability of drug possession increases.

### Quantity externality (cost of drug addiction)

We assume that society faces an externality cost of drug addiction related to the proportion of addicts  $H(b)$ ; where  $H^0(b) > 0$ ; and  $b$  is the proportion of addicts in the population. In equilibrium the proportion of addicts is given by

$$b^a = \int_0^z (1 - i^{-\frac{1}{2}}) (1 - i^{-\cdot}) \int_0^{y^a} (1 - i^{-d^a(z^a; y)}) g(y) dy + \int_{y^a}^z (1 - i^{-d^a(z^a; y)}) g(y) dy \quad (5.4)$$

The comparative static derivative with respect to  $\frac{1}{2}$  is:

$$\frac{\partial b^a}{\partial \frac{1}{2}} = \int_0^z (1 - i^{-\cdot}) \int_0^{y^a} (1 - i^{-d^a(z^a; y)}) g(y) dy + \int_{y^a}^z (1 - i^{-d^a(z^a; y)}) g(y) dy < 0: \quad (5.5)$$

Hence, as the probability of possession increases the proportion of addicts declines.

### Revenue collected in ...nes

At the optimum all ...nes are set so high that payments by individuals are always equal to the level of endowment they possess and we assume that the value to society of confiscated drugs is zero. Equilibrium ...ne revenue therefore equals,

$$F^a = \int_0^{\frac{1}{2}} \int_{y^a}^z [y - i^{-p^a d^a(z^a; y)}] g(y) dy + \int_{\frac{1}{2}}^z \int_{y^a}^z [y - i^{-p^a d^a(z^a; y)}] g(y) dy +$$

$$\frac{\partial F^a}{\partial \mu} = \int_0^{\bar{y}^a} [y - p^a d^a(z^a; y)] g(y) dy + \int_0^{\bar{y}^a} [y - p^a d^a(z^a; y)] g(y) dy - \int_0^{\bar{y}^a} (1 - \mu) [p^a (d_a - d^a)] g(y) dy \quad (5.6)$$

The first line in (5.6) is the expected net revenue obtained from rich drug users caught in possession of the drug. The second line in (5.6) is the expected revenue obtained from poor drug users caught in possession of the casual quantity, and the third line is the expected revenue from poor addicts caught stealing. The comparative static derivative with respect to the possession probability is

$$\frac{\partial F^a}{\partial \mu} = \int_0^{\bar{y}^a} [y - p^a d^a(z^a; y)] g(y) dy + \int_0^{\bar{y}^a} [y - p^a d^a(z^a; y)] g(y) dy - \int_0^{\bar{y}^a} (1 - \mu) [p^a (d_a - d^a)] g(y) dy \quad (5.7)$$

The sign of the derivative in (5.7) is ambiguous. Increasing the probability of possession results in more drug users apprehended for possession, but it also means fewer become addicts and steal.

## Policy instruments

There are three policy instruments under prohibition in addition to the setting of fines. The demand side strategies are as follows. The choice of the income tax  $\tau$  which raises revenue  $\tau \int_0^{\bar{y}^R} y g(y) dy = \tau E(y)$ ; where  $E(y) = \int_0^{\bar{y}^R} y g(y) dy$ : Society can affect the value of  $\mu$ ; the fraction of the population holding drug taking preferences, through educational expenditure  $E$ . We assume that  $\mu = \mu(E)$ ;  $\mu(0) = \frac{1}{2} < 1$ ;  $\mu' < 0$  and  $\mu'' > 0$ : We emphasize that throughout society is fixed and equal to the fraction  $1 - \frac{1}{2}$ . The probability of being caught in possession of the drug and the probability of being apprehended for theft are influenced by expenditures  $P^p$  and  $P^r$  respectively. We assume that  $\frac{1}{2} = \frac{1}{2}(P^p)$ ;  $\frac{1}{2}(0) = 0$ ;  $\frac{1}{2}' > 0$  for  $P^p > 0$ ;  $\frac{1}{2}'' > 0$ ;  $\frac{1}{2}'' < 0$  and  $\frac{1}{2}(1) = 1$ : Similarly  $\mu = \mu(P^r)$ ;  $\mu(0) = 0$ ;  $\mu' > 0$  for  $P^r > 0$ ;  $\mu'' > 0$ ;  $\mu'' < 0$  and  $\mu(1) = 1$ :

The supply side strategy is the choice of  $P^t$  which affects illicit supply. Let  $\bar{A} = \bar{A}(P^t)$ ; where  $\bar{A}(0) = 1$ ;  $\bar{A}'(P^t) < 0$ ;  $\bar{A}''(P^t) > 0$ ;  $\bar{A}' > 0$  for  $P^t > 0$  and  $\bar{A}(1) = 0$ : It can be seen that there are decreasing returns with respect to all of the demand and supply strategies.

## Society's welfare maximization problem under prohibition

We know that the optimal ...nes are set as high as possible, leaving society to choose the optimal values for  $E$ ;  $P^p$ ;  $P^t$ ;  $P^r$  and  $\zeta$ : Society is fully informed and makes use of all the equilibrium expressions derived above. Let  $x = (E; P^p; P^t; P^r; \zeta)$  be the vector containing the choice variables. The problem is as follows,

$$\min_x C(x) = \zeta + T^* \quad (5.8)$$

subject to

$$P^p + P^r + P^t + E + H(b^*) = \zeta E(y) + F^* \quad (5.9)$$

The asterisks denote equilibrium values and optimal consumption values under prohibition. The objective function (5.8) is equivalent to maximizing the indirect utility of non-drug users and the vector  $x$  contains, implicitly and explicitly, all taxes. Given risk neutrality, it is clear that all consumers wish to minimize  $C(x)$ : Society attains this subject to a break-even constraint shown in (5.9): expenditure, which includes the quantity externality  $H(b^*)$ ; should equal revenue which comprises tax revenue and ...ne revenue. As stated in the Introduction, the structure of the problem in (5.8) and (5.9) is reminiscent of a more general Diamond-Mirrlees commodity taxation problem.

Let the problem have the Lagrangian  $\mathcal{L}$  with  $\mu < 0$  being the multiplier associated with the constraint in (5.9).<sup>15</sup> The first order conditions of the minimization problem are given in the appendix. Let the solution to (5.8) and (5.9) be  $x^*$  with a value  $C^* = C(x^*)$  and suppose it is unique and that the second order conditions are satisfied.

Consider in greater detail the first order condition with respect to anti-possession expenditure  $P^p$  which can be rewritten as follows:

$$\frac{1}{P^p} \frac{dT^*}{dP^p} + \mu \left[ H'(b^*) \frac{db^*}{dP^p} + \frac{dF^*}{dP^p} \right] = \mu \frac{d\zeta}{dP^p} \quad (5.10)$$

where  $\epsilon_{P^p} = \frac{P^p}{C^*} \frac{dC^*}{dP^p} > 0$  is the elasticity of the possession probability with respect to expenditure on possession. The term  $\frac{d\zeta}{dP^p}$  increases in  $P^p$ : As  $\frac{dT^*}{dP^p} < 0$  and

<sup>15</sup>From the constraint it can be seen that if the expected endowment level were greater, it would allow expenditures to be reallocated in a way which can diminish  $T$  and  $\zeta$ . Thus the multiplier  $\mu$  is non-positive.

$\frac{db^a}{d\lambda} < 0$ ; then for the case where  $\frac{dF^a}{d\lambda} > 0$  the solution has  $P^{pa} > 0$ : However, if  $\frac{dF^a}{d\lambda} < 0$  and the other effects are relatively small, this may imply that prohibition is not optimal, that is  $P^{pa} = 0$ : The appearance of an elasticity term in (5.10) gives the solution a Ramsey like feature. Of course, the solution is such that the burden imposed on society by drug consumption is minimized in an efficient manner.

**Proposition 1** If the expression in the curly brackets in (5.10) is positive for all  $P^p \geq 0$ , then prohibition is not optimal.

Prohibition is unlikely to be optimal if a drug imposes relatively small externalities and where net revenues are decreasing in the possession probability.

## 6. The effects of legalization: a qualitative assessment

Having established the optimal strategy for society when a drug is prohibited, and discussed decriminalization, we now examine the merits or otherwise of legalization. The major differences between legalization and prohibition are the following. First, as for the case of decriminalization society does not penalize individuals for possessing and consuming the drug. Secondly, and crucially, legalization enables society to tax credibly the drug. In a legalized regime, however, illicit supply remains an issue and the choice of  $P^t$  continues to play a role. Under legalization we assume that society can supply (or license supply) an amount  $q^s$  of the drug. The equilibrium price under legalization is denoted as  $\tilde{p}$ , where a tilde appearing on any variable refers to values under legalization.

If a drug is legalized, society chooses its policy instruments to maximize welfare as in the prohibition regime. This results in a vector of optimal policy variables  $y^a = (E^a, P^{ra}, P^{ta}, \tilde{c}^a, g)$ ; the solution is shown in the appendix. Note that under legalization society faces different incentives. Although it remains optimal to expend resources  $E^a$  deterring consumption of the drug, it is likely to be the case that fewer resources will be devoted than in the case of prohibition. This is because the sale of the drug under legalization provides a tax revenue for society. Education  $E^a$  remains positive, however, as it is an effective way of combatting externalities at relatively low levels of expenditure given decreasing returns to scale.

In most cases it is not possible to state whether welfare is greater under legalization than prohibition without specifying functional forms explicitly. Rather

than compare the solutions under the two different regimes we examine whether welfare can improve by moving away from prohibition to legalization. In other words, if welfare can be shown to be higher away from prohibition it follows that legalization is optimal. As this line of reasoning is used in policy debates to support or oppose drug legalization, the analysis helps to shed light on the issue.

Suppose that society legalizes the drug and sets the policy variables equal to the optimal values under prohibition, except for  $P^p$  which by definition is zero under legalization. Furthermore, assume that decriminalization does not yield a higher welfare than prohibition. Assume initially that  $q^s = 0$ ; in which case the equilibrium price is  $p^a$  as before. In our analysis of legalization we make the following assumption; ...ne revenues are increasing in the probability of possession  $\frac{\partial F}{\partial \frac{1}{2}} > 0$ : (This assumption can be relaxed and the implications below modified without affecting the conclusions.) It is also useful at this stage to draw a distinction between what we term a weakly addictive (WA) drug and a strongly addictive (SA) drug. For a given distribution of income a WA(SA) drug is one where there is a positive(inverse) relationship between the crime externality and the price of the drug.

With the above assumptions and definitions in place the effect of legalization on society's budget constraint is as follows:

$$P^{ra} + P^{ta} + E^a + \underbrace{H(b)}_{>H(b^a)} > \zeta^a E(y) + \underbrace{F}_{<F^a} : \quad (6.1)$$

Note that  $H(b) > H(b^a)$  because the lower value for  $\frac{1}{2}$  leads to a greater proportion of addicts, see (5.5). It is clear that the inequality in (6.1) holds strictly for otherwise  $x^a$  would not be optimal under prohibition. Furthermore,  $T > T^a$ ; therefore  $C > C^a = T^a + \zeta^a$ : The expressions for  $b$ ;  $F$  and  $T$  are shown in the appendix.

Society faces several options in attempting to restore a balanced budget and improve welfare. An option previously unavailable is the setting of  $q^s > 0$  enabling society to raise revenue  $R = q^s[p_i - k]$ . As competition ensures that the equilibrium price equals  $p^a = k - \bar{A}$ ; if society were to set  $q^s < q(p^a; t_i, \frac{1}{2})$  it would not maximize  $R$ . We assume that society always sets  $q^s = q(p^a; t_i, \frac{1}{2})$  and supplies the entire market. The price society sells the drug at is nevertheless influenced by the threat of entry by illicit production. Thus  $\bar{A}$  plays a critical role in determining

the scale of tax revenue R. Modifying (6.1) to account for the tax revenue R gives

$$P^{ra} + P^{ta} + E^a + \underbrace{H(b)}_{>H(b^a)} + \underbrace{E(y)}_{<F^a} + R; \quad (6.2)$$

where  $R = q(k=\hat{A}; t_i \frac{1}{2})[k(1 - \hat{A})=\hat{A}]$  and  $\hat{A} = \hat{A}(P^{ta})$ : Hence, let  $R = R(P^t)$ :

If the left hand side is less than the right hand side in (6.2), it is clear that welfare can exceed the level implied by C: In the setting considered here legalization can make society better off when the following is satisfied:

$$R(P^t) > \underbrace{[H(b) - H(b^a)]}_{+ve} + \underbrace{[F - F^a]}_{-ve} + \underbrace{[T^a - T]}_{-ve} = \Delta; \quad (6.3)$$

**Proposition 2.** If  $R(P^t) + \Delta > 0$ , society is unambiguously better off legalizing the drug.

Proposition 2 states that tax revenues are large enough to offset changes in crime and quantity externalities, and any change in welfare revenue. Of course, initiatives like the NDCS are founded in the belief that Proposition 2 does not hold. As welfare revenues in practice tend to be a negligible source of revenue (and in many cases fail to cover the administrative costs of extracting fines), the NDCS suggests via revealed preference that the increase in the quantity and crime externalities is likely to be considerable under legalization.

As (6.1) would hold as an equality if decriminalization were to yield a welfare above that associated with the prohibition regime, this implies:

**Proposition 3.** When decriminalization yields higher welfare than prohibition, society is better off legalizing the drug.

Clearly legalization confers benefits because society obtains tax revenue R by removing the rent-seeking activities of illicit production.

If  $R + \Delta < 0$  it does not follow that legalization makes society worse off. Consider further policy changes aimed at restoring a budget balance. One option is to change the quantity of the drug supplied. Two cases are considered depending on the price elasticity of demand for the drug at the welfare optimum under prohibition.

Demand is price elastic at  $p = k=\hat{A}$

Here it is unclear whether society would find it in its interest to increase or decrease the amount of the drug brought to the market. If  $R$  is increasing in  $\hat{A}$  (that is, inversely related to the price of the drug), society can raise extra revenue by spending less on  $P^t$  and expanding output of the drug: For a marginal reduction in  $P^t$  ( $dP^t < 0$ ) the individual effects are as follows (the appendix shows the full derivatives).

$$H^0 \frac{db}{d\hat{A}} \hat{A}^0 dP^t > 0: \quad (6.4)$$

|{Z}  
+ve

In words (6.4) states that lowering the price of the drug through increasing  $\hat{A}$  leads to extra costs associated with addiction. The effect on net revenue, however, is ambiguous,

$$\frac{dF}{d\hat{A}} \hat{A}^0 dP^t ? 0: \quad (6.5)$$

However, the elasticity of demand and the assumption that  $R$  is inversely related to the price of the drug means

$$\frac{dR}{d\hat{A}} \hat{A}^0 dP^t > 0: \quad (6.6)$$

|{Z}  
+ve

By stimulating demand and increasing  $\hat{A}$  society saves the direct expenditure on  $P^t$ :

$$i \ dP^t > 0: \quad (6.7)$$

Furthermore, for a WA (SA) drug society benefits (suffers) as the value of crime is lower (higher):

$$i \ \frac{dT}{d\hat{A}} \hat{A}^0 dP^t > (<)0: \quad (6.8)$$

|{Z}  
i ve

For the deficit on the budget to be reduced it is necessary that the sum of the terms in (6.4)-(6.8), call it  $S$ ; is positive. If for some  $\hat{P}^t \in (0; P^{t^*})$  it is the case that  $\frac{R}{P^t} S dP^t$  generates sufficient income to restore a balanced budget and  $S$  is strictly positive at  $\hat{P}^t$ , welfare is greater under legalization. In other words, the ability to raise revenues from selling the drug more than compensate for changes in the externalities. For this case we can state the following:

**Proposition 4.** For a WA (SA) drug if there exists a  $\hat{P}^t \in (0; P^{t^*})$ ;

society is better off legalizing the drug and this yields: (i) a lower price for the drug, (ii) greater addiction, (iii) possibly lower (certainly higher) crime, and (iv) a possibly higher (certainly lower) income tax rate.

If  $R$  is inversely related to  $\hat{A}$ ; society can raise extra revenue by spending more on  $P^t$  and thus contracting output of the drug: Using analogous reasoning to that deployed above, if for some  $P^t \geq (P^{t*}; 1)$  a higher welfare level can be attained we can state:

**Proposition 5.** For a WA (SA) drug if there exists a  $P^t \geq (P^{t*}; 1)$ ; society is better off legalizing the drug and this yields: (i) a higher price for the drug, (ii) possibly lower addiction, (iii) certainly higher (possibly lower) crime, and (iv) a lower (possibly higher) income tax rate.

Arguably marijuana is not very addictive and has properties which make it closer to being a WA drug than a SA drug. Moore (1990) and Kleiman and Reuter (1986) have presented estimates showing that the price for marijuana has a relatively low mark-up over cost, and the 1997 NDCS states that "over the last decade, marijuana prices have dropped". Misket and Vakil (1972) have estimated a price elasticity of demand for marijuana of -1.50, which is relatively elastic. According to the 1997 NDCS marijuana is America's most commonly used illicit drug with an estimated 9.8 million users in 1995. If the proponents of the legalize marijuana viewpoint believe that welfare would be higher under legalization, these data suggest that it would likely result in an increase in its price because of taxation and Proposition 5 suggests that addiction might be lower but that drug-related crime would be higher.

Demand is price inelastic at  $p = k\hat{A}^\alpha$

Here  $R$  is inversely related to  $\hat{A}$ : The outcome is identical to that summarized in Proposition 5. Moore (1990) reports an estimate for the price elasticity of demand of alcohol at -0.8. Given that alcohol is supplied largely on competitive markets and its relatively high taxation leads to a large price-cost mark-up, its legalization may mean that drug-related crime is higher than it would be under prohibition.

Table 1 Taxonomy of outcomes shown in Propositions 4 and 5

Legalization Price/ Prohibition Price	WA Drug	SA Drug
Exceeds 1	Addiction lower or higher Crime higher	Addiction lower or higher Crime lower or higher
Unity	Greater addiction Crime higher	Greater addiction Crime higher
Below 1	Greater addiction Crime lower or higher	Greater addiction Crime higher

## 7. Conclusion

We have presented a model on drug consumption and externalities, in particular on crime and quantity externalities. The conceptual framework ties together for the first time in this context existing strands of economic theory: crime and punishment, rational addiction and optimal taxation. The model was used to consider policy and it was shown that illicit drug production, among other factors, is an important factor in welfare assessments. We highlighted how society's drug control policy is a taxation problem. The problem was extended to consider the question of legalization where we undertook a qualitative assessment and showed that the net benefits or costs to society of legalization depend on several factors: illicit drug production, the addictive property of a drug, the price elasticity of demand for a drug, the effectiveness of enforcement variables, income distribution, and significantly on how the quantity and value externalities respond to changes in policy variables. We showed that legalization may yield a welfare improvement despite the possibility of higher drug-related crime and higher addiction in some cases.

To answer any policy question in this politically sensitive area with confidence, however, requires careful empirical analysis to compute the size of the externalities. Our analysis provides a conceptual framework to guide such empirical investigations. However, we emphasize that our model is a first step towards developing a comprehensive framework for addressing the economics of drug control

policy. The model could be generalized in several directions. First, the number of illicit and legitimate goods could be increased and the utility and production functions made more general. Doing this would enrich the model in the direction of Diamond-Mirrlees. In a multi-drug setting it is likely that the portfolio of drugs consumed by an individual will influence the probability and type of addiction. Secondly, labor supply could be introduced and labor productivity could be influenced by drug consumption, explicitly accounting for another externality: foregone output or a production externality.<sup>16</sup> Thirdly, greater heterogeneity could be imposed across the agents in the economy, for example differing degrees of risk aversion could be introduced across consumers and/or illicit drug producers.

Fourthly, a richer characterization of the illicit drug sector could be considered, for example production might be treated as oligopolistic. Fifthly, we could consider the case where the quality of a drug for a consumer is difficult to determine prior to consumption. In this case we might envisage different policies where, for example, society might provide to addicts a drug with an assured minimal quality in an attempt to lower the quantity externality. Society organized needle exchanges for heroin addicts in an effort to reduce the risks of HIV infection is an example of such a policy observed in many countries (eg. Netherlands, Switzerland, UK, etc.). Finally, and perhaps most ambitiously, a dynamic representation could be developed. Here we could envisage future output being influenced by current drug consumption, for example through cumulative ill-health effects adding a further externality: a growth externality. In all these extensions problems of asymmetric information and uncertainty (particularly with regard to the magnitude of externalities) could be introduced, and considerations given to alternative forms of punishment.

The conceptual framework in this paper for addressing the economics of drug control policy brings together for the first time rational drug consumption, optimal tax theory, crime and other drug-related externalities. Using an optimal tax framework allows for a richer analysis of the issues and provides a foundation for much needed further analysis on this important topic.

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<sup>16</sup>Freeman (1996) discusses crime and the labour market.

## A. Appendix

First and second order conditions for individual drug consumption

In the following  $v^0 = v^0(\pm y_i, pd_a)$ : The second order condition for a rich user is,

$$\frac{\partial^2 [c^0_i \pm v^0 p]}{\partial y_i \partial v} + \frac{\partial [c^{00}_i \pm v^{00} p^2]}{\partial y_i} < 0$$

$$\frac{\partial^2 \{ [v(\pm y_i, pd_a) + c(d_a)] \pm [v(\pm y_i, pd) + c(d)] \}}{\partial y_i \partial v} < 0: \quad (A.1)$$

A sufficient condition for the second order condition to be satisfied is  $\frac{\partial^2}{\partial y_i \partial v} < 0$ ; as the first order condition in (3.4) implies  $c^0_i \pm v^0 p > 0$ : For a poor user the first order condition of expected utility maximization is obtained from the maximand in (3.7):

$$\frac{\partial}{\partial y_i} \{ [v + (1 - \beta) c] \pm (1 - \beta) [v(\pm y_i, pd_a) + c(d_a)] \} +$$

$$\frac{\partial}{\partial v} \{ (1 - \beta) c^0_i \pm v^0 p \} + \beta c^0_i \geq 0: \quad (A.2)$$

The inequality allows for the possibility of a corner solution. Where the solution is interior a sufficient condition for the second order condition to hold is  $\frac{\partial^2}{\partial y_i \partial v} < 0$  and  $(1 - \beta) c^0_i \pm v^0 p > 0$ :

### Comparative static derivatives for individual drug consumption

To obtain the comparative static derivatives for rich drug users totally differentiate (3.4). The second order condition (A.1) implies that the sign of  $dd^a = dt$  for an exogenous variable  $t$  is equal to the sign of  $\frac{\partial^2 u^a}{\partial d \partial t}$ : Hence,

$$\text{sgn} \frac{dd^a}{dp} = \text{sgn} \frac{\partial^2 u^a}{\partial d \partial p} = \frac{\partial}{\partial p} [v^0(\pm y_i, pd_a) d_a \pm v^0 d] + \frac{\partial}{\partial v} [v^{00} p d \pm v^0] < 0; \quad (A.3)$$

and

$$\text{sgn} \frac{dd^a}{dy} = \text{sgn} \frac{\partial^2 u^a}{\partial d \partial y} = \frac{\partial}{\partial y} [v^0 \pm v^0(\pm y_i, pd_a)] \pm v^{00} p > 0: \quad (A.4)$$

For poor drug users where (A.2) holds as an equality (an interior solution) yields,

$$\text{sgn} \frac{dd^a}{dp} = \text{sgn} \frac{\partial^2 U^a}{\partial d \partial p} = \text{sgn} \left( -v^0 d - [v^0 + v^0 p] \right) < 0; \quad (\text{A.5})$$

and

$$\text{sgn} \frac{dd^a}{dy} = \text{sgn} \frac{\partial^2 U^a}{\partial d \partial y} = \text{sgn} \left( -v^0 + v^0 p \right) > 0; \quad (\text{A.6})$$

Regularity requires  $\frac{dd^a}{dp} < 0$  and it follows from (A.5) that this arises when,

$$-v^0 d < -[v^0 + v^0 p] \Rightarrow \frac{v^0 p d}{v^0 d} > \frac{v^0 p}{v^0} \Rightarrow p > d^{-1}; \quad (\text{A.7})$$

Regularity also requires  $\frac{dd^a}{dy} > 0$  and from (A.6) this arises when,

$$-v^0 + v^0 p > 0; \quad (\text{A.8})$$

We assume that (A.8) holds throughout and therefore as a consequence it follows that (A.7) holds. For individuals on relatively low incomes and where the consumption bundle is a corner solution, it is immediately the case that  $\frac{dd^a}{dp} < 0$  and  $\frac{dd^a}{dy} > 0$ :

### Optimal second best policy under prohibition: first order conditions

The problem outlined in (5.8) and (5.9) results in the following first order conditions:

$$\frac{d^a}{dm} = \frac{dT^a}{dl} \left( 1 + H^0 \frac{db^a}{dl} + \frac{dF^a}{dl} \right) = 0; \quad (\text{A.9})$$

for  $m = E; P^p; P^r$  and  $P^t$ ; and  $l = \frac{1}{2}; \cdot$  and  $\hat{A}$  respectively; and for the tax rate

$$\frac{d^a}{d\tau} = 1 + \frac{dT^a}{d\tau} \left( 1 + H^0 \frac{db^a}{d\tau} + \frac{dF^a}{d\tau} \right) = 0; \quad (\text{A.10})$$

and finally

$$\frac{d^a}{d\tau} = E(y) \left( P^p + P^r + P^t + E + H(b^a) + F^a \right) \tau^{-1} = 0; \quad (\text{A.11})$$

### Optimal second best policy under legalization

Under legalization equilibrium terms are denoted with a tilde. As in the case of prohibition, the optimal ...nes are set as high as possible leaving society to choose the optimal values for  $E; P^t; P^r; q^s$  and  $\zeta$ : Competition reduces the choice set to  $y = (E; P^t; P^r; \zeta)$ . The problem in outline form is as follows,

$$\min_y C(y) = F + \zeta \quad (A.12)$$

subject to

$$P^r + P^t + E + H(b) = \zeta E(y) + F + R; \quad (A.13)$$

where

$$R = q\left(\frac{k}{\tilde{A}}; t_i \frac{1}{2}\right) \left[\frac{k}{\tilde{A}}; k\right]; \quad (A.14)$$

$$b = \int_0^{y^a} (1 - \tau) g(y) dy + \int_0^y (1 - \tau) g(y) dy; \quad (A.15)$$

$$F = \int_0^{y^a} (1 - \tau) (p^a(d_a; d^a)) g(y) dy; \quad (A.16)$$

$$F = \int_0^{y^s} (1 - \tau) r(z; y) g(y) dy; \quad (A.17)$$

The objective function (A.12) is like (5.8) and as in prohibition society must break even. Let the problem have the Lagrangian  $\tilde{L}$  with  $\lambda < 0$  being the multiplier. The first order conditions are:

$$\frac{d\tilde{L}}{dP^t} = \frac{dF}{dP^t} + \frac{dP^r}{dP^t} + \frac{dE}{dP^t} + \lambda \left[ H^0 \frac{db}{dP^t} + \frac{dF}{dP^t} + q\left(\frac{k}{\tilde{A}}; t_i \frac{1}{2}\right) \frac{dP^r}{dP^t} + \frac{dq}{dP^t} \left[\frac{k}{\tilde{A}}; k\right] \right] = 0; \quad (A.18)$$

$$\frac{d\tilde{L}}{dm} = \frac{dF}{dm} + \lambda \left[ 1 + H^0 \frac{db}{dm} + \frac{dF}{dm} + \frac{dq}{dm} \left[\frac{k}{\tilde{A}}; k\right] \right] = 0; \quad (A.19)$$

for  $m = E$  and  $P^r$ ; and  $\lambda = \lambda$  and  $\lambda$  respectively, and with respect to the income

tax

$$\frac{d-}{d\zeta} = 1 - \frac{d\bar{T}}{d\pm} - \frac{dF}{d\pm} - E(y) - H^0 \frac{db}{d\pm} + \frac{dq}{d\zeta} \left[ \frac{k}{\bar{A}} - k \right] = 0; \quad (A.20)$$

and ...nally

$$\frac{d-}{d\zeta} = E(y) - P^p + P^r + P^t + E + H(b) - F - R - \zeta^{-1} = 0; \quad (A.21)$$

Note  $\frac{dp}{d\bar{A}} = -k(\bar{A}^2) < 0$ : Let the optimal solution to (A.12) be denoted  $C^* = C(y^*)$ :

### Comparative static derivatives under legalization

Here we show the comparative static derivatives used in the assessment of the welfare implications of legalization.

$$\begin{aligned} \frac{d\bar{T}}{d\bar{A}} &= -\left[1 - G(y^s)\right] \frac{k}{\bar{A}^2} d_a i \\ \frac{k}{\bar{A}^2} \int_0^{y^s} \mu^{-1}(d) \frac{dd}{dp} [\pm y - p d_a] i^{-1}(d) d_a g(y) dy & \end{aligned} \quad (A.22)$$

In the case of a WA drug  $\frac{d\bar{T}}{d\bar{A}} > 0$  and for a SA drug  $\frac{d\bar{T}}{d\bar{A}} < 0$ :

$$\begin{aligned} \frac{db}{d\bar{A}} &= -\left[1 - \int_0^{y^s} \mu^{-1}(d) \frac{dd}{dp} \frac{dp}{d\bar{A}} g(y) dy\right] + \\ \int_0^{y^s} \mu^{-1}(d) \frac{dd}{dp} \frac{dp}{d\bar{A}} g(y) dy & \int_0^{y^s} \mu^{-1}(d) \frac{dd}{dp} \frac{dp}{d\bar{A}} g(y) dy > 0: \end{aligned} \quad (A.23)$$

Finally,

$$\frac{dF}{d\bar{A}} = -\left[1 - \int_0^{y^s} \mu^{-1}(d) [p(d_a - d)] g(y^s) \frac{d_a dp}{\pm d\bar{A}} + \right] \quad (A.24)$$

$$\int_0^Z y^{\mu} (1 - \rho(d)) (d_a - d) \frac{d\rho}{dA} - \rho(d) p(d_a - d) \frac{dd}{d\rho} \frac{d\rho}{dA} + \rho \frac{dd}{d\rho} \frac{d\rho}{dA} g(y) dy:$$

The sign of (A.24) is ambiguous.

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