THE ECONOMICS OF DRUG LEGALIZATION

Andrew E. Clark[1]

(CNRS and DELTA)

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ABSTRACT

There is no published economic analysis of the potential impact of drug legalization on Social Welfare. This paper treats legal and illegal drugs as different qualities of the same good, and uses price theory to analyse the social welfare effects of drug legalization and the optimal price of legal drugs. Both of these are shown to depend in an intuitive way on the relative importance of the externalities arising from drug use, such as crime and ill-health. Some simulations of the legalization of marijuana and cocaine, using reasonable parameter values, show that an increase in drug use usually results, but that the lower levels of per unit social harm in legal, as opposed to illegal, drug markets ensures that, in many cases, social welfare rises following legalization. Optimal drug policy is heavily dependent on the relationship between drug use and externalities, the inclusion of the consumer surplus from drug consumption in social welfare, and the functional form of the demand curve. A better understanding of these would seem necessary before any unequivocal statement about the advantages of legalization can be made.

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[1]Address: DELTA, 48 Boulevard Jourdan, 75014 Paris, France. Tel: 33-1-43-13-63-29. E-mail: Andrew.Clark@ens.fr. DELTA is a joint research unit of the CNRS, the EHESS and the ENS. I am grateful to John Burnham, Jonathan Caulkins, Jim Dana, Milton Friedman, the ISDD, K. Austin Kerr, Carsten Kowalczyk, Jeff Miron, Andrew Oswald, Tony Shorrocks, Richard Stevenson, Frances Woolley, Alex Zanello for advice and comments. I also thank seminar participants at Carleton University, Dartmouth, the Drug Policy Foundation International Conference (Washington DC), East Anglia, Ecole Nationale de Ponts et Chaussées, Essex, the Econometric Society European Meeting (Brussels), the Fourth International Conference on the Reduction of Drug-related Harm (Rotterdam), Free University of Amsterdam, Leicester, Liverpool, London Business School, Northeastern, the Public Sphere Conference (Manchester), Queen Mary and Westfield, Salford, Southampton and York for comments.

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1. Introduction.

The 'drug problem' is currently one of the most widely-discussed issues in many countries, and consistently appears close to the top of surveys asking people what they believe is the source of the greatest social concern. The scale of drug use is large. According to estimates from the 1995 National Household Survey on Drug Abuse, 10 million Americans had used marijuana in the past month, with a similar figure for cocaine of 1.5 million; and 72 million Americans aged twelve or older had tried illicit drugs at least once in their lifetime. Of this latter, 66 million had tried marijuana and 40 million had tried some other illicit drug. It has been estimated that revenue in the U.S. illegal drug market is one hundred billion dollars per year (Andelman, 1994). In 1992 over one million arrests for drug-abuse violations were reported to the FBI, and 58% of inmates in federal prisons were serving sentences for drug offences (Chambliss, 1994).

Despite the issue's high profile, it has attracted only little economic analysis. This paper considers one policy which has attracted a great deal of attention: legalization[2]. It asks whether drug legalization would increase social welfare, what price legal drugs should be sold at, and what might be the likely effects of legalization on the quantity of drugs used, spending on drugs, and the tax collected from drug sales.

Standard theory predicts that governments should intervene in drug markets because of the negative externalities involved in the sale and use of drugs. However, one of the most prevalent policies, prohibition, has apparently not worked as planned. Making drugs illegal has not eradicated drug use, rather it has changed the format of supply and demand by pushing all remaining use into the illegal market. And while drug use of any kind (*i.e.* legal or

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[2]. Articles discussing legalization have abounded in the media in recent years. A recent survey (Drug Policy Foundation, 1990) found that thirty six percent of Americans favoured legalization of drugs; fifty five percent favoured fighting all drug distribution and use.

illegal) involves some negative externalities, the purchase of a unit of a drug in the illegal market probably generates more negative externalities than would its purchase in a legal market. These additional externalities include the 'environmental' effect of drug trade on neighbourhoods, the violence associated with the illegal market (where there is no recourse to the Law in the event of a dispute), the income-generating crime that may result from the illegal market's high prices, the criminalization of those who purchase in the illegal market, the possible disincentive effect of what is seen as high-profit criminal activity on schooling and labour force participation, the health costs from adulterated and variable strength drugs, the increased risk of infection from needle-sharing and so on. Thus Prohibition has likely reduced the size of the drug market, but has also ensured that there are greater negative externalities associated with each unit of drugs consumed: the balance between these two effects is one of the key considerations in the welfare analysis of drug policy.

The paper is organized as follows. Section 2 uses a simple model of drug markets to analyse the implications of legalization on the quantities purchased, under first the assumption of a Perfectly Competitive illegal market and then of a Monopoly. Section 3 introduces a Social Welfare Function, which depends critically on the various externalities linked with the drug market, and identifies the conditions under which legalization will raise social welfare. Section 4 derives formulae for the optimal prices of legal drugs. Section 5 uses the model of the previous sections to present a number of simulations of the effect of legalization on quantities, drug spending, tax revenue, and social welfare. Section 6 concludes.

2. Market Structure and Drug Legalization.

i) Perfect Competition

Assume initially that the illegal market is Perfectly Competitive, with a horizontal supply curve at price c, and that legalization has no effect on the behaviour of sellers[3]. This

[3]. The supply curve will slope downwards if there are fixed costs associated with selling drugs; on the other hand it will slope upwards if there is a distribution of risk-aversion amongst (potential) sellers or if the risks from selling increase convexly with the quantity sold (for example, from kinked penalties as a function of quantity possessed).

competitive assumption ensures that there is zero *ex-ante* profit in illegal drug supply. The observed difference between the cost of drugs to suppliers and their retail price is then interpreted as a premium which compensates sellers for the concomitant risks, such as arrest, injury or death[4].

After legalization, the legal market can be supplied either publicly or privately[5]. In the former case, let the price of drugs be p_L. In the latter case, let there be perfect competition in legal supply, with firms supplying drugs at a price c'. It is reasonable to expect that $c' < c$ as legal firms will use technology that is at least as efficient as that of illegal firms, run no risk of arrest, and can benefit from economies of scale in production[6]. However, it does not necessarily follow that legalization will reduce market prices as the government levies a specific tax, J, on legal drugs, in much the same way as it currently does on alcohol and tobacco. The market price of privately supplied legal drugs is then c_L=c'+J, which may be higher or lower than the current illegal market price, *c*. For the purpose of the analysis, it does not matter whether legal drugs are privately or publicly supplied: in both cases the supply curve of legal drugs is horizontal.

We make the assumption that the demand curve for legal drugs is everywhere above that for illegal drugs: if both were the same price, consumers would choose legal instead of illegal drugs as there is no danger of arrest from purchasing legally, and legal drugs are safer than illegal drugs (because of the legal redress available in the former market they will not be cut with potentially toxic agents, and, as the strength of legal drugs will be carefully monitored, there will be a reduced chance of accidental overdose). In the same way, most

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4. Reuter *et al*. (1990) estimate these probabilities to be 22%, 7% and 1.4% respectively for young black male dealers in Washington D.C. Miron and Zwiebel (1995) argue that the effect of Prohibition on the supply curve is larger than that on the demand curve, as penalties are typically lighter for users than for sellers.

5. See Inciardi and McBride (1989) and Firing Line (1990). Jacobs (1990), Logan (1979) and Stevenson (1990) offer some suggestions about the form of legalization.

6. Nadelmann (1989) estimates that the export price of heroin is less than one percent of the price charged to users; similar figures for marijuana and cocaine are one percent and four percent respectively. For marijuana, see Geiringer (1994).

consumers would likely prefer a bottle of J&B to a bottle of moonshine, were both the same strength and price.

Let the 'premium', D_i, be the dollar cost to the consumer of buying unit *i* illegally rather than legally. To buy unit *i* in the illegal market a consumer is willing to pay illegal suppliers a price R_i, but the consumer also "pays" a premium (in terms of lost utility from the fear of arrest and from the poorer quality) of D_i, for a total of $R'_i = R_i + D_i$ (this sum of the dollar price and the premium is sometimes referred to as the full or effective price). The parameter D_i is one of the key unknowns in the analysis of drug markets. In this paper it is modelled using a linear form, $D_i = \text{"} + \$R_i$; ", \$ > 0. The rationale for this assumption is as follows. The expected loss from arrest from the purchase of unit *i* may be written as $\text{"} + \$_1R_i$, where $\$_1$ may be positive or negative. If individuals with a strong preference for drugs discount the danger of arrest, then $\$_1$ is negative. However, if R_i is correlated with income then the loss from arrest rises with R_i, giving a positive value of $\$_1$. A second part of the risk premium comes from individuals' valuation of the higher quality drugs in the legal market, which is considered to be a positive function, $\$_2R_i$, of the price which they are prepared to pay[7]. The total premium is thus $\text{"} + (\$_1+\$_2)R_i$; we here assume that $\$_1+\$_2 > 0$[8].

The inverse demand curve for illegal drugs is assumed to be linear,

$$R_i = a - bQ \tag{1}$$

Equilibrium quantity under Prohibition, Q_{IP}^{PC}, is thus

$$Q_{IP}^{PC} = \frac{(a-c)}{b} \tag{2}$$

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7. The assumption that there is a positive association between an individual's valuation of a good and their valuation of an increase in the quality of that good is a common one: see Mussa and Rosen (1978) and Tirole (1988). Work by Donnenfeld and White (1988) and Srinagesh and Bradburd (1989) considers that this association may in fact be negative. Reworking the analysis in this paper with a negative value of \$ did not substantially change the theoretical results.

8. This specification implies that someone who would not be willing to take advantage of free illegal drugs would nonetheless be prepared to pay a positive price for the legal version. A simpler specification is $D_i=\$R_i$, in which those who would not purchase at any price under Prohibition will not buy after legalization either.

where the PC superscript denotes Perfect Competition and the IP subscript denotes the illegal market under Prohibition.

The inverse demand curve for legal drugs is given by $R'_i = R_i + D_i = {''} + (1+\$)R_i$, which implies

$$R'_i = {''}+(1+\$)a - (1+\$)bQ. \tag{3}$$

After legalization, a unit of drugs will be purchased in the legal, rather than illegal, market if the difference in price, c_L-c, is less than the consumer's evaluation of the quality difference between them, D_i. If $D_i > c_L$-c for the individual in the market with the lowest D_i, then all purchasers will opt to buy in the legal market. As $\$$ is positive, the lowest D_i belongs to that individual who is currently just indifferent between buying and not buying, for whom R_i is equal to *c* and for whom D_i therefore equals $'' + \$c$. The critical price below which all post-legalization trade occurs in the legal market is hence

$$c_L\text{-}c < D_i \;]\; c_L < {''} + (1+\$)c \tag{4}$$

If (4) holds, the total quantity of drugs traded is equal to the quantity traded in the legal market, which is calculated by substituting c_L into the legal market demand curve, (3), yielding

$$Q_L^{PCL} = \frac{\alpha + (1+\beta)a - c_L}{b(1+\beta)} \tag{5}$$

where the PCL superscript denotes the case where the illegal drug market is "priced out" post-legalization. This case will subsequently be referred to as 'low-price legalization'. The L subscript refers to the legal market.

If (4) does not hold then the illegal market will co-exist with the legal market after legalization[9]. This case, 'high-price legalization', is depicted in Figure 1 below. Buyers with a high enough valuation of drug quality, *i.e.* those with $R_i < c_L$ and $D_i > c_L$-c (all those up to Q_L^{PCH}) will switch from the illegal to the new legal market. The marginal legal buyer has a premium represented by the distance AB, which is equal to the price difference c_L-c. The remainder, those between Q_L^{PCH} and $Q_L^{PCH}+Q_{IL}^{PCH}$, have $R_i > c$ but $D_i < c_L$-c, and hence

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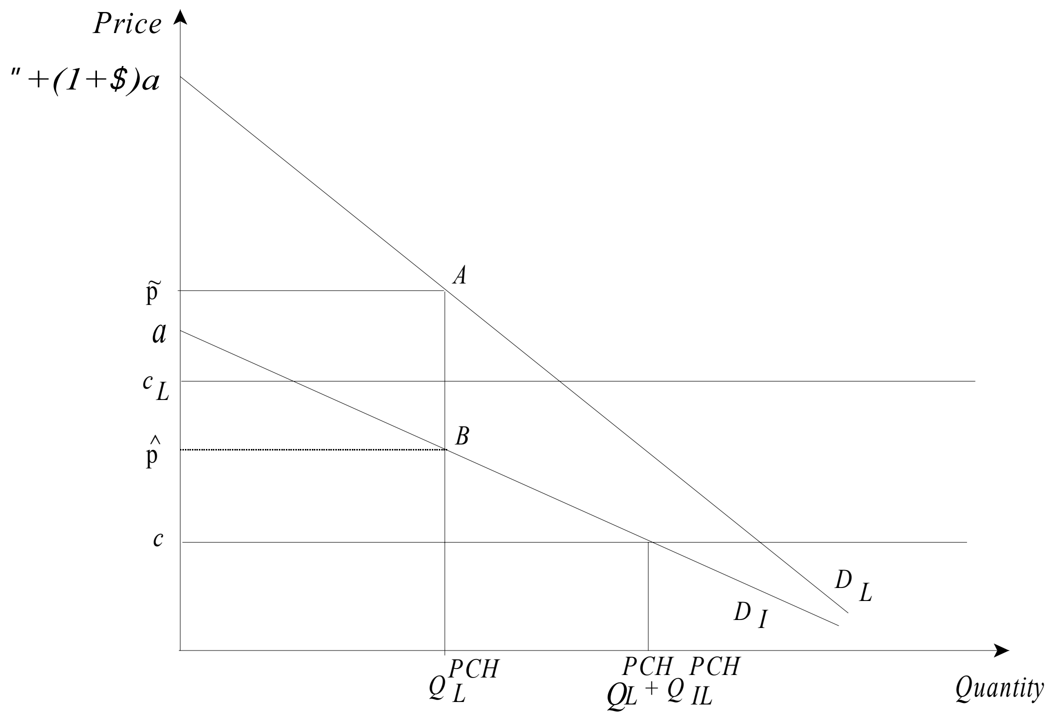
[9]. If the legal price is high enough, then no legal purchases will be made. From (6), legalization at a price greater than $'' + c + a\$$ is equivalent to Prohibition.

prefer to carry on using the illegal market. As D_i falls with Q, all of those who did not purchase under Prohibition will not purchase after legalization either, as they value illegal drugs at less than their price ($R_i < c$) and the higher quality offered by legal drugs is valued at less than the difference in price between the legal and illegal markets ($D_i < c_L$-c).

Figure 1. High-Price Legalization Under Perfect Competition.



The total quantity of drugs traded under high-price legalization, Q_{TL}^{PCH}, is determined by the intersection of *c* and D_I, the illegal demand curve, and is thus equal to that under Prohibition. The quantity of drugs purchased legally under high-price legalization can be derived by substituting $\hat{p}$ into the demand curve for illegal drugs, (1), or equivalently by substituting $\tilde{p} = "+(1+\$)\hat{p}$ into the legal demand curve, (3). As the marginal purchaser in the legal market is indifferent between purchasing legally and illegally, it must be true that $"+\$\hat{p}$ (the distance between A and B) is equal to c_L-c. Hence $\hat{p} = (c_L\text{-}c\text{-}")/\$$, and

$$Q^{L}_{PCH} = \frac{a\beta + c + \alpha - c_L}{\beta b} \tag{6}$$

As high-price legalization entails no rise in the quantity purchased,

$$Q_{IL}^{PCH} = \frac{(a-c)}{b} - \frac{a\beta + c + \alpha - c_L}{\beta b} = \frac{c_L - (\alpha + (1+\beta)c)}{\beta b} \tag{7}$$

The analysis so far has used the simplifying assumption, due to Perfect Competition, that there is no change in the price of illegal drugs after legalization, and that there is no ex-ante profit in the illegal market; both of these may be considered unrealistic. It is undeniable that some drug sellers make money (although Reuter *et al.*, 1990, find that many suppliers make relatively little), but also that large risks are run. It is difficult to know if sellers earn more than is necessary to keep them in the market, but a number of commentators have suggested that the violence that occurs in the illegal market is a sign that economic profit is being made[10], although others have found little evidence of co-ordination in illegal markets. The following sub-section considers the case of monopoly supply in the illegal drug market. In this case there is profit and the illegal price, which is a function of illegal quantity, falls after legalization.

ii) Monopoly

Consider the same demand curves as used above. The monopoly illegal drugs supplier sets price to maximise profit, (p-c)(a-p)/b, which results in a Prohibition price of p_{IP}^{M} = (a+c)/2 with corresponding quantity of Q_{IP}^{M} = (a-c)/2b: price is higher and quantity is lower than under Perfect Competition.

Market equilibrium after legalization is of the same nature as that described above for Perfect Competition. Consider first the case where the illegal and legal markets co-exist after legalization. As above, the marginal unit sold in the legal market will be that for which the price differential between legal and illegal drugs equals the difference in the buyer's willingness to pay. Let the price in the illegal market be p_{IL}^{MH} then, for the marginal unit Q_L^{MH}, c_L - p_{IL}^{MH} = $D_i(Q_L^{MH})$ = $\text{"+\$}\hat{p}$, where $\hat{p}$ is the R_i corresponding to Q_L^{MH}, as read off of the illegal demand curve. All those up to Q_L^{MH} have c_L - p_{IL}^{MH} > D_i. The remainder of the post-legalization purchasers remain in the illegal (monopolised) market. The monopolist

[10]. For example, Richardson (1992). The fact that supply is illegal may encourage monopolisation. Eckard (1991) notes that the ban on the TV advertising of cigarettes reduced competition between suppliers.

faces a residual demand curve starting from the price $\hat{p}$, p=$\hat{p}$ - bQ. The solution is analogous to that derived above for Prohibition, except that *a* is replaced by $\hat{p}$, giving p_{IL}^{MH} = (+c)/2 and Q_{IL}^{MH} = (-c)/2b. In equilibrium, the illegal market price will ensure that just enough is purchased illegally for the profit-maximising monopoly price to be p_{IL}^{MH}, so that

$$c_L - \frac{\hat{p}+c}{2} = \alpha + \beta\hat{p} \Leftrightarrow \hat{p} = \frac{2(c_L - \alpha) - c}{1+2\beta}.$$

Hence,

$$p_{IL}^{MH} = \frac{c_L - \alpha + \beta c}{1+2\beta} \tag{8}$$

and

$$Q_{IL}^{MH} = \frac{c_L - \alpha - (1+\beta)c}{(1+2\beta)b}. \tag{9}$$

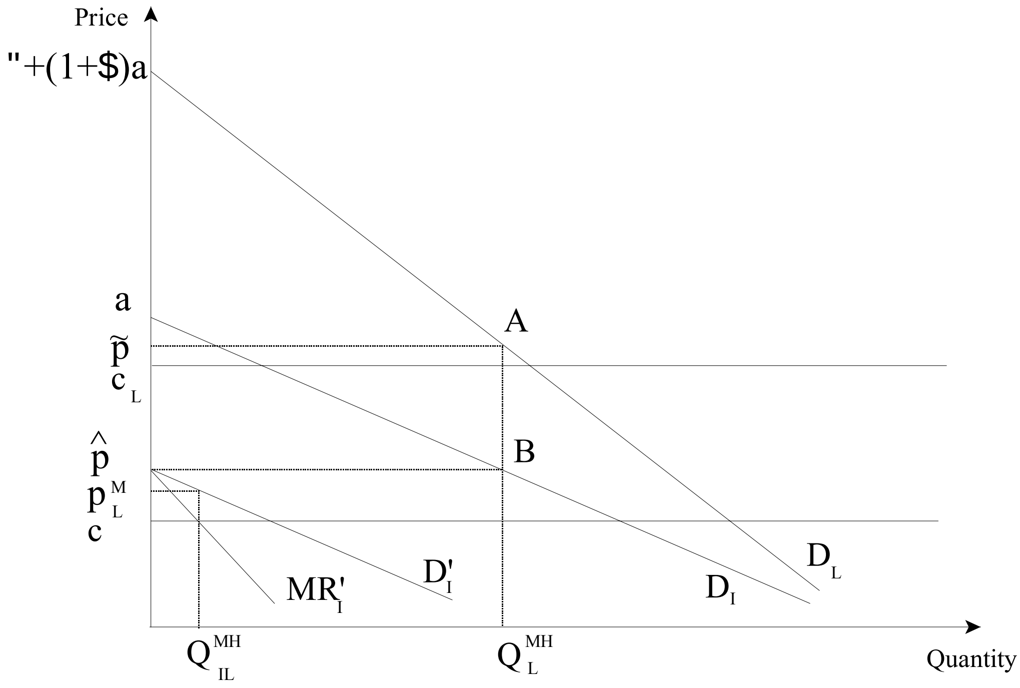
The legal market quantity is calculated by substituting $\hat{p}$ into the equation of the illegal demand curve:

$$\frac{2(c_L - \alpha - c)}{1+2\beta} = a - bQ_L^{MH} \Leftrightarrow Q_L^{MH} = \frac{a(1+2\beta) - 2(c_L - \alpha + c)}{(1+2\beta)b}. \tag{10}$$

From (10), the legal quantity is zero if c_L > "+ $ a+(a+c)/2: legalization at high enough price is equivalent to prohibition.

The equilibrium is represented in Figure 2. At the legal quantity of Q_L^{MH}, the marginal consumer would be prepared to pay $\hat{p}$ in the illegal market and $\tilde{p}$ in the legal market: the "premium" is for this marginal consumer is thus $\tilde{p} - \hat{p}$ = "+ $ $\hat{p}$. This is exactly equal to the difference in price between the two markets, c_L-$p^M{}_L$. All those to the left of Q_L^{MH} have premia greater than the price difference (and so prefer to buy legally). The equilibrium illegal price after legalization, $p^M{}_L$, comes from the maximisation of monopoly profit from the residual demand curve defined by Q_L^{MH}.

Figure 2. High-Price Legalization Under Monopoly



If the legal price is low enough ("low-price legalization"), the illegal market will be priced out after legalization. From (10), this occurs when Q_{IL}^{M}=0, *i.e.* c_L = "+ (1+$)c, the same price condition as that which pertains under Perfect Competition[11]. The analysis of low-price legalization under monopoly is identical to that above for the case of Perfect Competition.

iii) Comparative Statics

The above analysis allows two general results to be stated.

***Proposition 1**. Legalization never lowers the quantity of drugs traded.*

If the illegal market is monopolised, the equilibrium quantity rises, whatever the legal price. Under Perfect Competition, quantity rises if the legal price is low enough to drive out the illegal market, and is unchanged if the legal and illegal markets co-exist after legalization.

[11]. This may seem surprising, as the appropriate price difference is c_L-c under Perfect Competition and c_L-p_I^M under monopoly. But as the illegal market shrinks, p_I^M becomes closer and closer to c and, in the limit, when the illegal market is on the point of disappearing, equals it.

Proposition 2. *Regardless of the structure of the illegal market, the quantity purchased in the legal market is an increasing function of the intercept of the demand curve, the illegal price, and the size of the premium, D; it is a decreasing function of the legal price.*

The comparative statics results are summarised in Table 1. Intuitively, an increase in the premium increases drug use, and switches demand from the illegal to the legal market when both co-exist. One exception occurs under high-price legalization when the illegal market is competitive; here " and $ affect the split between the legal and illegal markets but have no effect on the total quantity purchased[12]; the same is true of the legal price.

Table 1. Comparative Statics Results

	Low-price Legalization	High-price Legalization: Perfect Competition			High-price Legalization: Monopoly		
	Q_{TL}^{L}	Q_{L}^{PCH}	Q_{IL}^{PCH}	Q_{TL}^{PC}	Q_{L}^{MH}	Q_{IL}^{MH}	Q_{TL}^{MH}
Demand intercept: *a*	+	+	0	+	+	0	+
Demand slope: *b*	-	-	-	-	-	-	-
Illegal marginal cost:	0	+	-	-	+	-	-
Premium intercept: "	+	+	-	0	+	-	+
Premium slope: $	+	+	-	0	+	-	+
Legal price: c_L	-	-	+	0	-	+	-

The results of this section will now be used to consider two policy questions: Should drugs be legalized? and at what price?

3. Social Welfare and Drug Policy.

Any policy discussion requires a measure of society's welfare under alternative drug policies: that used here, *W*, is defined as the sum of consumer surplus, tax revenue, and the externalities associated with the drug market. Consumer surplus in the legal and illegal drug

12. The specification of the premium used implies that, under high-price legalization, no-one who is not willing to purchase at the current illegal price will find it attractive to purchase at the (higher) legal price. The assumption of Perfect Competition ensures that the illegal price does not change after legalization. If the illegal market is monopolised, the first statement still holds true, but the dependence of the illegal price on the demand curve faced by the monopolist ensures a fall in price after legalization and a rise in the total quantity of drugs purchased.

markets is denoted by CS_I and CS_L respectively. The change in consumer surplus in other product markets is not considered here. Producer surplus under Perfect Competition is zero, and the producer surplus of a monopoly supplier of illegal drugs is assumed to have zero weight in the social welfare function.

The problem of drug policy is almost defined by the associated externalities. These may usefully be divided up into three broad groups. The first reflects the fact that drug use of any kind, whether in the illegal or legal market, results in some uncompensated harm to others. These harms, for example the higher risk of accident of drivers who have used drugs, the societal cost of any resulting ill-health[13] and the lower quality of life of those in close proximity to drug users (see Culyer, 1973, Manning *et al*., 1989, and Nadelmann, 1989), are assumed to be proportional to the total quantity of drugs, and are reflected in the social welfare function by a term $-N_1Q_T$.

The second set of externalities arises solely from drugs purchased in the illegal market, and are assumed to be proportional to the size of the illegal market. These externalities include the violence associated with illegal supply[14], the criminalization of

[13] Whilst crime and the risks to health and life from others are obvious externalities, the question of whether the effects of drugs on the user's own health lowers social welfare is a vexed one. The individual's own evaluation of the lower health risks associated with legal drugs is already included in the consumer surplus in the legal market, being part of the premium, D_i. One externality associated with users' ill-health are the medical costs of their illness. However, the shorter life-expectancy of users, with its implications for pension costs, tempers this effect and may even turn it positive (see Manning *et al*., 1989, and Viscusi, 1994). In addition, health may actually improve after legalization, despite any rise in use, as legal drugs will be safer than illegal drugs: they will not be cut with potentially toxic substances and, as their potency will be almost certainly carefully controlled and clearly labelled, there will be less likelihood of overdose. Figures from alcohol use in the Prohibition era provide conflicting evidence. In 1930 the rate of death from alcoholism was 5.5 per 100 000 of the adult population; by 1940, after repeal, this figure had dropped to 2.9 per 100 000 of the adult population (see Efron, Keller and Gurioli, 1974, Table 18). However, Burnham (1968) notes that hospital admissions for alcoholism, and the incidence of other alcohol-related diseases, fell after the introduction of Prohibition. Miron (1998*b*), who uses data on cirrhosis to proxy alcohol use, concludes that Prohibition was associated with only a small reduction in alcohol consumption.

[14] Upon which see De la Rosa *et al*. (1990). An interesting recent article by Miron (1998*a*) analyses the relationship between homicide and prohibition enforcement expenditure in annual US data from 1900 to 1995. He finds that, in addition to a trend and demographic variables, prohibition enforcement, by driving transactions into markets where violence is

purchasers via their exposure to criminal activity, and the costs of enforcement and imprisonment, corruption and the overloading of the criminal justice system. These externalities are measured by the term $-N_2Q_I$ in *W*.

The last externality concerns the link between spending on drugs and income-generating crime[15]. The extent of such crime will be likely roughly proportional to drug spending, and is measured by the term $-N_3(p_LQ_L + p_IQ_I)$ in the social welfare function, where p_I and p_L are prices in the illegal and legal markets respectively[16].

The social welfare function is thus

$$W = CS_I + CS_L + RJQ_L - N_1(Q_I + Q_L) - N_2Q_I - N_3(c_LQ_L + p_IQ_I). \quad (11)$$

One unit of drugs purchased legally thus costs society $N_1+N_3c_L$ dollars in externalities, whereas the same unit of drugs purchased illegally costs society N_1 dollars (because any unit of drug use, whether legal or illegal, causes this amount of harm) plus N_2 dollars (because of the additional harms associated with illegal drugs) plus N_3p_I (the income-generating crime resulting from purchases in the legal market).

Consumer surplus under the different regimes is easy to calculate, as all demand curves are linear. In the illegal market under Perfect Competition and Prohibition, consumer

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more likely to be used to resolve conflicts, explains between 25 and 50 per cent of US homicides.

[15]. Hunt (1991) and Walters (1994) document the existence of income-generating crime. Brown and Silverman (1980) find a statistically significant relationship between the price of heroin and the incidence of profit-motivated crimes, with elasticities of 0.36 for robberies, 0.25 for auto theft and 0.18 for burglaries. Leveson (1980) reports a positive relationship between crime and the number of drug users, and Speckart and Anglin (1985) find a positive linear relationship between property crime and the level of narcotics use. Ostrowski (1989) notes that crime in the US fell heavily after the repeal of Prohibition, and the level of crime in the Netherlands, where marijuana is decriminalised, has been compared favourably to that in the US. A recent theoretical paper relating drug policy to crime levels is Doyle and Smith (1997).

[16]. Other costs and benefits of legalization are discussed in Benson *et al*. (1992), Hamowy (1987), Kaestner (1996), van Kalmthout (1989), Kim, Benson and Rasmussen (1992), Mitchell (1990), Nadelmann (1988), Miron and Zwiebel (1991), Sollars (1992) and Sollars, Benson and Rasmussen (1994).

surplus is CS_{IP}^{PC}=½(a-c)Q_{IP}^{PC} = $(a\text{-}c)^2/2b$. Low-price legalization implies that there is subsequently consumer surplus only in the legal market, of

$$CS_L^{PCL} = \frac{1}{2}[\alpha + (1+\beta)a - c_L)Q_L^{PC} = \frac{(\alpha + (1+\beta)a - c_L)^2}{2b(1+\beta)}.$$

High-price legalization yields consumer surplus in both the legal and illegal markets. From Figure 1, post-legalization consumer surplus in the legal market is CS_L^{PCH} = ½(" + (1+\$)a - $\tilde{p}$)Q_L^{PCH} + ($\tilde{p}$ - c_L)Q_L^{PCH} which, after some rearrangement, becomes Q_L^{PCH}[2(" + (1+\$)a - c_L) - b(1+\$)Q_L^{PCH}]/2. That in the illegal market is given by CS_{IL}^{PCH} = ½Q_{IL}^{PCH}($\hat{p}$ - c) = Q_{IL}^{PCH}(c_L - " - (1+\$)c)/2\$.

If the illegal market is monopolised, consumer surplus under Prohibition equals CS_{IP}^{M} =½(a-p_{IP}^{M})Q_{IP}^{M} = $(a\text{-}c)^2/8b$. With low-price legalization, consumer surplus is identical to that calculated in the case of Perfect Competition above. High-price legalization involves legal market consumer surplus of CS_L^{MH} = ½(" + (1+\$)a - $\tilde{p}$)Q_L^{MH} + ($\tilde{p}$ - c_L)Q_L^{MH}, which after some manipulation, gives CS_L^{MH} = Q_L^{MH}[(1+\$)(1+2\$)a + 2\$" - (1+\$)c - 2\$$c_L$)]/(2(1+2\$)). Consumer surplus in the illegal market is CS_{IL}^{MH} = Q_{IL}^{MH}(c_L - " - (1+\$)c)/(2(1+2\$)).

Substituting from the relevant quantity equations in section 2, the expressions for social welfare in terms of the parameters of the model are therefore:

$$W_{\text{Prohibition}}^{PC} = \frac{(a-c)^2}{2b} - (\phi_1 + \phi_2 + \phi_3 c)\frac{(a-c)}{b} \tag{12}$$

$$\begin{aligned} W_{\text{Low-price-legalization}}^{PC} &= \frac{(\alpha + (1+\beta)a - c_L)^2}{2b(1+\beta)} + \psi(c_L - c')\frac{(\alpha + (1+\beta)a - c_L)}{b(1+\beta)} \\ &- (\phi_1 + \phi_3 c_L)\frac{(\alpha + (1+\beta)a - c_L)}{b(1+\beta)} \end{aligned} \tag{13}$$

$$\begin{aligned} W_{\text{High-price-legalization}}^{PC} &= \frac{(a\beta + c + \alpha - c_L)}{2\beta b}[2(\alpha + (1+\beta)a - c_L) - b(1+\beta)\frac{(a\beta + c + \alpha - c_L)}{\beta b}] + \frac{(c_L - \alpha - (1+\beta)c)^2}{2\beta^2 b} \\ &+ \psi(c_L - c')\frac{(a\beta + c + \alpha - c_L)}{\beta b} - (\phi_1 + \phi_3 c_L)\frac{(a\beta + c + \alpha - c_L)}{\beta b} - (\phi_1 + \phi_2 + \phi_3 c)\frac{(c_L - \alpha + (1+\beta)c)}{\beta b} \end{aligned} \tag{14}$$

$$W^{M}_{\Pr ohibition} = \frac{(a-c)}{4b}\left[\frac{(a-c)}{2} - 2(\phi_1+\phi_2) - \phi_3(a-c)\right] \tag{15}$$

$$W^{M}_{Low-price-legalization} = W^{PC}_{Low-price-legalization} \tag{16}$$

$$\begin{aligned} W^{M}_{High-price-legalization} &= \frac{(a(1+2\beta)-2(c_L-\alpha)+c)}{2b(1+2\beta)^2}[(1+\beta)(1+2\beta)a+2\beta\alpha-(1+\beta)c-2\beta c_L]+\frac{(c_L-\alpha-(1+\beta)c)^2}{2b(1+2\beta)^2} \\ &+[\psi(c_L-c')-\phi_1-\phi_3 c_L]\frac{(a(1+2\beta)-2(c_L-\alpha)+c)}{(1+2\beta)b}-(\phi_1+\phi_2+\phi_3\frac{(c_L-\alpha+\beta c)}{1+2\beta})\frac{(c_L-\alpha-(1+\beta)c)}{(1+2\beta)b} \end{aligned} \tag{17}$$

Table 2 summarises the effect of legalization, in this model, on each of the five dimensions of welfare, for both competitive and monopolised illegal markets. A plus (minus) sign indicates that legalization has a positive (negative) welfare effect in that dimension of social welfare, and an inequality sign demonstrates the relative size of the welfare effects under high-price and low-price legalization. The effects of low-price legalization are identical under Perfect Competition and monopoly, as the illegal market is eliminated in this case.

Table 2. The Welfare Consequences of Legalization compared to Prohibition.

	Perfect Competition			Monopoly		
	Low-price Legalization		**High-price Legalization**	**Low-price Legalization**		**High-price Legalization**
Consumer Surplus	+	>	+	+		+/-
Tax Revenue	+/-		+	+/-		+
Size of drug market externality [N_1Q_T]	-	<	0	-		-
Illegal drug market externality [N_2Q_I]	+	>	+	+	>	+
Drug spending externality [$N_3(c_LQ_L + p_IQ_I)$]	+/-		-	+/-		+/-

Legalization raises welfare through its effect on consumer surplus if the illegal market is driven out or if the illegal market is competitive. However, legalization's effect on consumer surplus is ambiguous if the illegal market is monopolised. The consumers who switch from the illegal to the legal market do so because their surplus is higher in the latter, but those who prefer to remain in the illegal market (those with a lower value of the premium) suffer reduced consumer surplus, due to the negative correlation between price and quantity under monopoly.

Tax revenue is positive under high-price legalization[17]. However, under low-price legalization, the legal price may be lower than production costs, requiring a subsidy. In the extreme, legal drugs could be given away; this may be optimal with a very high value of N_3.

Legalization unambiguously raises welfare by reducing the size of the illegal market, and reduces welfare by increasing the total quantity of drugs traded (except in the case of high-price legalization under Perfect Competition, in which case there is no change in total quantity). Low-price legalization brings about larger absolute changes than high-price legalization for both of the above effects.

Last, legalization has a mostly ambiguous effect on drug spending. Only in the case of high-price legalization under Perfect Competition (where total quantity is unchanged but part of the market switches to a higher-priced, higher-quality alternative) is there a definite impact on welfare (which in this case is negative as total spending rises).

By inspection, it is obvious that no one policy is preferred on all counts: both columns have negative as well as positive elements, and neither type of legalization is unambiguously preferred to the other. A sufficiently high value of N_2 would ensure that legalization raises welfare, while a sufficiently high value of N_1 (or N_3 in the case of high-price legalization under Perfect Competition) would reverse this policy conclusion. The welfare effect of legalization depends on the structure of preferences in a natural way:

Proposition 3. *Legalization is more likely to raise welfare the more important are illegal drugs (N_2) in the social welfare function, the less important is the total size of the drugs market (N_1) and the lower is the legal cost of production (c'). Under high-price legalization, a higher value of R makes legalization more attractive. The weight on drug spending (N_3), the illegal cost of production (c) and the parameters of the demand curves (a, b, " and $) have no clear effect on the desirability of legalization.*

This proposition follows directly from the expressions for welfare given in equations (12) to (17) above. In this model, neither the position of the illegal demand curve nor the

[17] Under high-price legalization, the legal price is greater than the prohibition illegal price, and this latter is (weakly) greater than prohibition unit production costs (*c*), which are in turn (weakly) greater than legal unit production costs (c').

extent by which the demand curve for legal drugs outstrips that for illegal drugs can be unambiguously presented as arguments for or against legalization.

Comparison of Prohibition welfare under Perfect Competition and monopoly shows that there is no preferred market structure for current illegal supply. Consumer surplus is higher under competition, but the size of the illegal market (and thus the total quantity) is lower under monopoly. Also, drug spending may be higher or lower than that under competition, depending on the cost of illegal drug production and the position (but not the slope) of the illegal demand curve.

Post-legalization it is not possible to compare welfare under competition and monopoly (in the case when the illegal market persists) as it is unlikely that the government's choice of price for legal drugs will be independent of the structure of the illegal market. This is the subject of the next section.

4. Optimal legal drug prices.

The price of legal drugs can be set by the government: either directly if the government itself sells the drugs, or via taxation if drugs are supplied privately. The expressions for welfare derived in section 3 allow formulae for the welfare-maximising legal price to be developed; the detailed derivation is contained in the Appendix. Welfare may be either concave or convex in c_L, so that the welfare-maximising legal price may be interior or at a corner. Under Perfect Competition and for low-price legalization under monopoly, the concavity of W comes from tax revenue, while convexity comes from consumer surplus and (minus) drug spending. For high-price legalization under monopoly, tax revenue is concave but consumer surplus may be concave or convex in the legal price.

In general, the optimal legal price is higher the larger is N_1 and the smaller is N_2 (in the sense of the price being higher for an interior solution and more likely at the high-price boundary when W is concave in c_L). Under low-price legalization, price is independent of N_2 (as the illegal market has been priced out), although higher N_2 makes low-price legalization a more attractive policy (see above). Analogously, N_1 does not affect the optimal price under high-price legalization and a competitive illegal market, as in this case legalization leads to no change in total quantity.

The above is intuitively attractive, as the higher is the legal price, the more the market looks like that under Prohibition, where the overall size of the drugs market is minimised, while that of the illegal market is maximised. Both spending on drugs and tax revenue are non-linear in the legal price, and there is no general monotonic relationship between their importance to society and the optimal legal price.

Proposition 4*. If the illegal market is competitive, it is not welfare-maximising for the legal and illegal markets to co-exist.*

This is obviously true under low-price legalization, where the legal price is set low enough to eliminate the illegal market; also under high-price legalization when welfare is convex, so that the optimal price is either at the low-price boundary (where the illegal market is just priced out) or at the high-price boundary (where no legal drugs will be purchased). Hence, imagine that there is an optimal interior price under high-price legalization when welfare is concave and consider the welfare effects of a small fall in the legal price. There is no change in the size of the drug market, and hence no change in the total quantity externality, but the size of the illegal market falls with the legal price, which raises welfare. Total consumer surplus rises, as consumers will only switch from the illegal to the legal market if their consumer surplus increases by doing so. All of the original legal buyers will also see their consumer surplus rise as the legal price falls, while there is no change in consumer surplus for those who remain in the illegal market. The rise in *W* due to consumer surplus is at least as large as $-)c_LQ_L$. The change in welfare from spending is $-N_3()c_LQ_L + c_L)Q_L + c)Q_I)$ and the change in welfare from tax revenue is $R()c_LQ_L + (c_L - c'))Q_L)$. The sum of these three terms, remembering that $)Q_L = -)Q_I$ as there is no change in total quantity, is $)c_LQ_L(-1-N_3+R)+)Q_L(-N_3(c_L-c)+R(c_L-c'))$. The first term is obviously positive because R is no greater than 1, and the second term is positive as c' is less than *c* and the concavity of *W* requires that N_3 be less than R. Total welfare thus rises and no interior price can be optimal. A mathematical proof is contained in the Appendix.

Proposition 5. *If the illegal market is competitive and if welfare is concave in the legal price, legalization raises welfare, and the illegal market should be priced out.*

This follows from Proposition 4: if a small fall in the legal price always raises welfare, then, starting from the high-price boundary (which is equivalent to Prohibition), welfare can be continually raised by reducing price, up to the point at which the illegal market is eliminated.

There is no simple relationship between the structure of the illegal market and the level of the optimal price. As Table 2 makes clear, there is no obvious hierarchy between high- and low-price legalization, with the choice of optimal price and policy for each market structure depending on the values that society places on the externalities associated with drugs. It could easily be the case that the same set of parameters implies high-price legalization under one market structure and low-price legalization under the other. Further, the same set of parameters may yield a convex social welfare function under one market structure and concave welfare under the other, with the corresponding differences in the optimal pricing of legal drugs.

5. Simulations.

The analysis of the previous sections shows that policy depends on the combination of a large number of different variables. To illustrate the results obtained above, this section carries out some simulations of legalization of first marijuana and then cocaine in the United States. Few markets can be as poorly documented as that of illegal drugs, but some information on prices and quantities is available in the Office of National Drug Control Policy's 1995 report.

According to Table 6 of this publication, marijuana cost $341.7 per ounce in 1993 (in 1994 dollars, for purchases of 1/3 of an ounce), with 26.14 million ounces being purchased (9 million users smoking an average of 18 joints per month; one ounce of marijuana making 73.5 joints). The current price and quantity, together with an estimate of the current elasticity of demand, allow the intercept and slope of a linear demand curve, as used above, to be calculated. The elasticity of demand for cigarettes is usually estimated to be around -0.7 (Becker, Grossman and Murphy, 1991and 1994, Chaloupka, 1991, Jones, 1989). An early estimate of the elasticity of demand for marijuana (Nisbet and Vakil, 1972) finds it to be somewhat higher than that for cigarettes, in the range of -1 to -1.5, perhaps because there are more substitutes for marijuana than for cigarettes. Recent estimates of the elasticity of demand for illicit drugs have produced some quite high numbers. Grossman, Chaloupka and Brown (1996) use a rational addiction approach to estimate the long-run price elasticity of demand for cocaine as -1.2. Saffer and Chaloupka (1996) find long-run demand elasticities of -1.7 and -0.9 for heroin and cocaine respectively, while van Ours (1995) uses historical data from the Dutch East Indies to estimate a price elasticity of demand for Opium of -1[18].

For the simulations an elasticity of demand of -1.1 is initially posited, for both marijuana and cocaine[19]. This implies an illegal demand curve with an intercept of 652.3 and a value of *b* of 11.88 (both in millions). Under competition, *c* equals the current illegal price ($341.7 per ounce), whereas if current price and quantity come from monopoly supply, *c* can be calculated as $31.1 per ounce.

Assigning numbers to the parameters of the Social Welfare function, N_1 to N_3, is a much more difficult task. For the purpose of this calculation it has first been assumed that the market for marijuana produces no income-generating crime, which may not be unreasonable, so that $N_3=0$. The N_1 harm from marijuana use is considered to be a combination of those

[18]. An alternative approach is to consider evidence on price and quantity movements associated with changes in legislation. Miron (1997) makes the point that Prohibition did not have a large effect on alcohol consumption, and that any fall was due to demographic developments. Mitchell (1990) adds that alcohol consumption fell in other countries where there was no Prohibition. The decriminalisation of marijuana in the Netherlands in 1976 seems to have been associated with a fall in use (van Kalmthout, 1989). One explanation of this phenomenon is provided by Lee (1993), who presents a model in which suppliers' price depends on their costs, which rise with the number of transactions (due to increased exposure). It is argued that the War on Drugs has made users more reluctant to visit dealers, which reduces the latter's costs and thus their price, bringing about an increase in use. Another is that the War on Drugs, by targetting large suppliers, has increased competition in the illegal market, resulting in lower prices. See also Reuter and Kleiman (1986).

[19] As monopolists, in the absence of rational addiction, always price in the elastic section of the demand curve, no monopoly outcome can be calculated with an elasticity of demand of less than one.

from smoking (for the health impact) and from alcohol (for intoxication)[20]. Manning *et al.* (1989) calculate that one packet of cigarettes costs society about 15 cents in uncompensated harm at a five percent discount rate. This harm has been doubled in the case of marijuana, to reflect potential increased harm from the smoking of unfiltered tobacco. Gieringer (1994) suggests that one marijuana joint is equivalent to 1 to 2 ounces of alcohol in terms of intoxication (2 to 4 12 oz. beers or 1/3 to 2/3 of a bottle of wine) and Manning *et al.* (1989) consider that each excess ounce of alcohol costs society $1.19. With each joint considered to cause the same harm as two cigarettes and two ounces of alcohol, one ounce of marijuana costs society $168 in N_1 harm (the harm that results from its use no matter which market it was purchased in). More difficult to quantify are the harms that result from the illegal marijuana market. For the moment, N_2 harm is set equal to N_1, so that the total harm per ounce from the illegal consumption of marijuana is $336. Nadelmann (1989) concludes that the export price of marijuana is 4% of its street price. Taking a conservative estimate of 10% implies production costs, c', of $35 per ounce. The last parameters are those associated with the premium, " and $. A "standard" case is considered: that of increasing willingness to pay by a factor of two for the legal market. This implies "=0 and $=1.

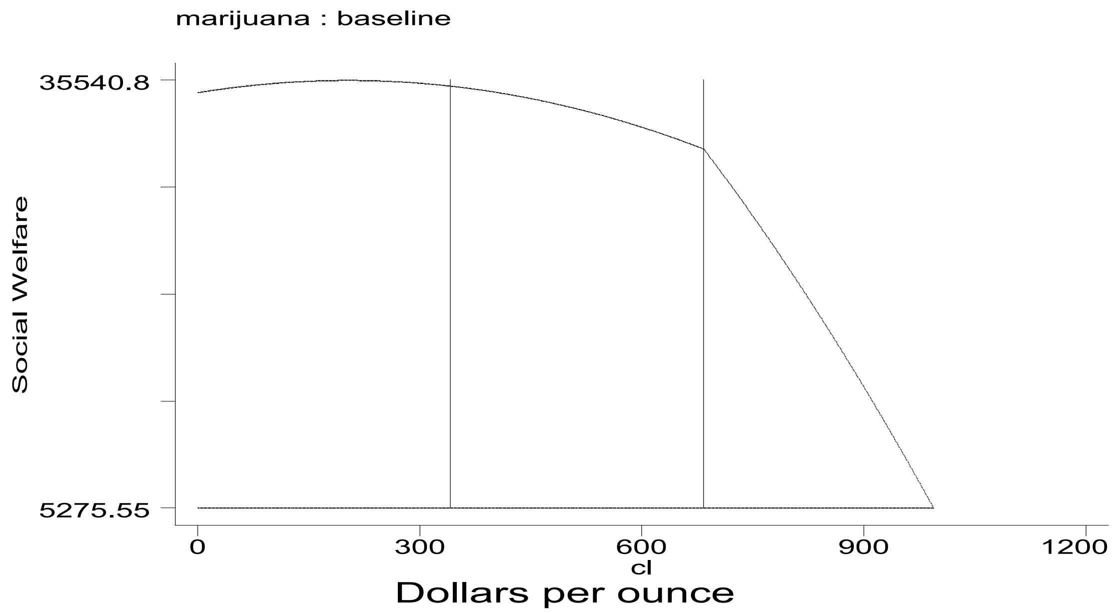
The 1994 illegal price of cocaine was $135 per gram, with estimated sales of 254 million grams per year. As Caulkins and Reuter (1998) point out, drugs are inordinately expensive. To put the price of cocaine in context, gold currently costs around $11 per gram. The above numbers imply a demand curve, if the current illegal market is competitive, with an intercept of 257.7 (million grams), and a value of *b* of 0.483×10^6. Illegal unit production costs, *c*, equal the illegal price ($135) under competition and equal $12.27 under monopoly. Legal production costs, c', are again assumed to be 10% of the current illegal price, and willingness to pay is assumed to double after legalization, as for marijuana.

Figure 3 illustrates the social welfare effects of legalizing marijuana and cocaine, when the illegal market is perfectly competitive, as a function of the legal price. The

[20] A recent report by a pharmacologist, Roque (1998), on the relative dangers of a number of addictive substances finds that marijuana is less dangerous than both alcohol and tobacco. The value of N_1 used here may therefore be too high.

horizontal line represents social welfare under prohibition, which is naturally independent of the legal price. The dashed vertical line shows the current illegal price, and the second vertical line represents the price below which the illegal market is completely priced out post-legalization, *i.e.* which divides the graph up into high-price and low-price legalization regions. Beyond a certain legal price no-one will buy legal drugs; at this price welfare under prohibition and legalization are equal to each other. The graphs show that legalization is preferred to prohibition, for these parameters, for both marijuana and cocaine. An interior price yields the highest welfare for marijuana, whereas a zero legal price is best for cocaine, as this ensures no income-generating crime.

Figure 3. Social Welfare and Drug Policy:
two baseline predictions with a perfectly competitive illegal market



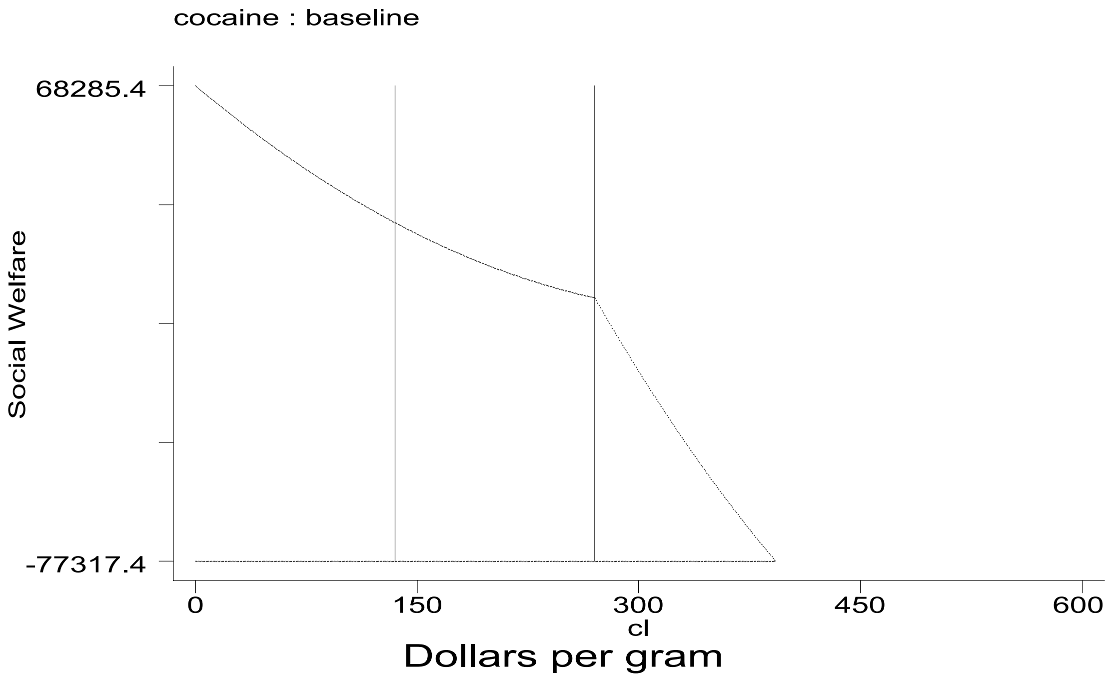


Table 3 formalises these results. The first row in each panel shows the current situation under Prohibition. Considering marijuana first, Table 3 shows that the best policy, no matter the structure of the current illegal market, is to legalize at a price low enough to eliminate the illegal market. The optimal legal price is around \$200 per ounce if the illegal market is competitive, and around $60 per ounce if the illegal market is a monopoly; these prices represent 40% and 82% reductions respectively from the current illegal level. The lower prices are associated with notable increases in the size of the market. With competitive illegal markets, drug spending rises by 5% but, as the new legal price is far higher than legal production costs, there is tax revenue of nearly $8bn per year. If the illegal market is monopolised, spending falls by almost two-thirds, due to the sharply lower price. This low price is still greater than production costs, yielding an estimated $1.4bn in tax revenue.

Table 3. "Baseline" Optimal Policy.

	Legal Quantity	Illegal Quantity	Total Quantity	Legal Price	Illegal Price	Spending ($ million)	Tax Revenue ($ million)
Marijuana	(m oz.)	(m oz.)	(m oz.)	($/oz.)	($/oz.)		
Prohibition	--	261	261	--	3417	8 932	--
Legalization: Perfectly Competitive Illegal Market	46.4	0	46.4	203	--	9 413	7 790
Legalization: Monopoly Illegal Market	52.3	0	52.3	62.1	3417	3248	1418
Cocaine	(m gr.)	(m gr.)	(m gr.)	($/gr.)	($/gr.)		
Prohibition	--	254	254	--	135	34 290	--
Legalization: Perfectly Competitive Illegal Market	534	0	533.6	0	--	0	-7 204
Legalization: Monopoly Illegal Market	534	0	533.6	0	--	0	-7 204

The policy in the cocaine market is somewhat different. Again, legalization raises welfare, but in this case the optimal policy is to supply legal cocaine at zero price, *i.e.* to give it away to users. This tactic eliminates both the illegal market and drug spending, although it does bring about a large increase in use. Tax revenue in this case is negative, as legal cocaine is subsidised.

There is no reason to believe that the values given to the key parameters in the above calculations are correct. Table 4 thus repeats Table 3's analysis under six alternative assumptions, A number of which are inherently favourable to Prohibition:

i) Illegal and legal drug markets are identical in terms of harm per unit (N_2=0);

ii) Drugs are associated with very high levels of per unit harm no matter which market they are purchased in (N_1 is multiplied by ten, taking on values of $1680 per oz for marijuana and $1350 per gram for cocaine);

iii) There are strong income-generating crime effects for both marijuana and cocaine, with each dollar spent on them resulting in ten dollars of crime-induced social harm (N_3=10);

iv) The demand for currently illegal drugs is very elastic. Here I replace Table 3's price elasticity of 1.1 with an elasticity of 2;

The last two cases refer to the value of the numeraire, consumer surplus. Examination of the components of the change in welfare following legalization in Table 3 reveals that around 80% of this rise is accounted for by an increase in consumer surplus. A recurrent question in the realm of drug policy (for example, Davies, 1992, and Warburton, 1990) is whether drug users "really" enjoy taking drugs, or whether they, by unfortunate mistake, become addicted and have to keep consuming to avoid the (temporary) catastrophic fall in well-being associated with re-adjustment to abstinence[21]. Pogue and Sgontz (1989), in their article on the optimal price of alcohol, note that "Determining the efficiency implications of alcohol taxes is complicated by the question of whether and how much abusers, especially alcoholics, benefit from alcohol consumption" (p.235). With respect to drugs, Nadelmann (1992) has commented that much of the polemic surrounding prohibition and legalization comes down to a "difference of opinion regarding the balance of power between psychoactive drugs and the human will" (p.92).

For the purpose of these simulations, I have taken the extreme paternal case that no drug consumer acts in their own best interest, so that all of the consumer surplus associated with drugs is ignored for the calculation of social welfare[22].

v) Paternalism (2=0);

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[21] An alternative argument for setting 2 < 1 is that the consumption expenditure switched into drugs after legalization has to come from somewhere, where there was presumably consumer surplus. In the limit, the gain in consumer surplus from legalization may approach zero.

[22] This discounting of consumer surplus has implications for the theoretical part of the paper. If 2 is no longer set equal to one, neither Proposition 4 nor Proposition 5 are true.

The last case combines *ii)*, *iii)* and *v)*: very harmful drugs, strong income-generating crime effects and no consumer surplus from drug use. This could be labelled the worst-case scenario for proponents of legalization.

vi) The worst-case scenario (N_1 multiplied by ten, N_3=10 and 2=0).

Table 4 is divided into two panels, referring to competitive and monopoly illegal markets respectively. Within each panel, the italicised rows reproduce the baseline optimal policies described in Table 3. The six lines following each of these show how policy, prices, quantities, spending and taxes change under the six different scenarios outlined above.

Table 4's results show that optimal policy is indeed dependent on these critical parameter values. If the illegal market is monopolised, prohibition is best for two out of the seven cases investigated for cocaine. The paternalistic case for both drugs with a monopoly illegal market produces high-price legalization as the best policy, with the illegal and legal markets co-existing after legalization. Strong income-generating crime implies zero legal prices for both marijuana and cocaine, with consequent budgetary costs. Only when we discount drug-related consumer surplus does it become optimal to charge for legal cocaine, and in general 2=0 produces higher legal drug prices. An elastic demand curve for drugs increases the optimal price for marijuana when the illegal market is monopolised. Last, optimal policy and legal price are very sensitive to the assumption that drug-related consumer surplus does not count in Social Welfare, reflecting the large part that consumer surplus represents in the calculation of the latter.

Table 4. Optimal Policy Under Alternative Assumptions.

			Post-legalization						
	Drug	**Optimal Policy**	**Legal Quantity**	**Illegal Quantity**	**Total Quantity**	**Legal Price**	**Illegal Price**	**Drug Spending**	**Tax Revenue**
Current Illegal Market = Perfect Competition									
Baseline	*Marijuana*	*Low-price legalization*	*46.4*	*0.0*	*46.4*	*203.0*	---	*9413*	*7790*
No extra harm in the illegal market (N_2=0)	Marijuana	Low-price legalization	46.4	0.0	46.4	203.0	---	9413	7790
Drugs very harmful (N_1 x 10)	Marijuana	Legalization: High/Low price boundary	26.1	0.0	26.1	683.4	---	17870	16954
Strong income-generating crime effect (N_3=10)	Marijuana	Low-price legalization	54.9	0.0	54.9	0.0	---	0	-1922
Elastic demand for drugs (elasticity=2)	Marijuana	Low-price legalization	62.9	0.0	62.9	203.0	---	12767	10566
No drug-related consumer surplus (2=0)	Marijuana	Legalization: High/Low price boundary	26.1	0.0	26.1	683.4	---	17870	16954
"Worst case" scenario (N_1 x 10, N_3=10 and 2=0)	Marijuana	Low-price legalization	54.9	0.0	54.9	0.0	---	0	-1922
Baseline	*Cocaine*	*Low-price legalization*	*533.6*	*0.0*	*533.6*	*0.0*	---	*0*	*-7204*
No extra harm in the illegal market (N_2=0)	Cocaine	Low-price legalization	533.6	0.0	533.6	0.0	---	0	-7204
Drugs very harmful (N_1 x 10)	Cocaine	Legalization: High/Low price boundary	254.1	0.0	254.1	270.0	---	68607	65177
Strong income-generating crime effect (N_3=10)	Cocaine	Low-price legalization	533.6	0.0	533.6	0.0	---	0	-7204
Elastic demand for drugs (elasticity=2)	Cocaine	Low-price legalization	761.3	0.0	761.3	0.0	---	0	-10277
No drug-related consumer surplus (2=0)	Cocaine	Legalization: High/Low price boundary	254.1	0.0	254.1	270.0	---	68607	65177
"Worst case" scenario (N_1 x 10, N_3=10 and 2=0)	Cocaine	Prohibition	0.0	26.1	26.1	---	135.0	34303	0
Current Illegal Market = Monopoly									
Baseline	*Marijuana*	*Legalization: High/Low price boundary*	*52.3*	*0.0*	*52.3*	*62.1*	---	*3248*	*1418*
No extra harm in the illegal market (N_2=0)	marijuana	High-price legalization	49.5	1.4	50.9	110.9	47.3	5558	3759
Drugs very harmful (N_1 x 10)	marijuana	High-price legalization	17.2	17.5	34.8	*686.9*	239.3	16030	11233
Strong income-generating crime effect (N_3=10)	marijuana	Low-price legalization	54.9	0.0	54.9	0.0	---	0	-1921
Elastic demand for drugs (elasticity=2)	marijuana	Low-price legalization	62.9	0.0	62.9	203.0	---	12767	10566
No drug-related consumer surplus (2=0)	marijuana	High-price legalization	26.9	12.7	39.6	514.5	181.9	16149	12899
"Worst case" scenario (N_1 x 10, N_3=10 and 2=0)	marijuana	Low-price legalization	54.9	0.0	54.9	0.0	---	0	-1921
Baseline	*cocaine*	*Low-price legalization*	*533.4*	*0.0*	*533.4*	*0.0*	---	*0*	*-7201*
No extra harm in the illegal market (N_2=0)	cocaine	Low-price legalization	533.4	0.0	533.4	0.0	---	0	-7201
Drugs very harmful (N_1 x 10)	cocaine	Prohibition	0.0	254.0	254.0	---	135.0	34290	0
Strong income-generating crime effect (N_3=10)	cocaine	Low-price legalization	533.4	0.0	533.4	0.0	---	0	-7201
Elastic demand for drugs (elasticity=2)	cocaine	Low-price legalization	761.3	0.0	761.3	0.0	---	0	-10277
No drug-related consumer surplus (2=0)	cocaine	High-price legalization	477.5	15.2	492.8	46.6	19.6	22569	15823
"Worst case" scenario (N_1 x 10, N_3=10 and 2=0)	cocaine	Prohibition	0.0	254.0	254.0	---	135.0	34290	0

The "worst-case" scenario implies prohibition as the best policy for cocaine, but legalization at zero price for marijuana. In fact, "worst-case" is something of a misnomer, as legalization allows very low drug prices to minimise drug spending, something which prohibition cannot achieve. In consequence, high values of N_3 tend to push optimal policy towards zero price legalization. The fact that optimal policy remains prohibition for cocaine, but not marijuana, for the last of the seven cases investigated results from the somewhat higher value of N_2 for marijuana. In fact, if we increase the value of N_3 slightly to 11, optimal cocaine policy under competition becomes legalization at a price of zero; if N_3 is increased to 20, the same conclusion results under monopoly also.

Jeff Miron wrote recently that "A policy of taxing drugs at the highest rate that fails to generate a black market is almost certainly preferable to prohibition" (Miron, 1997, p.648). The numbers in Table 4 illustrate a number of cases in which prohibition is preferable to legalization; they also show that legalization at the high/low-price boundary is only the best policy for 5 out of the 28 parameter sets investigated (and only one out of fourteen when the illegal market is monopolised). Legalization at a price lower than this boundary is best in 16 cases, 12 of which involve a zero price for legal drugs. The key parameter driving this latter is N_3, the income-generating crime variable[23]. This, together with N_1 and 2, seems likely to be one of the key parameters in the evaluation of optimal drug policy.

There is no consensus on what form the demand curve for drugs takes: much of the empirical work implicitly assumes a constant elasticity form, as log-log equations are estimated. As a check, the top panel of Table 4 was recalculated using a constant elasticity demand curve: $Q=ap^{-b}$. One disadvantage of this functional form is that it implies infinite consumer surplus (and as we are comparing the area under two *different* demand curves, it is not possible to simply compute the *change* in consumer surplus). To skirt this problem, I calculate optimal policy with consumer surplus totally discounted, as in case number six in Table 4. The results are summarised in Table 5 below, which shows the baseline, high elasticity and worst-case outcomes. The income-generating crime case gives the same

[23] While a value of 10 for N_3 might seem exaggerated, it is important to remember that this variable captures the fear of crime, as well as the so-called economic losses.

outcome as the worst-case, and all of the other configurations yield the same prediction as the baseline case.

Table 5. Some Examples of Optimal Policy With a Constant Elasticity Demand Curve.

					Post-legalization			
	Optimal Policy	**Legal Quantity**	**Illegal Quantity**	**Total Quantity**	**Legal Price**	**Illegal Price**	**Drug Spending**	**Tax Revenue**
Marijuana								
Baseline	Legalization: boundary	26.1	0.0	26.1	683.0	---	17870	16954
Elastic demand for drugs (elasticity=2)	Low-price legalization	46.4	0.0	46.4	406.0	---	18838	17214
Worst case scenario	Prohibition	0.0	26.1	26.1	---	341.7	8932	---
Cocaine								
Baseline	Legalization: boundary	254.1	0.0	254.1	270.0	---	68607	65177
Elastic demand for drugs (elasticity=2)	Legalization: boundary	254.1	0.0	254.1	270.0	---	68607	65177
Worst case scenario	Prohibition	0.0	254.1	254.1	---	135.0	34290	---

It is worth repeating that all of the above have been calculated for a value of 2 of zero and under Perfect Competition in the illegal market. Rows 1and 3 of Table 5 can thus be compared to the sixth case and seventh cases respectively of Table 4. Row 2 of Table 5 is a mixture of the fifth and sixth cases of Table 4.

The baseline results (with 2=0) yield identical policy prescriptions to those with linear demand. However, the worst-case now implies prohibition for both marijuana and cocaine, as opposed to legalization at zero price in Table 4. This seems to be the main difference between the two functional forms: the infinite quantity associated with zero price when demand curves are constant elasticity rules out zero-price legalization.

6. Conclusions

Economists have devoted an enormous amount of attention to prices and quantities in markets, but far less to the question of whether certain goods should be prohibited. This paper has made a start on this question, using price theory to predict quantities in the legal and illegal drug markets, which are considered as two different qualities of the same good. Both competition and monopoly in the current illegal drugs market are considered. The choice of optimal policy is made by a Social Welfare function, defined over consumer surplus, tax revenue (from a purchase tax on the legal drugs market), and three different classes of drug-related externalities: those resulting from drug use in *any* market, whether legal or illegal, such as some health costs or "drugged driving"; those uniquely associated with the illegal market, such as violence and policing costs; and those from income-generating crime. Optimal policy depends in a natural way on the relative importance of these externalities.

To illustrate, the Social Welfare function has been parameterised for the case of marijuana and cocaine. The model predicts that legalization of both would raise welfare, and suggests that the latter should be effectively given away, to avoid concomitant problems of income-generating crime. A number of experiments with different demand and externality parameters suggest that legalization, often at a price low enough to drive out the illegal market, has the potential to raise social welfare.

It is, however, perhaps wise not to be too sanguine about these simulation results. First, it should be emphasised just how little we know about many of the key parameters here and, second, the model used is a simple one. One omission relates to the use of different kinds of policing (either of consumers or of suppliers). Enforcement, which is costly, either pushes the demand curve inwards or raises suppliers' costs: a joint policy of legalization and policing will be superior to one of legalization only. Although some work has considered enforcement expenditure (Andelman, 1994, Graham, 1991, Lee, 1993, and White and Luksetich, 1983), it has yet to be incorporated into a full-blown model of legalization.

One particular case concerns the relaxation of penalties for illegal supply after legalization. The correct comparison is thus between prohibition with illegal cost c and legalization at illegal cost $(c$, $(<1$. To check, the four baseline results in Table 4 were recalculated for $(=½$. The only change was that the optimum legal price for marijuana with monopoly illegal supply dropped from \$62 to \$35 per oz. As seems reasonable, cheaper illegal supply after legalization may pull down the legal price.

The current model has also said nothing about the effect of drugs on the labour market; this would be another component of N_1. In a competitive labour market, any productivity effect should be reflected in lower wages and is thus internalised (apart from the impact of labour taxes). Here individuals' decisions to change the level of effort or of labour supply, in light of their associated returns in the labour market, come from a change in preferences. If productivity is not reflected in wages then there will be external effects. In fact, most empirical work (Gill and Michaels, 1992, Kaestner, 1993, and Sickles and Taubman, 1991) finds that drug use is associated with higher wages, although the problems of non-representative samples (those who drop out are not included) and of omitted variables, most estimates being on cross-section data, should be signalled (on this latter, see Kaestner, 1994, who finds inconclusive results in NLSY panel data).

Further topics include substitution between drugs. Model (1993) considers the prevalence of drug mentions in hospital emergency room episodes. Using the decriminalization which occurred in twelve US cities between 1973 and 1978 as a natural experiment, her regression analysis shows that "marijuana decriminalization was accompanied by a significant reduction in episodes involving drugs other than marijuana and an increase in marijuana episodes". DiNardo and Lemieux (1992) show that the rise in the legal minimum drinking age was associated with a fall in alcohol use, but a rise in marijuana use[24]. Legalization of marijuana, or of other drugs, may well bring about additional welfare effects through changes in the menu of externality-producing goods consumed. On the supply side, we may see the growth of a third source: home-grown. The extent to which this matters depends obviously on the type of drug considered, on the restrictions to which it is subject (taxed or not, how heavily policed etc.), and on market prices. It is worth noting that Table 4's simulations yield legal marijuana prices that are mostly lower than the current illegal price, which will reduce the incentive to grow one's own.

Perhaps the most important weakness of any attempt to model the effect of legalization on social welfare has already been mentioned: how should the consumer surplus associated with drug use, which is predominant in calculations of social welfare, be treated? Miron and Zwiebel note that "it is remarkable how uniformly the utility from drug consumption is ignored in public discourse on drug policy - even by economists" (p. 182). This may reflect some political or moral agenda, or simply that there is no consensus on how to proceed. The consumer is sovereign in economics, but many would argue that addictive consumption does not give rise to higher utility in the sense that textbook economics

[24] However, Pacula (1998) uses NLSY micro data to show that alcohol and marijuana seem to be complements rather than substitutes.

supposes. The answer to this question may go beyond the boundaries of standard economic enquiry, but it is indispensable for the choice of the best policy in the drug market.

APPENDIX. The Derivation of Optimal Legal Prices

Low-price legalization (Perfect Competition and Monopoly)

In this case $0 < c_L < '' + (1+\$)c$. From equation (13),

$$\frac{dW}{dc_L} = \frac{\alpha+(1+\beta)a-c_L}{b(1+\beta)} + \psi\frac{\alpha+(1+\beta)a-c_L}{b(1+\beta)} + \psi\frac{(c_L-c')(-1)}{b(1+\beta)} - \phi_3\frac{\alpha+(1+\beta)a-c_L}{b(1+\beta)} - \frac{(\phi_1+\phi_3 c_L)(-1)}{b(1+\beta)} \quad \text{(A1)}$$

and

$\frac{d^2W}{dc_L^2} = \frac{(1+2\phi_3-\psi)}{b(1+\beta)}$. Setting dW/dc_L equal to zero yields a legal price of

$$c_{L1} = \frac{(1+\phi_3-\psi)(\alpha+(1+\beta)a-\phi_1-\psi c')}{(1+2\phi_3-2\psi)} \quad \text{(A2)}$$

If $(1+2N_3-2R) < 0$, then *W* is concave and c_{L1} is the optimal price as long as c_{L1} lies between 0 and $'' + (1+\$)c$; (A2) yields the relevant inequality conditions for N_1. The formulae for optimal price under low-price legalization and concavity of *W* are thus:

i) If $N_1 \;\#\; (1+N_3-R)('' + (1+\$)a) - Rc'$, *the optimal legal price is* $c_L = 0$ *(the low-price boundary);*
ii) If $(1+N_3-R)('' + (1+\$)a) - Rc' < N_1 < (1+N_3-R)(1+\$)(a-c) - (N_3-R)('' + (1+\$)c) - Rc'$, *the optimal legal price is* c_{L1}*;*
iii) If $N_1 \;\$\; (1+N_3-R)(1+\$)(a-c) - (N_3-R)('' + (1+\$)c) - Rc'$, *the optimal legal price is* $c_L = '' + (1+\$)c$ *(the high-price boundary).*

If $(1+2N_3-2R) > 0$, then *W* is convex, and the optimum will either be at $c_L = 0$ or $c_L = '' + (1+\$)c$. The high-price boundary is best if $W^*_{cL = '' + (1+\$)c} > W^*_{cL = 0}$. If not, then $c_L = 0$ is best. Using (13), it can be shown that the above inequality is true if

$N_1 > ½[''+(1+\$)a+(1+\$)(a-c)(1+2N_3-2R) - 2Rc']$.

Thus, for low-price legalization and welfare which is convex in c_L, the optimal price conditions are as follows:

iv) If $N_1 < ½[''+(1+\$)a+(1+\$)(a-c)(1+2N_3-2R) - 2Rc']$, *the optimal legal price is* $c_L = 0$ *(the low-price boundary).*
v) If $N_1 > ½[''+(1+\$)a+(1+\$)(a-c)(1+2N_3-2R) - 2Rc']$, *the optimal legal price is* $c_L = '' + (1+\$)c$ *(the high-price boundary).*

High-price legalization (Perfect Competition)

In this case $'' + (1+\$)c < c_L < '' + c + \$a$. From (14),

$$\frac{dW}{dc_L}=\frac{-1}{2\beta b}[2(\alpha+(1+\beta)a-c_L)-(1+\beta)\frac{a\beta+c+\alpha-c_L}{\beta}]+\frac{a\beta+c+\alpha-c_L}{2\beta b}(-2+\frac{1+\beta}{\beta})+\frac{(c_L-\alpha-(1+\beta)c)}{\beta^2 b}$$
$$+\frac{\psi}{\beta b}(a\beta+c+\alpha-c_L)-\frac{\psi}{\beta b}(c_L-c')-\phi_3\frac{a\beta+c+\alpha-c_L}{\beta b}+\frac{(\phi_1+\phi_3 c_L)}{\beta b}-\frac{(\phi_1+\phi_2+\phi_3 c_L)}{\beta b} \qquad \text{(A3)}$$

and $\frac{d^2W}{dc_L^2}=\frac{(1+2\phi_3-\psi)}{\beta b}$. Setting dW/dc$_L$ equal to zero yields a legal price of

$$c_{L2}=\frac{(1+\phi_3-\psi)(a\beta+c+\alpha)+\phi_3+\phi_2-\psi c')}{(1+2\phi_3-2\psi)} \qquad \text{(A4)}$$

If (1+2N$_3$-2R) < 0, then *W* is concave and c$_{L2}$ is the optimal price, as long as c$_{L2}$ lies between " + (1+$)c and " + c + $a; (A4) yields the relevant inequality conditions for N$_2$. The formulae for optimal price under high-price legalization with Perfect Competition and a welfare function concave in c$_L$ are thus:

vi) If N$_2$ $ (1+N$_3$-R)$(c-a) +N$_3$("+$c)- R("+(1+$)c-c'), the optimal legal price is c$_L$ = "+(1+$)c (the low-price boundary);
vii) If N$_3$("+$a)- R("+c+$a-c') < N$_2$ < (1+N$_3$-R)$(c-a) +N$_3$("+$c)-R("+ (1+$)c-c'), the optimal legal price is c$_{L2}$;
viii) If N$_2$ # N$_3$("+$a)- R("+c+$a-c'), the optimal legal price is c$_L$ = "+c+$a (the high-price boundary).

If (1+2N$_3$-2R) > 0, then *W* is convex, and the optimum will either be at c$_L$ = " + (1+$)c or c$_L$ = " + c + $a. The high-price boundary is best if W*$_{\text{cL =" + c + \$a}}$ > W*$_{\text{cL = " + (1+\$)c}}$. If not, then c$_L$ = " + (1+$)c is best. Using (14), it can be shown that the above inequality is true if

N$_2$ < ½[$(c-a)+2R(c'-"-(1+$)c)+2N$_3$("+$c)].

Hence the following results have been established for optimal legal price under high-price legalization with Perfect Competition and convexity of welfare:

ix) If N$_2$ > ½[$(c-a)+2R(c'- "-(1+$)c)+2N$_3$("+$c)], the optimal legal price is c$_L$ = " + (1+$)c (the low-price boundary).
x) If N$_2$ < ½[$(c-a)+2R(c'- "-(1+$)c)+2N$_3$("+$c)], the optimal legal price is c$_L$ = " + c + $a (the high-price boundary).

High-price legalization (Monopoly)

In this case, " + (1+$)c < c$_L$ < " +$a +(a+c)/2. From (17),

$$\frac{dW}{dc_L}=\frac{-2}{(1+2\beta)b}[\frac{(1+\beta)(1+2\beta\alpha)-a(1+\beta)c-2\beta c_L}{2(1+2\beta)}\frac{a\beta+c+\alpha-c_L}{\beta}+\psi(c_L-c')-\phi_1-\phi_3 c_L]+\frac{a(1+2\beta)-2(c_L-\alpha)+c}{(1+2\beta)b}(\frac{-2\beta}{2(1+2\beta)}-\psi-\phi_3)$$
$$+\frac{2(c_L-\alpha-(1+\beta)c)}{2b(1+2\beta)^2}-(\phi_1+\phi_2+\phi_3\frac{c_L-\alpha-\beta c}{1+2\beta})\frac{1}{(1+2\beta)b}-\frac{\phi_3}{(1+2\beta)b}-\frac{c_L-\alpha-(1+\beta)c}{(1+2\beta)b} \qquad \text{(A5)}$$

and $\frac{d^2W}{dc_L^2} = \frac{4\beta - 4(1+2\beta)(\psi - \phi_3) + 1 - 2\phi_3}{(1+2\beta)^2 b}$. Setting dW/dc_L equal to zero yields a legal price of

$$c_{L3} = \frac{a(1+2\beta)^2(1+\phi_3-\psi)+\alpha[1+4\beta-2\phi_3-2(\psi-\phi_3)(1+2\beta)]+c(\beta-\phi_3-(1+2\beta)(\psi-\phi_3))+\alpha)-(1+2\beta)(2\psi c'+\phi_1-\phi_2)}{4\beta-4(1+2\beta)(\psi-\phi_3)+1-2\phi_3} \quad \text{(A6)}$$

If 4$-4(1+2$)(R-N3)+1-2N3 < 0, then *W* is concave and cL3 is the optimal price, as long as cL3 lies between " + (1+$)c and " +$a +(a+c)/2; equation (A6) yields the relevant inequality conditions for N1. The formulae for optimal price under high-price legalization with Monopoly and a welfare function concave in cL are thus:

xi) If N1 # [a(1 +2$)(1+N3-R)+ 2 "(R-N3) + c(R+2(1+2$)(R-N3)-1-2$) - 2Rc'+N2], the optimal legal price is cL = " + (1+$)c (the low-price boundary);
xii) If [a(1 +2$)(1+N3-R)+ 2 "(R-N3) + c(R+2(1+2$)(R-N3)-1-2$) - 2Rc'+N2] < N1 < ½[a(1+2N3+2(R-N3)(1+2$)) + 4 "(R-N3) +c(2R-2N3-1) - 4Rc' + 2N2], the optimal legal price is cL3;
xiii) If N1 $ ½[a(1+2N3+2(R-N3)(1+2$)) + 4 "(R-N3) +c(2R-2N3-1) - 4Rc' + 2N2], the optimal legal price is cL = " +$a +(a+c)/2 (the high-price boundary).

If 4$-4(1+2$)(R-N3)+1-2N3 > 0, then *W* is convex, and the optimum is either cL = " + (1+$)c or cL = " +$a +(a+c)/2. The high-price boundary (which is equivalent to Prohibition) is best if W*cL =" +$a +(a+c)/2 > W*cL = " + (1+$)c. If not, then cL = " + (1+$)c is best. Substitution into (17) shows:

xiv) If N1 # ¼[(3+4$)(a-c) + 8(R-N3)("+(1+$)c)+2N3(a+c)-8Rc'+4N2], the optimal legal price is cL = " + (1+$)c (the low-price boundary).
xv) If N1 > ¼[(3+4$)(a-c) + 8(R-N3)("+(1+$)c)+2N3(a+c)-8Rc'+4N2], the optimal legal price is cL = " +$a +(a+c)/2 (the high-price boundary).

Proof of the Optimality of Eliminating the Illegal Drugs Market under High-price Legalization and Perfect Competition.

Consider the right-hand side of condition *vi)* above:
(1+N3-R)$(c-a) +N3("+$c)- R("+(1+$)c-c') = (1+N3-R)$(c-a)+(N3-R)("+$c) - R(c-c').
c-c' is positive, as legal drugs will cost less to produce than illegal drugs. The concavity of *W* in cL requires that 1+2N3-2R < 0, which in turn requires that N3-R < 0. In addition, as R is no greater than 1, 1+N3-R > 0. Hence all of the three terms on the right-hand side of the above inequality are negative, ensuring that any non-negative value of N2 implies that the optimal policy is to drive out the illegal market.

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