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Licensing and regulation of the cannabis market in England and Wales: Towards a cost-benefit analysis

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Summary

About this study

We agree with David Cameron's observation on drugs policy that "it would be very disturbing if some radical options were not at least looked at".[1] Among the radical options that are often proposed is the creation of a system of licensed cannabis supply subject to taxation and regulation of supply and demand sides of the market. In this study, we consider a hypothetical reform of this kind and identify a long list of possible sources of net social cost and benefit that could result. We attempt to quantify them, using the concept of net external benefit as an evaluation criterion. Net external benefit is the total value in cash-equivalent terms of the costs and benefits that cannabis use imposes on society outside the user him/herself, and it therefore excludes the potential net benefits ('enjoyment') accruing to cannabis users in a reformed market. Our evaluation is consequently conservative in that it contains an inherent bias in favour of the prohibitionist *status quo*. In our view, it is impossible with available UK evidence to produce a credible estimate of net consumption benefits. Despite the bias this entails, it gives a far more reliable picture of the policy question than the many widely-cited estimates of the "social cost of drug use", which include internal costs (potential harms to drug users) but ignore completely the internal benefits which are the reason that recreational drugs are used in the first place.

The estimates underpinning our evaluation should not be seen as predictions of what would happen if such a policy were to be introduced in some future period, since they relate to the market situation as it existed in England and Wales in 2009/10, and they abstract from any transitional adjustments (and any accompanying transitional cost). We have not attempted to extend the evaluation to cover Scotland or Northern Ireland, since most of the data resources available to us cover England and Wales only.

In constructing the estimates, we consider a wide range of evidence and the difficulties involved in drawing conclusions from that evidence. We provide simple, largely subjective, quantitative indications of the degree of uncertainty involved in our estimates, some of which should be regarded as illustrative calculations rather than formal estimates. Our aim is not to produce a definitive cost-benefit analysis of a licensed and regulated cannabis market – which we believe to be impossible in the present state of knowledge – but to set out clearly the range of considerations that need to be considered in forming a view about this policy, and to indicate which aspects of the evaluation are likely to be critical to the outcome of a full cost-benefit analysis.

[1] House of Commons Select Committee on Home Affairs 2001, Examination of witnesses, question 123

Main conclusions

[1] The heated public debate on cannabis policy is much too limited in scope. We have identified seventeen distinct sources of social cost or benefit that might contribute to the outcome of a comprehensive market reform and attempted to quantify thirteen of them. The relative importance of these sources depends critically on the form of regulation and the nature of market responses to reform. Consequently, any considered view on the question of reform needs to take account of a large number of factors and be contingent on a specific view about the detailed nature of the reform. Few of the most vocal participants in the debate on drug policy reform take a sufficiently broad perspective.

[2] At present, there is so much uncertainty about some of the important issues involved in the introduction of a licensed and regulated cannabis market that a clear conclusion is not possible. In particular we lack a good understanding of the demand behaviour which underlies the steady fall in cannabis prevalence over the last decade or so, and the degree to which the association between cannabis use and long-term adverse outcomes is truly causal. In our view, all unambiguous claims for or against radical policy options should be treated with caution.

[3] Psychopharmacological research suggests that harm from cannabis use is related to the chemical composition of the drug, so product regulation similar to that in the tobacco market would have some advantages. Several alternative forms of regulation could be used in a licensed market and policy designers need to bear in mind the different consequences each might have for the harmfulness of consumption. Relatively *laisser faire* reforms which encourage large numbers of small producers make it difficult to control product characteristics and may lead to higher levels of overall potency and in turn more harmful long-term outcomes.

[4] Cost benefit evaluations should not assume that there are zero personal benefits from consumption: such an assumption would be unthinkable in any other application of cost benefit analysis. Our use of a net external benefit criterion is based on the view that the consumer necessarily perceives at least as great a personal benefit from consumption as there is personal cost and risk from consumption. It is a conservative approach, producing results biased in favour of the status quo under the assumption of competent well-informed decision-makers. However, we need a much better understanding of the vulnerable groups who may be making poor consumption decisions because of inadequate information or imperfectly developed decision-making capacity.

[5] Given the lack of a convincing empirical model of market demand for high- and low-potency forms of cannabis and the uncertainty about the form that product regulation would take, there is a wide range of plausible market responses to reform. It is likely that consumption in overall volume terms will rise significantly as a consequence of the switch to legal status and

the lower price that results. But it is possible that, for some forms of product regulation, average potency would fall, with aggregate consumption of the psychoactive ingredient THC rising much less than consumption of the good itself, and possibly even declining.

[6] Our results are set out in Table S1 below. The direct impacts of reform in terms of potential changes in aggregate policing, criminal justice and drug treatment costs appear to be modest and largely insensitive to the nature of regulation and the market response to it. We estimate an annual aggregate net benefit of roughly £200-300m from this source as a consequence of a move to a regulated market.

[7] Another direct effect of reform will come through its impact on drug-related crime. One might expect crime related to cannabis consumption to increase if reform reduces price and increases demand, while crime related to cannabis supply would be reduced as illicit supply is driven out of the market. At the individual level, we have found no statistically significant evidence of a causal link between cannabis use and acquisitive or violent crime, but a modest significant link with supply activity – suggesting an overall net saving on crime costs from reform. However, the large size of the cannabis market, the potentially high personal costs for the victims of violent crime, and the substantial statistical uncertainty around the estimates imply that, at the aggregate level, projected net social benefit of reform is highly uncertain. We can be confident of a substantial additional net benefit from reform through a reduction in drug-related crime if we assume that the demand response is low or moderate. However, if very large demand responses to market reform are envisaged, it is not possible to draw any definite conclusions about the cost-benefit balance for the impact on crime.

[8] The indirect effects of policy reform include the social costs of long-term impacts on physical and mental health, the impact on labour market outcomes through the scarring effect of a criminal record, and the 'gateway' effect on the risk of involvement with harder drugs. For all of these, we estimate the external costs and benefits to the rest of society, excluding the internal costs and benefits borne by the cannabis user. These indirect impacts of reform are hard to estimate with any confidence because of the difficulty of isolating the effect of unobserved confounding factors that produce spurious correlation between cannabis use and observed outcomes. The public debate about cannabis policy has focused heavily on mental health costs, but we find these to be modest, because of the relatively small number of individuals involved and the modest effect size suggested by the research literature. In total, we expect net external costs of the impact on physical and mental health to range from zero for the low demand response scenario to around £85m in the case of a strong demand response to reform. Even in the worst case, these costs are modest in relation to projected savings on policing and criminal justice costs.

Table S1 Summary of aggregate external net benefits from cannabis licensing in England and Wales (2009 prices)

	Market response scenario		
	Low-response (15% quantity increase, 10% fall in THC)	Mid-response (20% quantity increase, 5% increase in THC)	High-response (40% quantity increase, 25% increase in THC)
Policing	+ £105m [£65m, £147m]	+ £105m [£65m, £147m]	+ £105m [£65m, £147m]
Court procedures	+ £97m [£58m, £143m]	+ £97m [£58m, £143m]	+ £97m [£58m, £143m]
Custodial sentences	+ £84m [£50m, £125m]	+ £84m [£50m, £125m]	+ £84m [£50m, £125m]
Community sentences	+ £5m [£3m, £8m]	+ £5m [£3m, £8m]	+ £5m [£3m, £8m]
Tax on earnings lost during incarceration	+ £10m [£8m, £12m]	+ £10m [£8m, £12m]	+ £10m [£8m, £12m]
Assumed market regulation / health promotion costs	- £45m	- £45m	- £45m
Cost of cannabis-related accidents	+ £13m [£8m, £21m]	- £6m [-£11m, -£4m]	- £32m [-£53m, -£20m]
Cannabis dependency treatment costs	+ £5m [£2m, £7m]	- £2m [-£3m, -£1m]	- £11m [-£16m, -£6m]
Cannabis-induced crime	+ £17m [£6m, £28m]	- £15m [-£145m, £114m]	- £569m [-£1.4bn, £256m]
Mental illness treatment costs	+ £16m [+£8m, +£43m]	- £8m [-£21m, -£4m]	-£41m [-£106m, -£20m]
Physical illness treatment costs	- £16m [-£31m, -£8m]	- £21m [-£41m, -£11m]	- £43m [-£82m, -£21m]
Criminal record scarring	+ £23m [+£11m, +£57m]	+ £23m [+£11m, +£57m]	+ £23m [+£11m, +£57m]
Gateway consequences	+ £48 [£0m, +£96m]	+ £28 [-£20m, +£80m]	- £13m [-£220m, £0m]
	Unquantified effects		
Consumption of other substances	**?**	**?**	**?**
Failures of decision-making	**?**	**-**	**--**
Credibility of health information	**+**	**+**	**+**
Drug tourism	**-**	**-**	**-**
Total quantifiable direct and indirect effects	**+ £361m [+£277m, +£461m]**	**+ £253m [+£98m, +£415m]**	**-£430m [-£1.3bn, +£400m]**

Note: subjective ranges of uncertainty in brackets; figures may not sum to totals because of rounding. **?** = direction of effect uncertain; **-** = probable net cost of modest size; **--** = probable net cost, possibly large; **+** = probable net benefit of modest size.

[9] We estimate modest external net benefits from reform through the avoidance of scarring effects of criminal records in the labour market of roughly the same magnitude as the external cost to society of the impact on mental health.

[10] Another greatly exaggerated focus of the public debate on cannabis policy is the "gateway effect" – the possible increase in risk of involvement in hard drugs caused by exposure to cannabis. In our view, the evidence for a large gateway effect among cannabis consumers is weak, and there is an often-overlooked offsetting gateway on the supply side, drawing cannabis users into drug dealing. Licensing of supply might lead to a rise in demand and thus harm through the demand gateway, but it would also remove many people from illicit cannabis supply and thus reduce harm through the supply gateway. We estimate that reform could generate a net external *benefit* in the range £20-80m under the most plausible assumption of a moderate demand increase. Only a large demand response would be likely to generate a net social cost.

[11] Overall, taking account of all thirteen reform effects that we were able to estimate quantitatively, the total effect of reform is a net external benefit of around £280-460m if we anticipate a low demand response; a net benefit of £100-415m for the most plausible moderate demand response; and a projected net external cost of £430 in the case of a large demand response. This last estimate is very uncertain, with an indicative range of uncertainty from -£1.3bn to +£400m.

[12] There are many other possible effects of reform which we believe are not possible to quantify with any degree of confidence. Four of these may be particularly important: indirect effects of relative price changes on the consumption of other harmful substances including tobacco, alcohol and other illicit drugs; failures of decision making by certain vulnerable groups whose evaluations of their personal costs and benefits may be unreliable as a basis for welfare evaluation; the possible improvement in the credibility of health information achievable by separating health messages from legal penalties; and the possibility of "drug tourism" as a response to a unilateral UK policy initiative. Although we cannot quantify these effects, it is likely that they will follow a similar pattern to the quantified effects: no substantial net social costs if demand response is low or moderate and a risk of large social costs only if the demand response is large. The degree of uncertainty, particularly in the last case, is again very high.

[13] Tax revenues are a transfer of resources within society rather than a net benefit to society, but they are an important aspect of policy outcomes. The conjectured impact on the government budget is summarised in Table S2 below. We estimate that tax revenue from licensed cannabis supply in England and Wales would fall somewhere in the range £0.4-0.9bn, which is far less than some of the assumptions that have appeared in the policy debate. We

expect tax revenue to be lower in the case of strong demand response to reform, because of the large residual illicit market for high-potency cannabis that could exist in that case. Overall, the contribution of cannabis licensing in England and Wales to reduction of the government deficit is expected to lie in the range £0.5-1.25bn.

Table S2 Summary of aggregate government budget implications of cannabis licensing in England and Wales

	Market response scenario		
	Low-response (15% quantity increase, 10% fall in THC)	Mid-response (20% quantity increase, 5% increase in THC)	High-response (40% quantity increase, 25% increase in THC)
Commodity taxes			
Taxes on licensed cannabis	+ £768m [£564m, £871m]	+ £594m [£436m, £674m]	+ £541m [£397m, £614m]
Other indirect taxes	**?**	**?**	**?**
Taxes on earnings			
Tax lost during incarceration	+ £10m [+£8m, +£12m]	+ £10m [+£8m, +£12m]	+ £10m [+£8m, +£12m]
Tax lost due to scarring	+ £23m [£11m, £57m]	+ £23m [£11m, £57m]	+ £23m [£11m, £57m]
Public expenditure			
Enforcement costs	+ £291m [£176m, £423m]	+ £291m [£176m, £423m]	+ £291m [£176m, £423m]
Health information and dependency treatment	- £41m [-£43m, -£39m]	- £47m [-£48, -£46m]	- £58m [-£61m, -£51m]
Mental illness treatment	+ £16m [-£0m-£53m]	- £21m [£0m-£53m]	- £43m [£0m-£107m]
Physical illness treatment	- £16m [-£31m, -£8m]	- £21m [-£41m, -£11m]	- £43m [-£82m, -£21m]
Total	+ £1,051m [£816m, £1,225m]	+ £841m [£645m, £1,000m]	+ £724m [£525m, £882m]

[14] Uncertainty about the magnitude of certain impacts and the response of demand to market reform make it impossible to give an unambiguous *ex ante* evaluation of the net social benefit of reform. However, it seems clear that the risk of large net social costs is only significant if there is a large demand response to reform. This suggests that a good way to proceed in practice might be to introduce the reform together with a monitoring system to give early warning of any large demand response, particularly among the very young or other vulnerable groups. One of the clear lessons to be learned from policy experience over the last decade or so is that it is possible to reverse policy quickly if monitoring were to suggest a large expansion of

demand. Policy monitoring should distinguish between consumption of low- and high-potency forms of cannabis, since the largest social costs are linked to the latter rather than the former.

Recommendations for future research

Where next? This study has revealed the existence of large gaps in our knowledge and in the data resources that would be required to supply the missing evidence. Some of these gaps could be filled by carrying out quite straightforward research – for example, to improve estimates of policing and criminal justice unit costs. Some gaps may never be filled adequately, because of the extreme difficulty of estimating the true long-term causal effects of variations in drug use on outcomes. Two important areas of uncertainty where progress may be possible are drug-related crime and drug demand behaviour, but it would require greater sustained investments in data and research effort.

(*i*) *Data*

The Home Office relies heavily on the British Crime Survey (now known as the Crime Survey for England and Wales) as the primary source of data on drug use. The BCS has significant shortcomings: it is a cross-sectional survey that does not allow analysis of the dynamics of drug use at the individual level; it gives data on drug use and crime victimisation but not respondents' own criminal activity; and it under-represents prolific offenders and drug users. In this study, we have exploited research based on a combination of the Arrestee Survey (AS) and Offending Crime and Justice Survey (OCJS), to avoid the under-recording of cannabis consumption by the BCS and to estimate the volume of cannabis-related crime. The abandonment of both the AS and OCJS in 2006 makes it now virtually impossible to construct these estimates using current, nationally representative data. If drugs policy is to be evidence-based, this gap in our data resources is a serious problem and should be reconsidered.

(*ii*) *Demand analysis*

A second obvious gap in our data resources is the lack of regular, representative data on drug prices and potency, which makes it almost impossible to attempt an analysis of demand in the current cannabis market. The uncertainty inherent in our estimates is greatest in the scenario which envisages a large demand response to market reform. We see this outcome as relatively implausible, given the limited evidence of response to less radical policy liberalisation in many countries and the lack of any detectable increase in demand in response to the reclassifications of cannabis in 2004 and 2009, but the evidence on demand behaviour is weak. Published attempts to estimate demand responses come from US and Australian data and do not give a good basis for projecting the effect of reform in the UK. Standard statistical models of cannabis use also fail to offer any clear explanation for the steady decline in cannabis demand over the

last decade and they do not capture the important distinction between low- and high-potency forms of the drug or explain the structural shift in the cannabis market. There is a clear need for a better understanding of the demand for cannabis, which will only be achievable with better data on consumption, price and potency.

1 Introduction and objectives

Policy on illicit drugs is the subject of perpetual heated debate, both at the international level, where there is pressure for revision of the UN conventions which seek to dictate elements of national policy, and at the national level, where successive UK governments have flirted with various ideas for reform. Proponents of 'tough' and 'liberal' drugs policy have often adopted strong positions, using highly selective interpretations of limited research evidence to support their arguments. Few participants in the public debate on drugs policy acknowledge the large uncertainties that exist in the research evidence and the debate is often conducted in emotive terms, using vague conceptions of 'tough' and 'liberal' policy, and sometimes making large deductive leaps that have little backing in logic. Perhaps the worst aspect of the public debate is that the very act of contemplating certain policy options can attract vehement criticism and even risk to the reputations of policy analysts who do so.

People on different sides of the argument often choose to emphasise different elements of the cannabis policy issue. For example, May et al (2002) give quotations from interviews with two police officers who personally used very different operational policies. One was concerned with the potential damaging consequences of a criminal record for a minor cannabis offence:

> *"If you stop someone and they are not aggressive or abusive and they don't have a criminal record, I can't see the point in giving them a criminal record for a bit of cannabis."*

Another officer was concerned with a different set of possible long-term consequences:

> *"I feel that cannabis leads onto heavier drugs. Most hard drug users start with cannabis and before you know it you have a heroin addict."*

Others might be concerned about the costs of using criminal justice procedures against cannabis users, or the costs of treatment for cannabis dependency, or the mental health consequences of long-term use, or a host of other considerations. Few participants in the policy debate are prepared to consider the whole range of factors that are relevant to policy decisions.

No serious researcher or commentator on drugs policy believes that cannabis is harmless. Although there are many uncertainties about the health consequences of cannabis use, the research literature demonstrates convincingly that potential harms do exist. However, the existence of a potential harm does not automatically provide justification for a prohibitionist policy. If it did, we would certainly be prohibiting alcohol and tobacco and, taken to the extreme, we would also be considering banning many everyday activities and pastimes – including David Nutt's famous example of horse-riding (Nutt 2008). The absurdity of examples like this tells us that there is a very wide logical gap between the revelation of health risks by medical research and any specific policy prescription. The current stance of cannabis prohibition may be a good

policy option, but it cannot be assumed so automatically on grounds of demonstrable risk of harm to cannabis users.

Prohibition is (probably) a deterrent to cannabis consumption and it raises supply costs and market price, which also restrains demand. It may also have an informational role as a signal to consumers of potential risk. However, it has drawbacks too. If the only market is a black market, the authorities sacrifice the power of taxation, which is a way of influencing price and generating tax revenue. They also sacrifice the ability to regulate the market in other ways, particularly in terms of product characteristics like potency. It is also likely that confounding the health education message with legal prohibition destroys the credibility of that message in the minds of some cannabis users.

Our aim in this study is not to produce a definitive cost-benefit verdict on cannabis licensing and regulation, because a definitive analysis is simply not possible, given the limited evidence that is available. Instead, we set out a reasonably complete list of the issues that would have to be addressed by a comprehensive cost-benefit analysis and attempt to provide an indication of their likely importance. We have three primary objectives: (*i*) to give the policy debate the broad perspective that it requires; (*ii*) to make advances in the quality of evidence available for some of these issues; and (*iii*) to identify – if possible – a key set of elements of the cost-benefit calculation which are likely to have the biggest influence on the conclusions and which consequently deserve particular attention in future research.

The estimates presented here vary in their sophistication, with some being little more than back-of-the-envelope – albeit quite a large envelope. All are subject to considerable uncertainty, which we try to convey by means of subjective high-low ranges based mostly on judgement rather than science. Despite their variable quality, we hope that, by putting these specific estimates into the public domain, we will provide a starting point for a more coherent policy debate.

All the estimates reported here relate to England and Wales rather than Great Britain or the UK. This is dictated by the coverage of some critical data sources produced by the Home Office, whose remit extends only to England and Wales. This incomplete geographical coverage is far from ideal, because it would not be feasible to introduce some forms of this policy on one side of the Anglo-Scottish land border only. Although there are significant differences between the illicit drugs markets in England and Scotland, we would not expect the exclusion of Scotland to make a large quantitative difference to our calculations, since the Scottish population comprises only 8.6% of the population of Great Britain (mid-2010 figures).

This is not the first attempt to apply the principles of cost-benefit analysis to regulation of the

cannabis market. Atha and Davis (2011) provide some estimates for the UK suggesting a modest net social benefit of reform (mainly due to large projected savings in criminal justice costs), and also very large net gains to the government budget. However, their analysis rests on strong assumptions, and we are sceptical about the very high projections of tax revenue. Some potentially important indirect long-term effects (particularly on health) are not costed.

There have been only a few attempts at comprehensive cost-benefit studies outside Britain. In the USA, Kilmer et al (2010) and Caulkins et al (2013) have examined California's Proposition 19 which was defeated in a referendum in November 2010. With a specific excise tax of $50 per ounce, they project a large reduction in production costs and a consequent fall in the retail price causing a possibly large increase in total consumption. But there is a great deal of uncertainty, arising from our limited understanding of behavioural demand responses to price changes. They envisage significant but modest effects relating to the costs of law enforcement, regulation and treatment, but highly uncertain changes in the costs associated with longer-term indirect consequences. The type of policy reform they consider precludes strong product controls and could therefore cause a worrying rise in average potency; a more direct approach to regulation may be feasible in the European context. In Australia, Shanahan and Ritter (2011, 2013) have produced estimates for the state of New South Wales, presented unconventionally in the form of aggregate welfare measures for the status quo and reform settings, so the effect of reform is the difference between the two. Shanahan and Ritter envisage a system involving product controls and monopolistic distribution through state or non-profit cannabis-only retail outlets, with licensing of commercial producers alongside individual small-scale cultivation permitted for people over 21. Their findings suggest significant net benefits from criminal justice cost savings and consumption benefits from increased cannabis use, which are offset by projected social losses from the costs of market regulation and reduction of educational attainment. Their projection of overall net social benefit of reform lies well within the margin of uncertainty for the analysis.

We first give a brief overview of the drugs market in England and Wales over the relevant period and then set out our own approach to evaluation, before presenting the results of the analysis. We would like to emphasise that we have approached our objectives with a completely open mind. None of the authors of this report is committed to any ideological position in relation to illicit drugs, nor did any of us start with any specific view about the desirability of a licensed and regulated cannabis market.

2 The illicit drugs market in England and Wales since 2000

2.1 The policy environment

British policy on cannabis and, to a lesser extent, other illicit drugs has seen large swings of opinion by government since 2000. The main developments in drugs policy are outlined in Table 2.1.1. Throughout the period, a prohibitionist legal stance has been maintained, with illicit drugs classified into three categories, A, B and C, which were defined initially by the 1971 Misuse of Drugs Act. Classification combines two purposes, which are often seen to be in conflict: to indicate an official view of the potential harmfulness of each substance; and to define enforcement penalties for possession, trafficking and related offences. At the start of the millennium, cannabis had been included in class B since 1971 and, as a consequence, carried maximum penalties for possession and supply of 5 and 14 years respectively. At the time, this compared with life imprisonment (supply) and 7 years (possession) for class A drugs, and 5 years (supply) and 2 years (possession) for class C.

The Blair government's first drugs strategy appeared in 1998, overseen by a "Drugs Tsar", Keith Hellawell. The strategy had four loosely-stated aims: prevention of drug use by young people; protection of communities from drug-related anti-social and criminal behaviour; encouraging existing drug users to give up; and reduction of the availability of illicit drugs. There was a commitment to (initially unspecified) policy targets and, in the early years, the Home Office engaged in a process of developing specific targets and corresponding quantitative performance indicators, including the development of a Drug Harm Index (MacDonald et al 2005), which has been quoted in both the 2008 and 2010 drugs strategy documents in relation to class A drugs. The policy instruments to be used in achieving the aims of the drugs strategy were not initially specified except in the most general terms, but there was a generalised commitment to drug treatment and co-ordination of policy across agencies. Development of new policy initiatives has been problematic throughout the last decade, with early disagreement between the Home Secretary (then David Blunkett) and the Drugs Tsar, who resigned in July 2002 over the proposed softer line on cannabis; and, later on, between the Home Secretary (then Alan Johnson) and the chairman of the Advisory Council on the Misuse of Drugs (then David Nutt), over the latter's criticism of the government's maintenance of a hard line on ecstasy classification, contrary to ACMD advice.

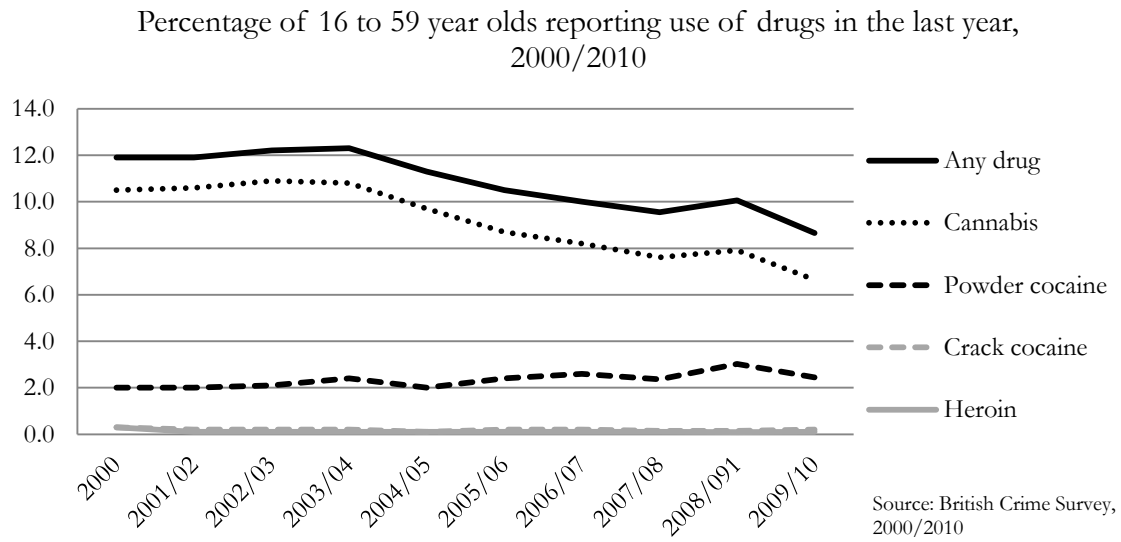
Table 2.1.1 Major developments in drugs policy affecting England and Wales since 2000

Date	Event
Jul 2001	Start of 13-month cannabis decriminalisation experiment in London Borough of Lambeth.
Oct 2001	Home Secretary David Blunkett announced intention to reclassify cannabis from class B to class C.
May 2002	House of Commons Home Affairs Committee's report supported cannabis reclassification; also recommended reclassifying ecstasy from A to B; and advocated a large expansion of treatment provision.
Jul 2002	Drug Tsar Keith Hellawell resigned in protest at plans to reclassify cannabis.
Nov 2002	Updated Home Office Drugs Strategy confirmed cannabis reclassification and proposed increased maximum penalty for class C supply of 14 years imprisonment; expansion of CJS-triggered drug treatment.
Jan 2004	Reclassification of cannabis implemented; policing guidelines indicated confiscation and warning as normal action on possession; maximum penalty for supply of class C drugs raised to 14 years.
May 2005	Judgement of the Court of Appeal (Criminal Division), in R v Quayle, Wales and others, that a defence of medical necessity for relief of chronic pain is not admissible for cannabis offences.
Jan 2006	2005 Drugs Act implemented: magic mushrooms put in class A; burden of proof shifted to defendant in cases involving possession of more than the (unspecified) amount required for personal use; compulsory drug testing for suspects in crimes believed to involve class A drug use or recipients of Anti-Social Behaviour Orders.
Jul 2006	House of Commons Science and Technology Committee's report on drugs policy criticised the drug classification system and the organisation and operation of the ACMD, both generally and in relation to its recommendations on magic mushrooms and ecstasy. It found no evidence to support the gateway theory or deterrence effects from drug classification.
Jan 2006	The ACMD advised retaining cannabis in class C, following Government request for reconsideration in light of concerns about psychotic illness and increased supply of high-potency sinsemilla ("skunk").
Feb 2008	Revised Home Office Drugs Strategy specified 8 quantitative policy targets to be monitored.
May 2008	Home Secretary Jacqui Smith announced intention to reclassify cannabis from class C to class B.
Jan 2009	Cannabis reclassified as class B. AMCD recommendation for downgrading of MDMA to class B rejected by the Home Secretary.
Oct 2009	Firing of chairman (David Nutt) followed, over the following six months, by the resignation of seven other members of ACMD in protest at government's treatment of ACMD. Formation in Jan 2010 of Independent Scientific Committee on Drugs.
Dec 2010	Police Reform and Social Responsibility Bill introduced, with provisions to: remove restrictions on the area of expertise covered by the membership of the ACMD (relaxing the requirement for at least 6 scientist members); and allow the Home Secretary to place temporary restrictions on substances by statutory instrument.
Dec 2010	Consultation on a revised Home Office Drugs Strategy emphasising: (i) individual responsibility to seek help and overcome dependency: (ii) a holistic approach to support drug-dependent people; (iii) demand reduction; (iv) a "crack down" on drug suppliers; (v) the role of local communities. A payment-by-results system proposed for the drug treatment system.

2.2 Consumption trends

Drug consumption is difficult to measure given its illicit nature, nevertheless several large-scale surveys ask annually about drug consumption using questions that are consistent over time and thus allow us to construct time series of reported drug prevalence. Here we provide an overview of consumption trends over the last decade among the general population, using data from the British Crime Survey (BCS) and the surveys of Smoking, Drinking and Drugs Use among Young People in England (the "Schools Surveys"). These are the surveys used to derive the UK government's reported levels of drug prevalence (see UK Focal Point, 2010). To put the UK situation into an international context, we also present data from the European School Survey Project on Alcohol and Other Drugs (ESPAD) , which in 2007 collected data on school students in 35 countries.

Figure 2.2.1 Trends in drug use among 16-59 year olds in England and Wales



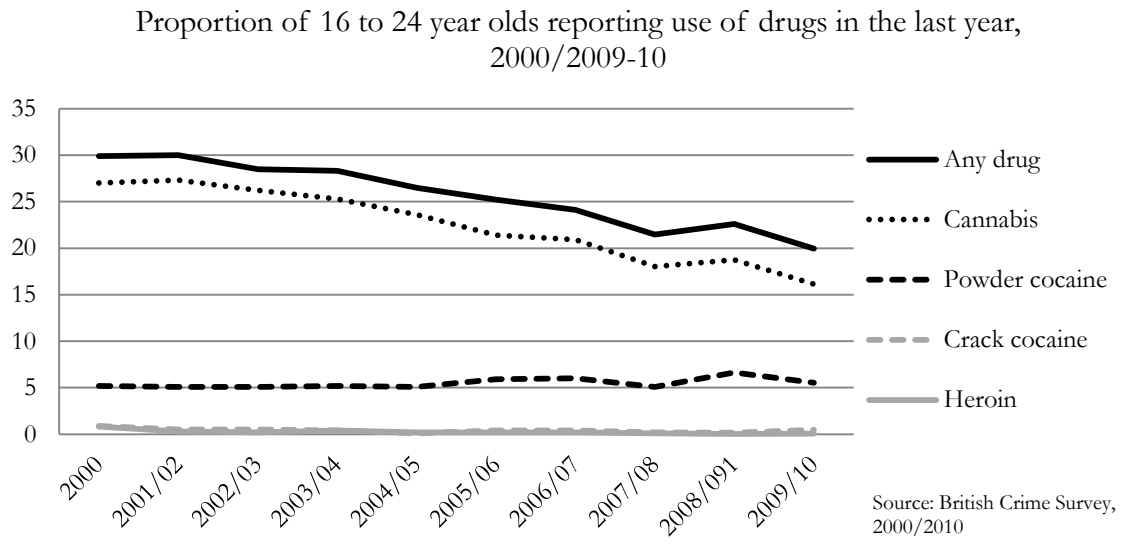
Note: 'Any drug' comprises powder cocaine, crack cocaine, ecstasy, LSD, magic mushrooms, heroin, methadone, amphetamines, cannabis, tranquillisers, anabolic steroids, amyl nitrite, glues, any other pills/powders/drugs smoked plus ketamine since 2006/07 interviews and methamphetamine since 2008/09 interviews.

The BCS samples adults aged 16-59 years in private households in England and Wales. Figure 2.2.1 shows the proportion of respondents who reported using drugs of different types in the previous year. Overall drug prevalence among 16-59 year olds was stable at about 12% for the first part of the decade before beginning an almost continuous decline in 2004 that reduced prevalence to just above 8% in 2009/10. The decline was driven by the falling use of cannabis, which fell from 10% in 2000 to about 6% in 2009/10, but the overall drop also masked a rise in the use of powder cocaine. Cocaine is much less common than cannabis but experienced a large

proportionate increase in prevalence, from 2% in 2000 to about 3% by the end of the decade. Use of crack and heroin was negligible among the general population (annual prevalence of 0.3% or less) for the entire decade.

Figure 2.2.2 looks at the same trends but focuses on 16-24 year olds only, who are known to consume the bulk of illicit drugs. Not surprisingly, the trends in prevalence are similar to those across the full age range, but it appears that the fall in cannabis use among the younger age group began slightly earlier, in 2001, than might be inferred from Figure 2.2.1. Annual cannabis prevalence fell from 30% in 2000 to 20% in 2009/10. There was also a small increase in the prevalence of powder cocaine, but almost no use of crack or heroin.

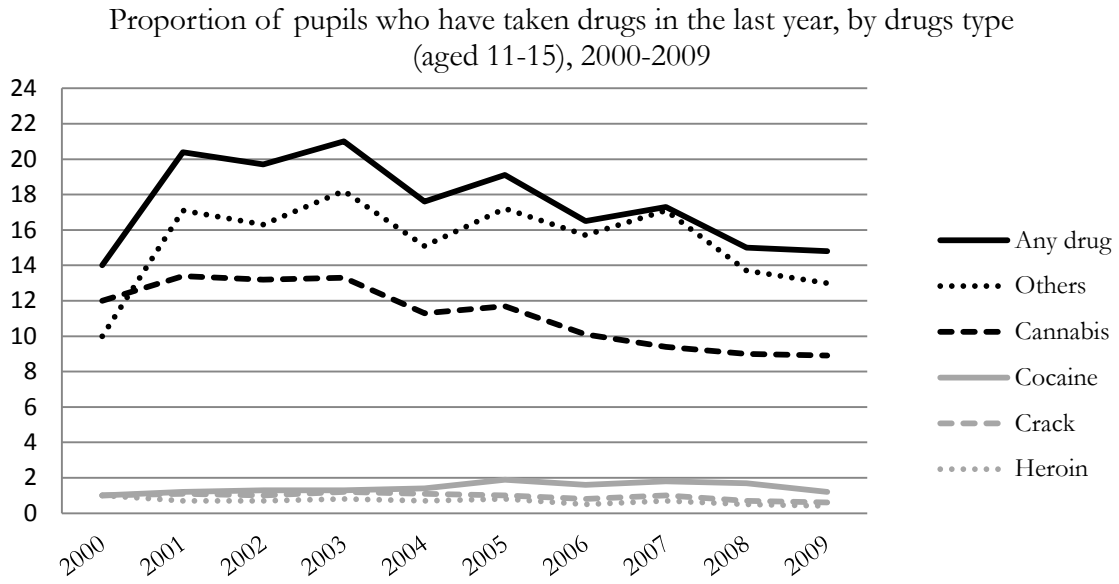
Figure 2.2.2 Trends in drug use among 16-24 year olds in England and Wales



See note to Figure 2.2.1.

The BCS gives us no information about another important group of drugs consumers, those under 16. To follow the trends in their drug use, we present data from the Schools Studies (for England only) in Figure 2.2.3. Again, we see evidence that overall drug use declined after about 2003, falling from an annual prevalence of about 20% to 15% in 2009 (it is not clear what is behind the apparent sharp increase from 2000 to 2001). Cannabis prevalence follows a similar decline, from 13% to 9%, as does a residual category of other drugs (including ecstasy and solvents). As for adults, there was also an increase in the annual prevalence of powder cocaine, from 1% in 2000 to around 2% near the end of the decade, although the prevalence was only about a fifth of that in the 16-24 year age group. School pupils report higher prevalence of crack and heroin (0.5–1%) than adults, though they remain low and there is no apparent trend.

Figure 2.2.3 trends in drug use among 11-15 year olds in England



Note: 'Others' includes ecstasy, amphetamines, poppers, LSD, magic mushrooms, ketamine, methadone, glue, gas, aerosols and other solvents, tranquilisers, anabolic steroids and other drugs, excluding cannabis.
Source: annual school surveys of Smoking, Drinking and Drug Use.

Although drug use seems to have fallen in recent years in England and Wales, it remains high compared to other European countries. ESPAD has collected four sweeps of data since 1995 on the substance use of 15-16 year old European school students. We use data from the fourth sweep in 2007. Figure 2.2.4 shows the percentage of students who had ever taken cannabis: with a prevalence of 29%, the UK is among the highest consuming countries, behind only France, Switzerland , Slovakia and the Czech Republic. More than half the surveyed countries reported average prevalence of less than 20%.

Figure 2.2.4 Lifetime cannabis prevalence among 15–16 year olds in Europe

It is important to bear in mind that these survey-based estimates of drug prevalence are likely to be substantial under-estimates of true drug prevalence. There are two main reasons for this.

Under-reporting Drug possession is illegal and survey respondents may be reluctant to admit their past drug use at interview. Methods such as Computer-Assisted Self Interview (CASI) are routinely used to ensure the confidentiality of responses and these methods have been shown to elicit higher rates of self-reported prevalence, but there remains some evidence of under-reporting. A review by Pudney et al (2006) suggested that under-reporting might be 5-6% for

cannabis.

Nonresponse Survey participation is voluntary, and there is a significant refusal rate in all the surveys which provide evidence on drug use. If drug-users are more likely to refuse co-operation, then the achieved sample will over-represent non-drug users and under-estimate prevalence. A further problem for survey measurement is that some prolific drug users live in "chaotic" conditions and are hard to contact, either because they have no formal home or because their pattern of activity makes contact difficult. Pudney et al (2006) attempted to overcome this problem in their study of the drugs market in 2003/4 by combining general-population surveys with a survey of arrestees which was believed to have better coverage of this hard-to-reach group. Their estimates, which are shown in Table 2.2.1, suggest that estimates of last-year prevalence based on household surveys like the British Crime Survey understate the number of cannabis users by at least 30%.[2] This is a large bias, but less than the degree of under-estimation found for more damaging drugs like heroin and crack.

Table 2.2.1 Alternative estimates of England and Wales drug prevalence (users within previous year)

	BCS 2003/4 estimate: ages 16-59[a]	Pudney et al (2006) estimate: ages 17-59	Pudney et al (2006) estimate: all ages
Cannabis	3.363	4.824	5.521
Amphetamines	0.483	0.877	0.985
Ecstasy	0.614	1.210	1.289
Cocaine	0.755	1.326	1.390
Crack	0.055	0.241	0.302
Heroin	0.043	0.206	0.244

[a] Source: Chivite-Matthews et al (2005)

It was not feasible in this study to repeat the Pudney et al (2006) analysis to adjust for under-estimation of prevalence, because much of the data used in that study is not available for more recent years. Consequently, some of the prevalence-related estimates of policy costs and benefits presented in sections 5 and 6 and summarised in section 7 are likely to be under-estimates, although we do not expect the overall cost-benefit balance to be severely distorted.

2.3 Drug prices and purity

We review trends in the price (and purity) of illicit drugs in the UK using the available data since 2000. The data come from three main sources: the Serious Organised Crime Agency (SOCA) and forensic services; a survey of drug and alcohol services, police forces and service user groups conducted by the charity DrugScope; and a survey of drug users by the Independent Drug

[2] These prevalence figures were excluded from the version of Pudney et al (2006) published by the Home Office, apparently to avoid conflict with BCS estimates.

Monitoring Unit (IDMU).

The data provided by SOCA (and its predecessor before 2006, the National Criminal Intelligence Service, NCIS) are collected from police forces around the UK, who obtain information using a variety of means, including test purchases, prisoner interviews and informants (UK Focal Point on Drugs, 2010). SOCA does not publish the data itself but does provide them in standardised form to international bodies such as the United Nations Office on Drugs and Crime (UNODC) and the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). Reports to the EMCDDA are passed via the UK Focal Point on Drugs, which publishes summary prices from the SOCA data in its annual reports on the UK drugs situation. The UK Focal Point also publishes data on drug purity, based on seizures analysed by the Forensic Science Service (FSS) and, more recently, LGC Forensics.

DrugScope is a charity which offers advice and support to organisations in the drug sector, and promotes evidence-based policy development. Every year since 2005, DrugScope has surveyed drug action teams (DATs), police forces and service user groups in 20 towns and cities across the UK. Average prices from the surveys are published in *Druglink* magazine, and we use the available data from 2006 onwards (also summarised in UK Focal Point on Drugs, 2010).

The Independent Drug Monitoring Unit is a company that monitors the state of the drugs market in the UK and provides expert witnesses in court cases. They conduct an annual survey which collects information on drug consumption and prices paid by drug users who volunteer to take the survey (mainly online). We use data published on the IDMU website covering prices from 2004 onwards.

The three data sources are clearly very different from each other in their sampling methods, respondent populations, response modes and geographical coverage. Illicit drugs are far from being a standardised product, and so there will be differences in reported prices owing to variation of drug types and quality (for example, the IDMU survey collects separate prices for five types of cannabis , compared to only two or three in the other sources) and differences in purity. It is not feasible to make adjustments for all these differences, and given the lack of data harmonisation we would expect average prices to differ over sources. However, our main interest is not to compare alternative price estimates at a point in time, but to get a picture of trends over the last decade. As will be seen below, the trends from the three sources are broadly consistent with one another.

Cannabis

We distinguish three forms of cannabis:

(*i*) *Sinsemilla* ("without seeds") is a herbal form prepared from the flowering tops of

unpollinated female plants. Sinsemilla is believed to be mainly produced domestically rather than imported, using indoor production methods with artificial lighting. It is often referred to as "skunk", especially varieties with a particularly strong aroma. Sinsemilla commands the highest market price.

(*ii*) *Herbal* cannabis refers to all other unprocessed material from the cannabis plant. It is mostly imported.

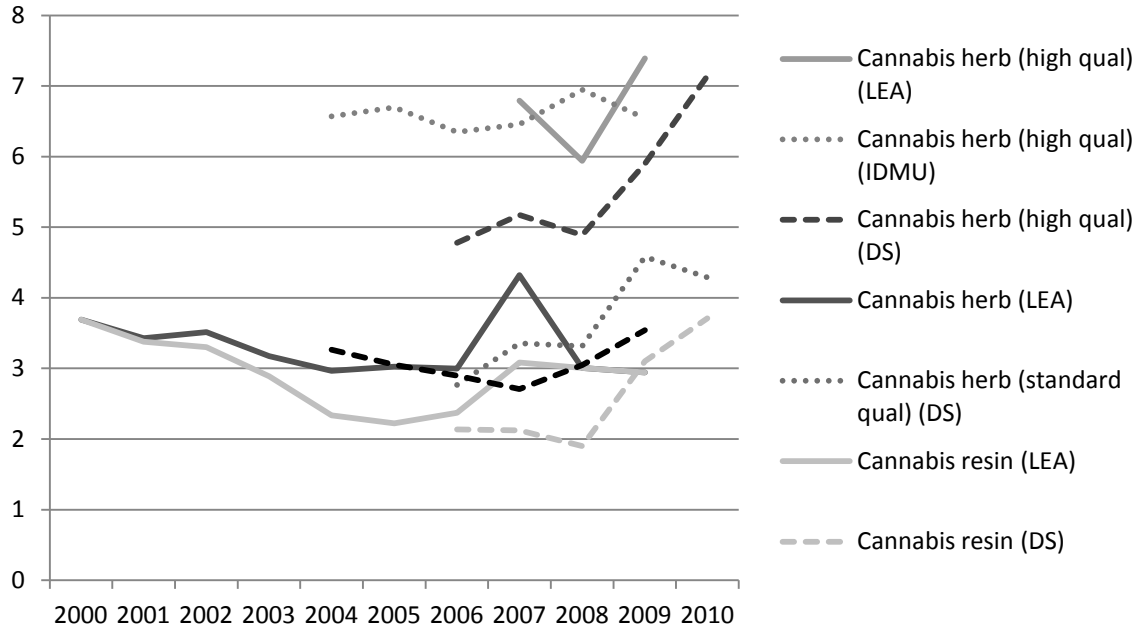
(*iii*) *Resin* or *hashish* is extracted from the cannabis plant and (mainly) imported from North Africa in the form of compressed dark brown or black blocks.

Figure 2.3.1 shows the price of cannabis, distinguishing between these three types. The long run of SOCA data show that the prices of resin and standard quality herb both fell during the first half of the decade, from a high of nearly £4 per gram in 2000 to around £2–£3 in 2006. The trends are broadly corroborated by the IDMU data from 2004. All the data sources then show a resurgence of prices from around 2006 onwards. By 2010, standard herbal cannabis and resin were back up to around £4 per gram, with high-quality cannabis being sold for about £7 per gram after showing significant rises from 2008 onwards (the IDMU data are an exception here, indicating that sinsemilla prices were flat overall from 2004-9).

We should note that the reference purchase weights used in the SOCA and DrugScope data were reduced in 2006 and 2008 respectively (see notes to Table 1), which would lead to a one-off increase in the price per gram equivalent in these years (given that larger drugs purchases are cheaper per unit weight). This change may overstate the apparent upward trend, however IDMU reports that there were large increases in all cannabis prices in 2010 (full data not yet published), providing further evidence for a reversal of the falls in the first half of the decade.[3] It is tempting to attribute the increased price of cannabis since 2009 to the effect of reclassification to class B that occurred at the start of 2009, but this would be unsafe, since there is no corresponding evidence of a fall in price following the earlier reclassification to class C in January 2004.

[3] Online press release: "IDMU Survey reports big hike in 2010 UK Drug Prices", http://www.idmu.co.uk/big-hike-in-2010-uk-drug-prices.htm

Figure 2.3.1 Price of cannabis per gram equivalent since 2000 (indexed to 2010 prices)



Note: Data sources are in parentheses: LEA is law enforcement agencies, DS is DrugScope, IDMU is Independent Drug Monitoring Unit. High quality herbal cannabis is skunk or sinsemilla. Prices are in £ per gram equivalents converted from street prices: LEA prices are based on the price for an ounce until 2006, and the price for 1/8 ounce from 2007; Drugscope prices are based on the price for an ounce until 2008, and the price for ¼ ounce from 2009; IDMU prices are based on the price for 1/8 oz. LEA data sources: UK Focal Point (2001), NCIS data for 2000; UK Focal Point (2005), NCIS data for 2001-2003; UK Focal Point (2010), NCIS/SOCA data for 2004-2009. DrugScope data source: UK Focal Point (2010). IDMU data source: pages from IDMU website http://www.idmu.co.uk/prices.htm

The concept of purity is ambiguous in the case of cannabis, which has a complex chemical structure involving many different compounds ("cannabinoids"). The primary psychoactive constituent of cannabis is Δ^9-tetrahydrocannabinol (THC), but perceptions of product quality are influenced by other product characteristics, and these quality variations are reflected in the large number of named product varieties ("Red Seal", "Black Moroccan", "Northern Lights", etc). There is some evidence from police seizures of cannabis to suggest that there has been a sharp rise in the average potency (THC content) of purchased cannabis since 2002, due almost entirely to a shift from low-potency imported herb and resin to higher-potency sinsemilla (see Table 2.3.1). There is no discernible trend in average THC content within each of the sinsemilla, herb and resin categories since 2000 (ACMD 2008, Table 5). The rising trend in market share of sinsemilla has been much exaggerated in parts of the news media but it is a striking change in the structure of the retail market. However, it should be borne in mind that police seizures are unlikely to be representative of all cannabis purchases, and may over-represent cannabis "connoisseurs" who would, in any case, constitute an increasing share of the market if the falling trend in cannabis prevalence is due to an exit from the market of marginal consumers who

would otherwise have used only low-potency cannabis. Since 2009/10, the British Crime Survey has included a question asking respondents to distinguish between skunk and other forms of cannabis and responses to that question suggest a lower market share, with around half of cannabis users reporting use of at least some skunk.[4]

Table 2.3.1 Market share of cannabis types

Year	% sinsemilla	% herbal	% resin
	Market share (by weight)		
2002[a]	15	15	70
2004/5[b]	55	45 (herb & resin combined)	
2008[b]	81	3	16
	Median potency (THC content)		
2004/5[b]	14.0	2.1	3.5
2008[c]	15.0	9.0	5.0

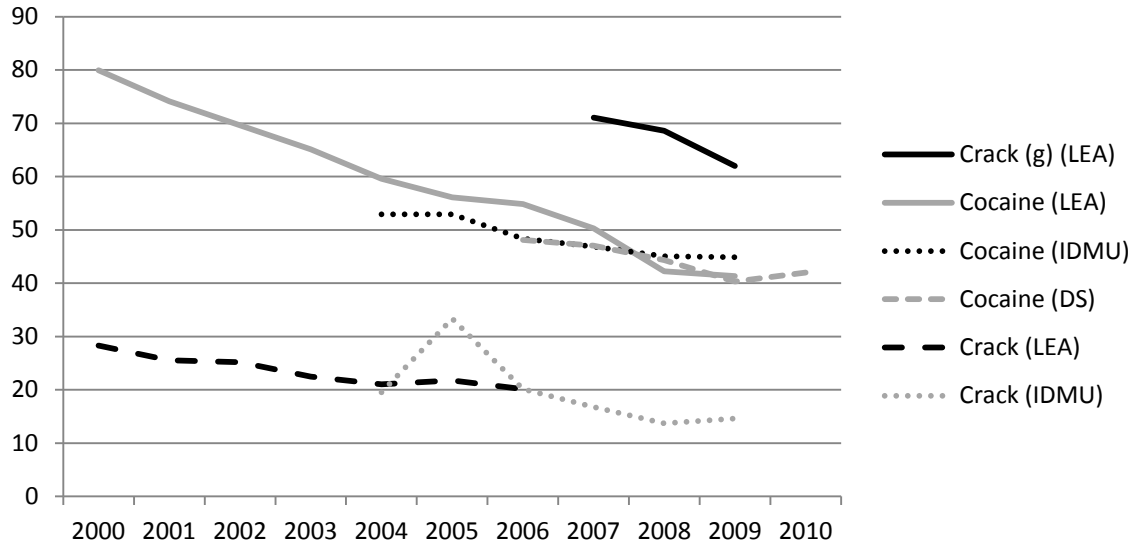
[a] King et al (2005); [b] Potter et al (2008); [c] Hardwick and King (2008)

Powder cocaine and crack

Figure 2.3.2 shows that the prices of powder cocaine and crack have been falling almost continuously since 2000 (the top line segment is the gram price provided by SOCA from 2007 onwards; other crack prices are per rock). Cocaine fell from £80 per gram in 2000 to only £40 per gram in 2009, while crack also roughly halved in price from £30 per gram in 2000. However, these trends can be misleading because it is also known that the purity of cocaine and crack have declined in recent years. The UK Focal Point also publish data from the FSS (and latterly, LGC Forensics) on the purity of drugs seizures, showing that the purity of both cocaine and crack fell fairly continuously over the decade (from 52% in 2000 to 20% in 2009 for cocaine, and from 66% to 27% over the same period for crack). Using these annual data, we have made approximate adjustments to the price trends in Figure 2.3.2. The adjusted data in Figure 2.3.3 suggest that the adjusted price of cocaine and crack was fairly stable over most of the decade, but began to rise quite sharply after 2007. This is also in line with IDMU reports of low cocaine and crack purity.[5]

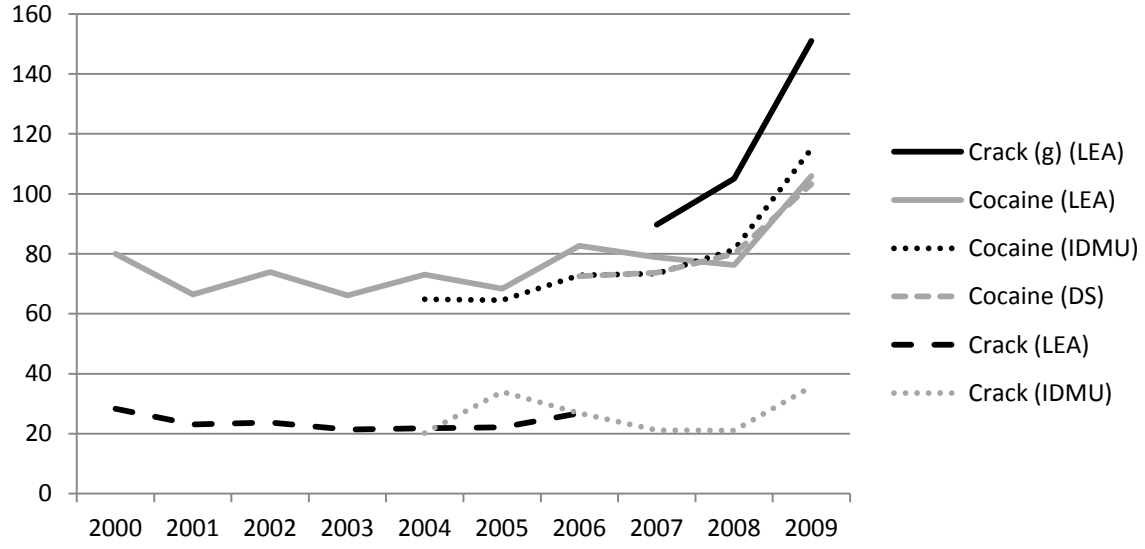
[4] Note that the term skunk is often used only for certain particularly pungent types of sinsemilla, so this may understate the market prevalence of high-THC sinsemilla to some unknown extent.
[5] http://www.idmu.co.uk/big-hike-in-2010-uk-drug-prices.htm

Figure 2.3.2 Price of powder cocaine (g) and crack cocaine (rock) since 2000 (indexed to 2010 prices)



Note: See note to Figure 2.3.1. LEA crack prices are per gram from 2007 (per rock previously).

Figure 2.3.3 Purity-adjusted price of powder cocaine (g) and crack cocaine (rock) since 2000 (indexed to 2010 prices)

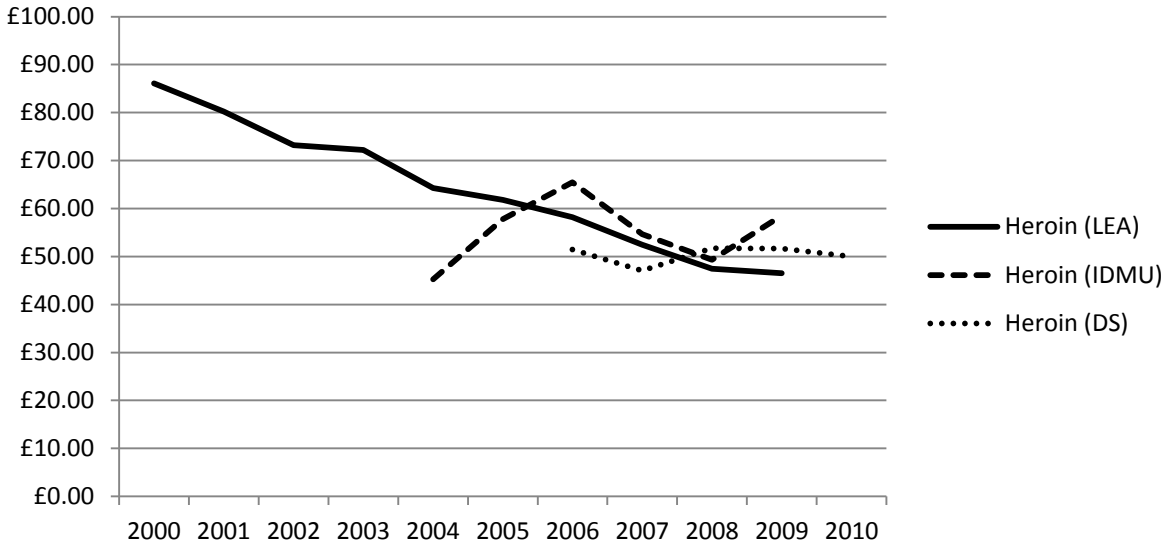


Note: See notes to Figures 2.3.1 and 2.3.2. Purity data sources: UK Focal Point (2002), FSS data for 2000–2002; UK Focal Point (2010), FSS data to 2007, FSS and LGC Forensics from 2008 onwards.

Heroin

Figure 2.3.4 shows a slightly different picture for heroin prices. The SOCA data show a long term downward trend, while the IDMU and DS prices for the second half of the decade show that prices were flat overall, although somewhat volatile.

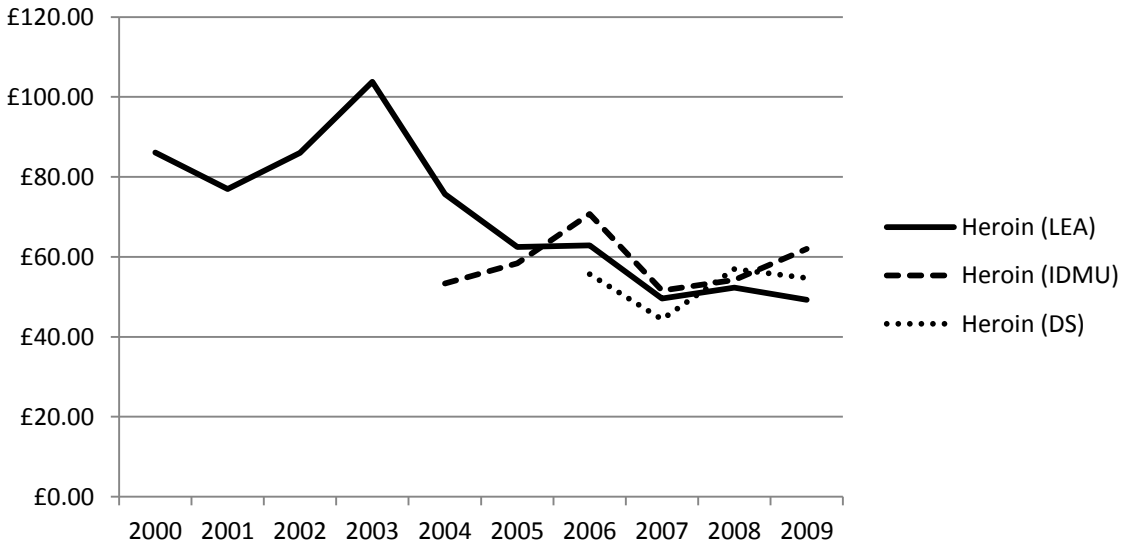
Figure 2.3.4 Price of heroin(g) since 2000 (indexed to 2010 prices)



Note: See notes to Figure 2.3.1.

Adjusting the prices for purity (Figure 2.3.5) suggests that the downward trend in prices since 2000 was interrupted by a large adjusted price hike in 2003 owing to a drop in purity. Nevertheless, recent prices still appear to be near historic lows.

Figure 2.3.5 Purity-adjusted price of heroin(g) since 2000 (indexed to 2010 prices)

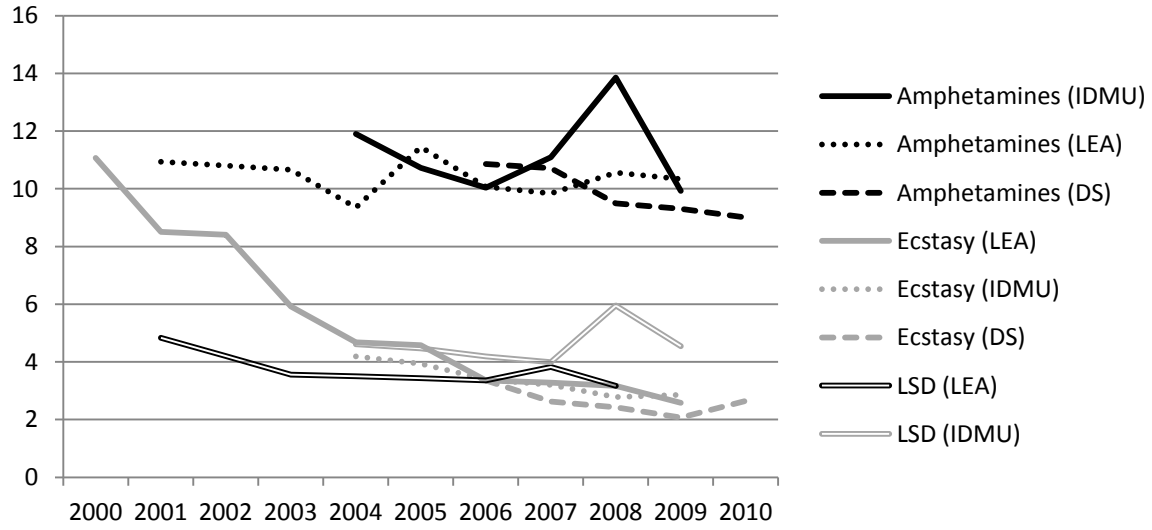


Note: See notes to Figure 2.3.1and 2.3.3.

Amphetamines, ecstasy and LSD

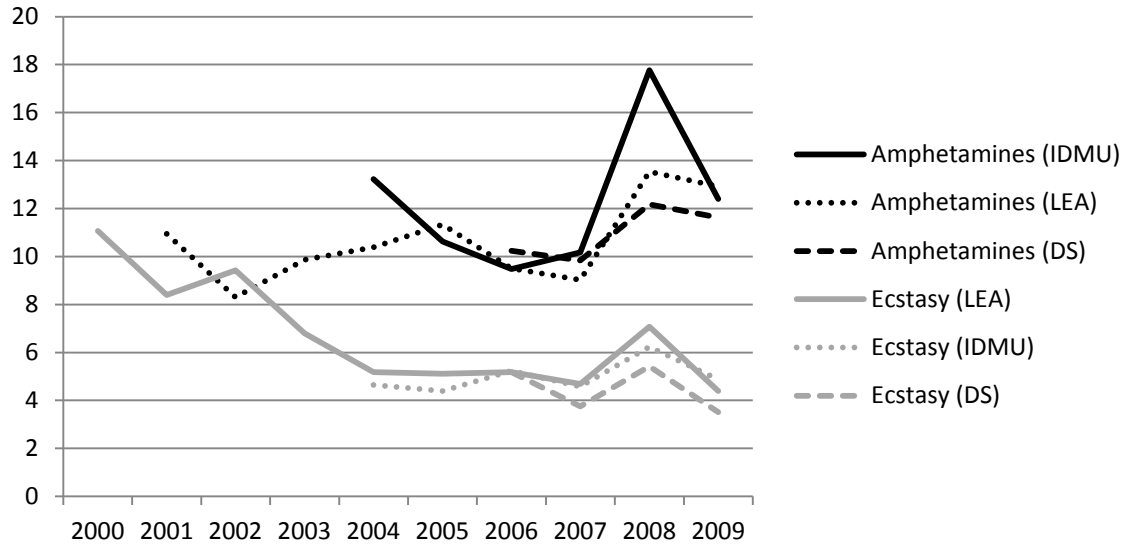
Finally, we turn to amphetamines, LSD and ecstasy. The data suggest that LSD and amphetamine prices have been broadly flat in recent years, with perhaps an uptick in 2008, while the price of an ecstasy tablet has fallen dramatically, from £11 in 2000 to just over £2 in 2009 (Figure 2.3.6).

Figure 2.3.6 Price of amphetamines (g), ecstasy (tab) and LSD (tab) since 2000 (indexed to 2010 prices)



However, as for cocaine and crack, there are have been large falls in the purity of ecstasy tablets (from 74mg of MDMA base per tab in 2000 to 44mg in 2009, according to FSS/LGS Forensics data; UK Focal Point, 2010). Making an adjustment for purity, Figure 2.3.7 indicates that the "real" price of an ecstasy tab in 2009 (in terms of purity in 2000) was closer to £4 than the nominal street price of £2. Amphetamines also declined slightly in purity; thus there was a moderate increase in the adjusted price over the decade. (We have no data on the purity of LSD tabs and so cannot make any adjustment.)

Figure 2.3.7 Purity-adjusted price of amphetamines (g) and ecstasy (tab) since 2000 (indexed to 2010 prices)



The overall picture emerging from the data is that drug prices have either fallen or remained stable since 2000, although falling prices have been partly or largely offset by declines in purity (especially for cocaine and ecstasy). There is some evidence of a recent resurgence in cannabis prices and the effective price of cocaine and crack may also be being driven up by continuing falls in purity.

2.4 Enforcement

The Misuse of Drugs Act (MDA) has been the primary legislation for controlling psychoactive substances in the UK since 1971. This Act is intended to prevent the non-medical use of certain drugs and created a classification system that used the harm caused by a drug to define the maximum penalty associated with its possession and misuse. Drugs subject to this Act are known as 'controlled' drugs. The Act defines a series of offences, including unlawful supply, intent to supply, import or export (collectively known as 'trafficking' offences), unlawful production, and unlawful possession. The police have the special powers to stop, detain and search people on 'reasonable suspicion' that they are in possession of a controlled drug. The table below presents the current classification of controlled drugs and the maximum penalty that applies in relation to its possession or supply.

Table 2.4.1 Classification of drugs and maximum penalty under the Misuse of Drugs Act

Classification	Drug	Maximum penalty	
		Possession	Supply
Class A	Powder cocaine Crack cocaine Ecstasy LSD Magic mushrooms Heroin Methadone Methamphetamine Injectable Class B drugs (such as amphetamines)	7 years + fine	Life + fine
Class B	Amphetamines Barbiturates Cannabis (since January 2009) Codeine	5 years + fine	14 years + fine
Class C	Anabolic steroids Ketamine (since April 2006) Minor tranquillizers (librium, valium, etc.) GHB/GBL BZP	2 years + fine	14 years + fine

Source: Drugscope (http://www.drugscope.org.uk/)

Figure 2.4.1 shows that drugs offences are a major contributor to the prison population (almost 13,000 prisoners, over 15% of the prison population), second only to the category of violence against the person. A majority of these cases involve drugs other than cannabis, but this does emphasise the far-reaching consequences of treating drugs as a criminal justice issue, since imprisonment is likely to have a long-term impact on the future legal employment opportunities open to those who fall foul of the law. A significant number of people are introduced to opiates for the first time while in prison, partly because the short detection window of heroin makes it relatively easy to evade mandatory drug testing (Dolan et al 2007).

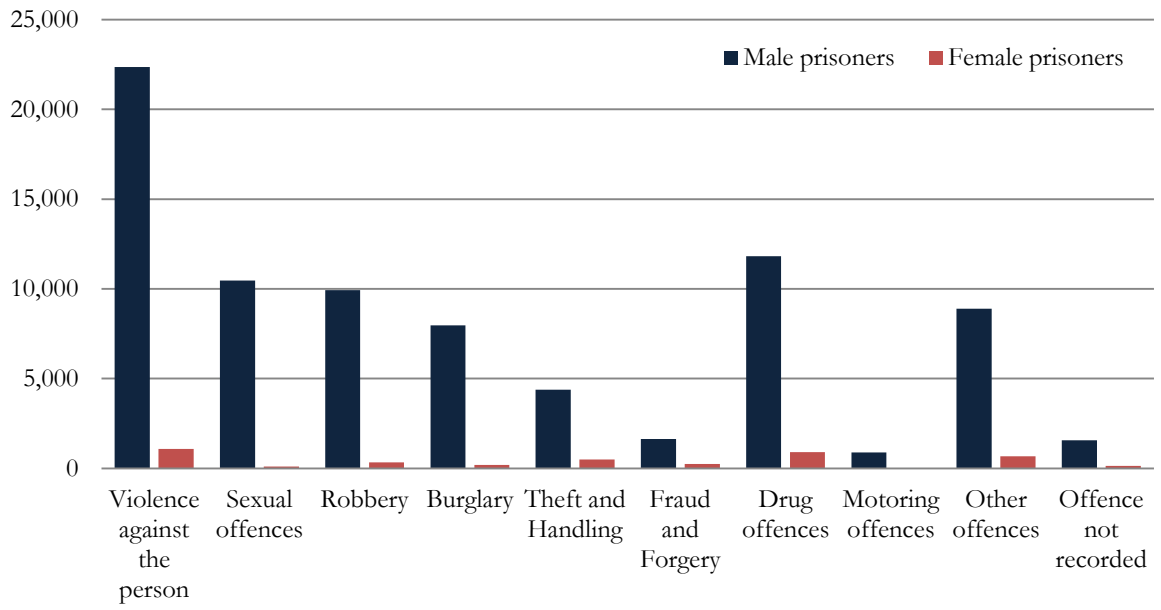
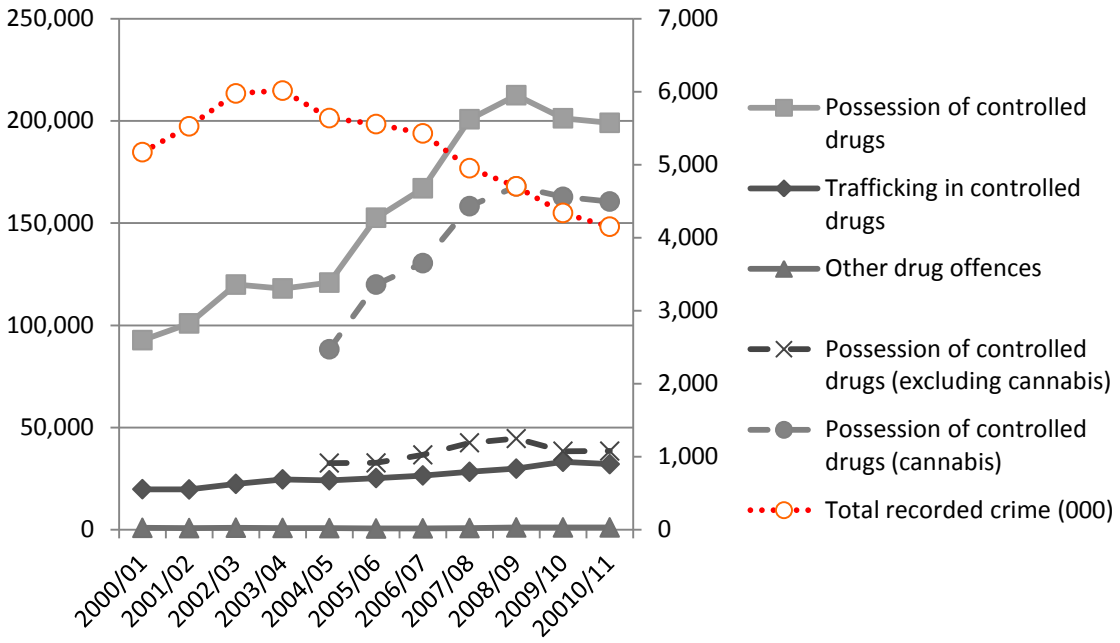


Figure 2.4.1 Prison population by offence class, 2010

As discussed in section 2.1, the classification of cannabis has been subject to several changes over time. In 2004, the then Home Secretary David Blunkett announced that cannabis was to be re-classified as a Class C drug. At the same time, the Association of Chief Police Officers (ACPO) issued guidance stating that those found in possession of cannabis should be given a warning and have the drug confiscated rather than being arrested. The intention was to reduce the potential unintended harm associated with the criminalisation of cannabis use and the workload of police officers. However, it is clear that the new system, perhaps together with the increasing importance of policing targets, created a perverse incentive to give and formally record offences that might otherwise have been dealt with informally. As Figure 2.4.2 shows, the recorded number of possession offences increased sharply after the introduction of 'cannabis warnings' in 2004.[6] This increase is entirely explained by cannabis possession offences and occurred at the same time as the number of trafficking and other drug offences was relatively flat, while the total recorded number of crimes (right axis) was actually falling.

[6] A cannabis warning is a spoken warning given by a police officer, either on the street or at the police station. The police have the option of using a cannabis warning when someone is caught with a small amount of cannabis for personal use.

Figure 2.4.2 Total recorded crime and drug offences, 2000/01 – 2010/11

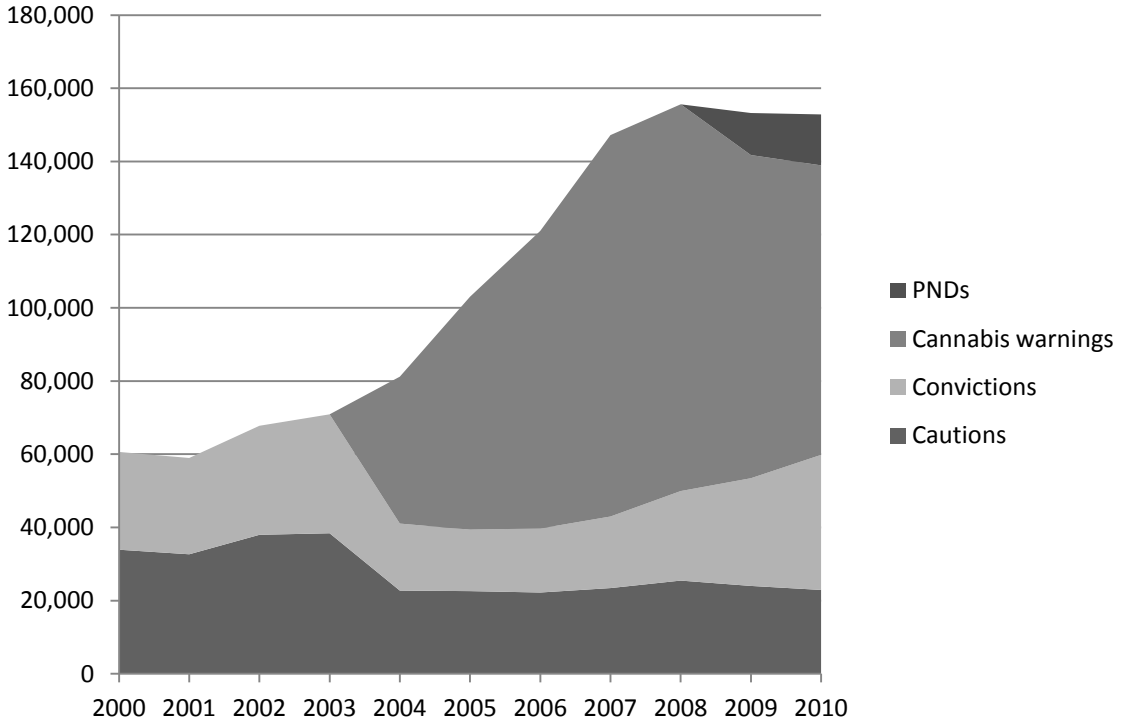


Source: Crime in England and Wales 2010/11 and 2009/10

Figure 2.4.3 shows the composition of the total number of police recorded cannabis possession offences by type of disposal. Out-of-court disposals, such as cannabis warnings and (as from January 2009) Penalty Notices for Disorder[7] (PNDs), account for the entire increase in cannabis possession offences brought to justice in recent years. Indeed, since 2004 the number of offences resulting in a caution or conviction actually fell. In percentage terms, cannabis warnings represented about 53% of the total number of cannabis possession offences in 2004 (40,138), reached a peak of 74% in 2007 (104,207), and then fell back to about 57% (79,100) in 2010, with PNDs accounting for a further 10% in the same year (13,916).

[7] PNDs are tickets that police officers can issue at the scene of an incident or in custody - they carry an on-the-spot fine of £80.

Figure 2.4.3 Cannabis possession offences by type of disposal

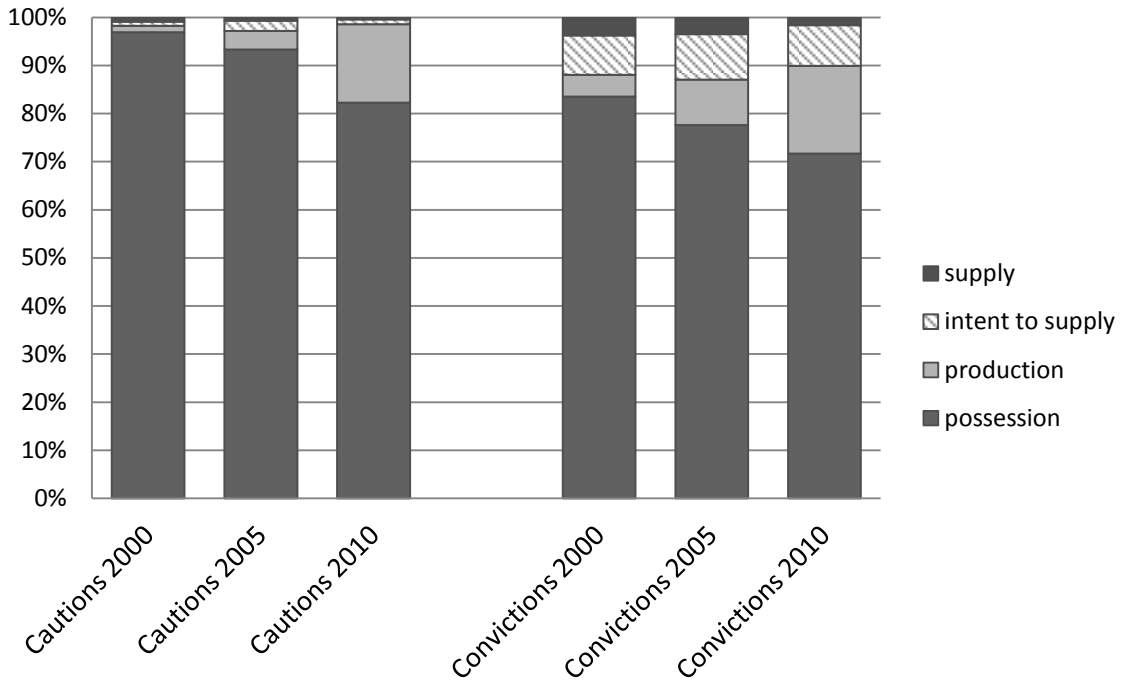


Source: Criminal Justice Statistics, various years

Another interesting trend that has emerged in the past decade is an increase in home-grown cannabis. Traditionally cannabis has been imported in the UK through drug dealers. However, in the past 10 or 15 years there has been a noticeable increase in the domestic production of cannabis. This is mainly due to technological innovations, such as the development of more resistant strains of cannabis which can grow also in temperate climates, and the increased availability of ultraviolet lights and hydroponic techniques. The success of intelligence-led interdiction of cross-border trade in cannabis may also have encouraged the increase in domestic production. As Figure 2.4.4 shows, this trend is reflected in the composition of cannabis cautions and warnings by type of offence. Although possession offences still constitute the vast majority of all cannabis offences dealt with in court, production offences (which include cultivation for personal use) resulting in cautions increased from 1.3% in 2000 to 16.4% in 2010, while those resulting in a conviction went from 14.5% in 2000 to 18.3% in 2010.

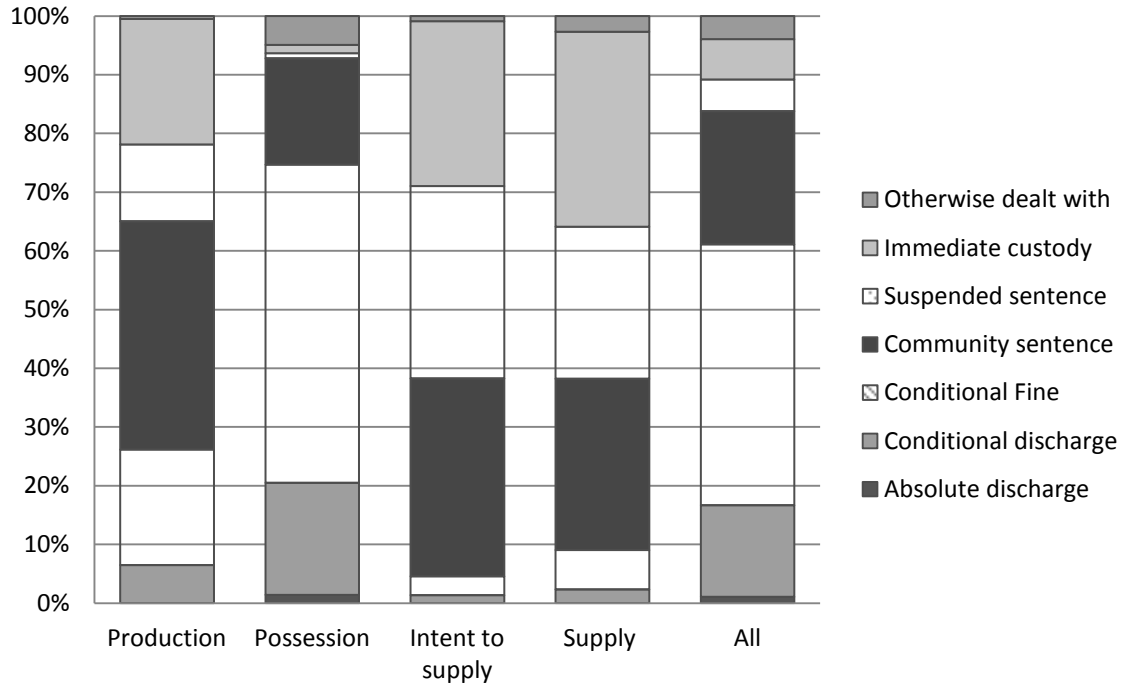
As shown in Figure 2.4.5, in 2010 the most common outcome received by adults sentenced for a cannabis offence was a fine, which was administered to over 41% of individuals found guilty of a cannabis offence and about 54% of those convicted of a possession offence. About 22% were sentenced to a community order, which was most frequent (39%) among those charged with production offences. Immediate custody was very infrequently applied to possession offences (only 1% of these), while it is most commonly used for supply offences (33%).

Figure 2.4.4 Cannabis cautions and convictions by type of offence



Source: Criminal Justice Statistics, various years

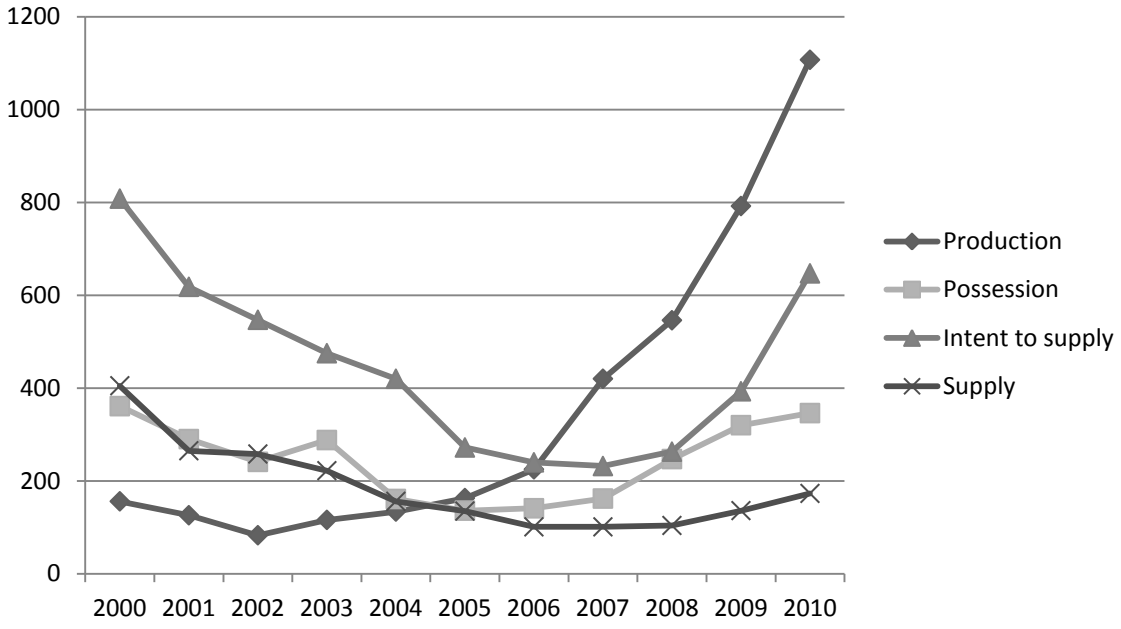
Figure 2.4.5 Persons sentenced by type of disposal 2010



Looking at trends, Figure 2.4.6 shows that the total number of people sentenced to immediate custody for supply, intent to supply, and possession offences has been decreasing over time until

2007, and increasing thereafter. By contrast, and in line with the trend shown in Figure 2.4.4, the number of individuals in custody for production offences has been increasing steadily since 2003. It is unclear whether this reflects an increasing tendency to use supply or production, rather than possession, charges in marginal cases.

Figure 2.4.6 Persons sentenced to immediate custody by type of cannabis offence

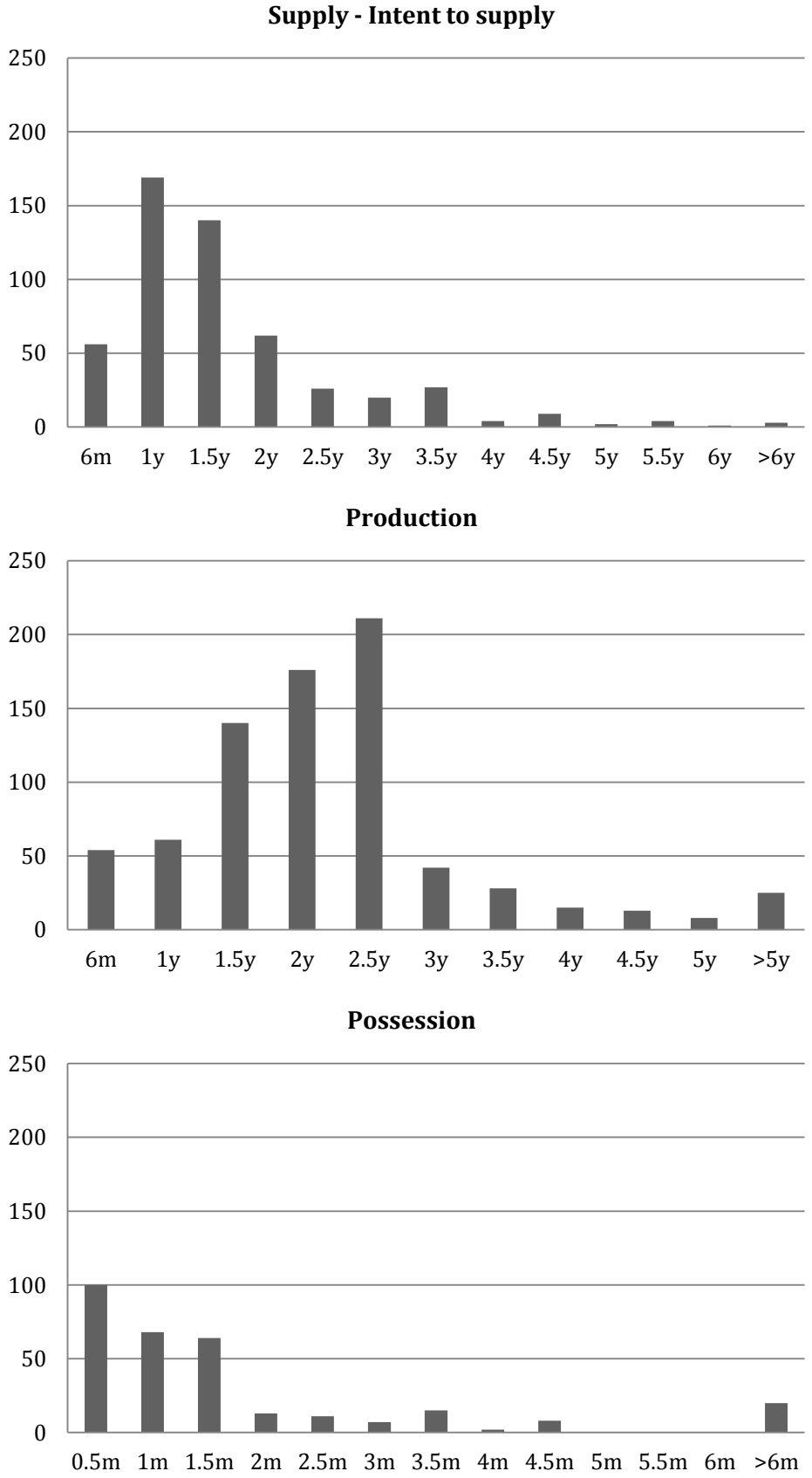


Source: Criminal Justice Statistics

In 2009, the average duration of a custodial sentence was 1 year and 3 months for a supply or intent to supply offence, 1 year and 9 months for a production offence, and only 2 months for a possession offence. The distribution of sentences is however rather skewed, as shown in Figure 2.4.7, with longer sentences being rather infrequent in particular when considering supply and possession. In terms of trends, Figure 2.4.8 shows that the average length of a custodial sentence for cannabis production remained stable at around 1 year until 2006, but then saw a steady increase in more recent years, presumably as a result of the increased incidence of large-scale home-grown cannabis cultivation.

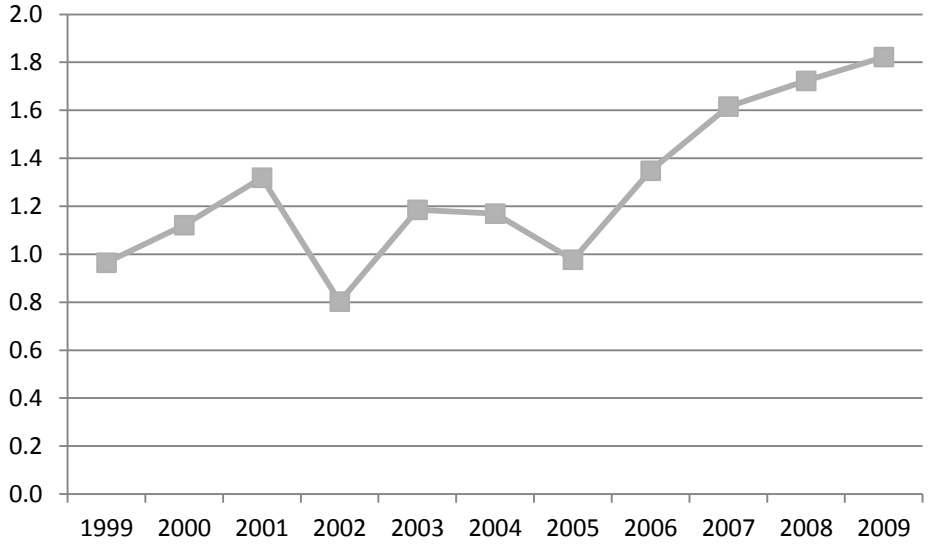
Finally, Figure 2.4.9 shows the average fine amount for cannabis possession offences from 1999 to 2009. The average fine in 2009 was equal to £84, and this has changed little since 1999. As the values shown are in nominal amounts, the figures actually imply a modest reduction in the value of the average fine over time.

Figure 2.4.7 Distribution of length of sentence by type of cannabis offence - 2009



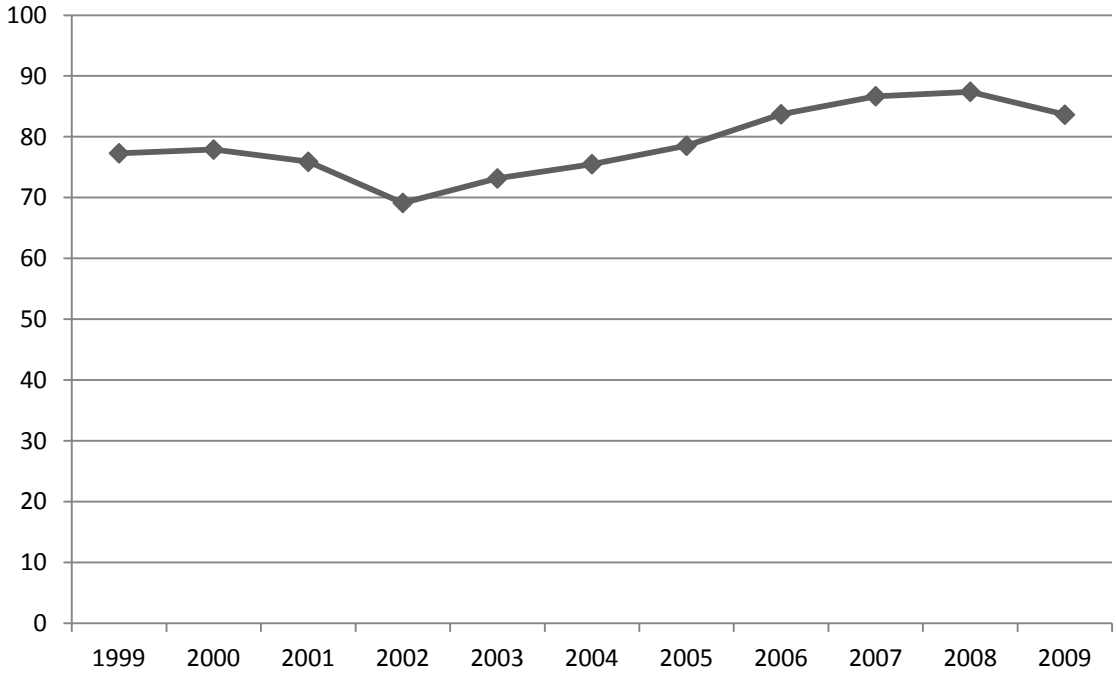
Source: Criminal Justice Statistics

Figure 2.4.8 Average sentence length for production offences



Source: Criminal Justice Statistics

Figure 2.4.9 Average fine amounts for cannabis possession offences



Source: Criminal Justice Statistics

2.5 Treatment

With the launch of the first ten-year drug strategy *Tackling Drugs to Build a Better Britain*[8] in

[8] See http://www.archive.official-documents.co.uk/document/cm39/3945/3945.htm.

1998 a range of policies aimed at overcoming the negative effects of problem drug use were gradually introduced in the UK. During these years (1998- 2008) the main focus was on tackling the use of illegal drugs by increasing the range of treatment programmes, imposing tougher legal sanctions, and establishing widespread public information campaigns. The second ten-year plan, based on the 2008 strategy *Drugs: protecting families and communities*[9], shifts the attention to the protection of children, young people and families affected by drug misuse. Both strategies emphasise the importance of treatment and seek to improve its quality and effectiveness (Department of Health, 1996; Gossop et al. 2001; Gossop 2006; NTA 2006).

The range of treatment interventions offered in England and Wales at present is very heterogeneous, including advice and information, care planning, psycho-social help, community prescribing, inpatient drug treatment and residential rehabilitation. In addition, drug misusers are offered relapse prevention and aftercare programmes, hepatitis B vaccinations, testing and counselling for hepatitis B and C, HIV, and needle exchange. Oral opiate substitution maintenance treatment with methadone is the most common pharmacological treatment used in treating heroin addiction. Given the sheer diversity of treatments on offer, co-ordination and integration between different providers is key in helping problem drug users. The monitoring of such a complex system differs between England and the devolved administration of Wales, and has changed dramatically over the last decades.

In England, the Regional Drug Misuse Database collected information about new presentations to drug services, or presentations after a break of six months or more, during the period between 1990 and 2001. This system was then superseded by the National Treatment Monitoring System (NDTMS), which collects data on all individuals in structured community-based services or residential and inpatient services (Tier 3 or 4). Responsibility for managing the NDTMS was transferred from the Department of Health to the National Treatment Agency (NTA) in 2003. The NTA reorganized the NDTMS, changing the definition of drug treatment and data collection methods between 2001 and 2005, and later revised the way in which substances are reported. As a consequence, very little information on treated *individuals* is available before 2004/05 and consistent data on main drug type goes back only to 2005/06.

A separate monitoring system has developed in Wales, where the Welsh National Database for Substance Misuse has been in operation since 2001. The system did not cover the majority of treatment agencies until 2005/06, though. Moreover, the data in this case mainly consist of the number of *referrals* (individuals can be referred more than once during the same year), while the classification of the main drug problem differs substantially from that used by the NDTMS.

[9] See http://www.gos.gov.uk/497468/docs/664685/Drug_strategy. PDF.

In what follows, therefore, we will report data for England and Wales separately. For each country we show the total number of individuals or referrals and the percentages by specific drug type for all the years available. Where possible, we distinguish between young people (aged less than 18 in England, and less than 20 in Wales) and adults (aged 18 or above in England, and 18 or more in Wales), as the distribution by drug type is very different for these two groups.

Figure 2.5.1 shows the number of individuals in contact with treatment services in England from 1998/99 to 2009/10. As we can see, this number has grown steadily over these two decades going from 85,000 individuals in 1998/99 to more than 220,000 individuals in 2009/10. In the last three years of data, however, this growth has tapered off. Although a strict year-on-year comparison is not advisable, due to changes in the methods of collection and definitions of treatment over time, the trend shown coincides with an increasing amount of resources devoted to treatment programmes during this period.

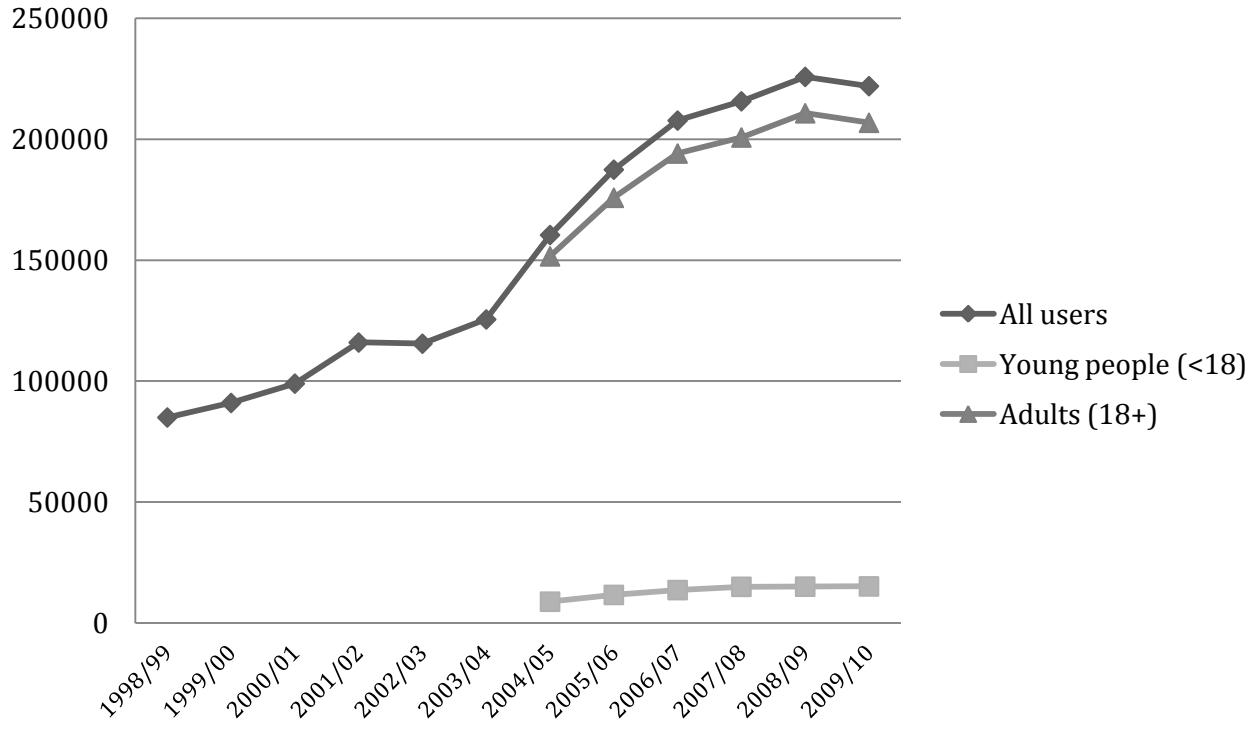


Figure 2.5.1 Number of individuals in contact with drug treatment services - England

Source: *Statistics from the National Drug Treatment Monitoring System (NDTMS)*, various years

We know, for example, that government funding for drug treatment services in England has risen significantly since 2001. Table 2.5.1 reports the most recent figures available for the combined funding from the Home Office and the Department of Health, known as the Pooled Treatment Budget (PTB) for drug treatment services for adults. At 2008/09 prices, this has

spiralled from £225m in 2004/05 to £381m in 2009/10. NTA also estimates that the drug treatment workforce has also grown significantly, from 6,000 practitioners and managers in 2002 to over 10,000 in March 2005 (NTA, 2006).

Table 2.5.1 Drug treatment budgets in England, recent years

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Adult pooled treatment budget	£225m	£300m	£380m	£383m	£373m	£381m*
Local funding	£226m	£226m	£224m	£207m	£208m	n.a.
Total	£481m	£526m	£604m	£590m	£581m	n.a.

Source: NTA, http://www.nta.nhs.uk/funding.aspx; * data for 2009/10 from Drugscope.

Figure 2.5.1 also shows the number in treatment by age group from 2004/05 onwards. It is clear that the vast bulk of people in contact with drug treatment services are aged 18 or above and that their share of the total number in treatment has not changed dramatically over the period for which data are available. In line with the general increase in the number of individuals in treatment, the graph shows that the number of people below 18 has gone from 8,800 in 2004/05 to around 15,000 in the period 2007/08-2009/10, but the latter figure still represents only 6.8% of the total.

The next two figures show the percentage of individuals in contact with treatment services by main problem drug. The NDTMS collects up to three substances as problematic for the individual at the point of triage. Data up to 2004/05 (not shown) used the first recorded substance to indicate why the individual is in treatment. More recently, the NTA has adopted a different definition of 'primary drug': individuals who have any opiate recorded in any of the three NDTMS substances and not crack cocaine will be reported under the group *opiates only*, where an individual has crack cocaine recorded and not an opiate they will be reported under the *crack only* category, if an individual had both opiates and crack cocaine recorded they will be reported under the *opiates and crack cocaine* category, and if neither opiates nor crack cocaine are recorded, then the first substances in the three NDTMS items reported is considered the main problem drug. This change in methodology was deemed necessary in order to monitor the increasing number of individuals presenting problems with both opiates and crack cocaine.

Figure 2.5.2 refers to the population of individuals aged 18 or above, i.e. the adult population that we know represents the overwhelming proportion of individuals in drug treatment. As we can see, over 50% of these individuals presents with an opiate problem (most frequently

heroin), while about 30% reports crack cocaine and opiates in combination as the main problem drugs. If we add to these individuals those with a crack only addiction, we account for about 83/84% of the adult population in treatment. The remainder is divided into those with cocaine problems (about 4-6%), those presenting with cannabis (6%), and those taking other main drugs (4%). The only visible changes over time are represented by a shift from *opiates only* to *opiates and crack cocaine* categories, the incidence of all other reported drug problems has remained constant in the last few years.

Figure 2.5.3 shows the distribution of the young population – individuals below 18 – by main problem drug. Here the picture is very different from what we have just seen. The proportion of young people reporting a problem with a Class A drug is very small. The main problem drug is represented by cannabis. In 2009/10 the number of people reporting a cannabis problem was over 13,000, i.e. about almost 87% of the total population of young people in contact with drug treatment services. And this percentage has been increasing over the past few years, as it was about 78% in 2005/06.

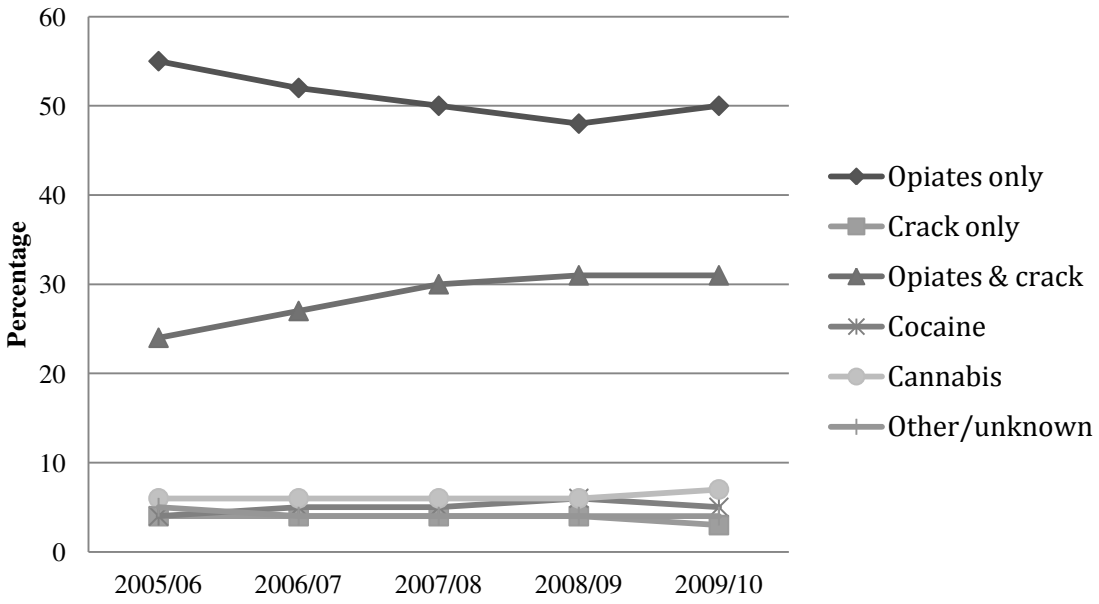


Figure 2.5.2 Adults (18+) in treatment by primary drug group - England
Source: *Statistics from the National Drug Treatment Monitoring System (NDTMS)*, various years

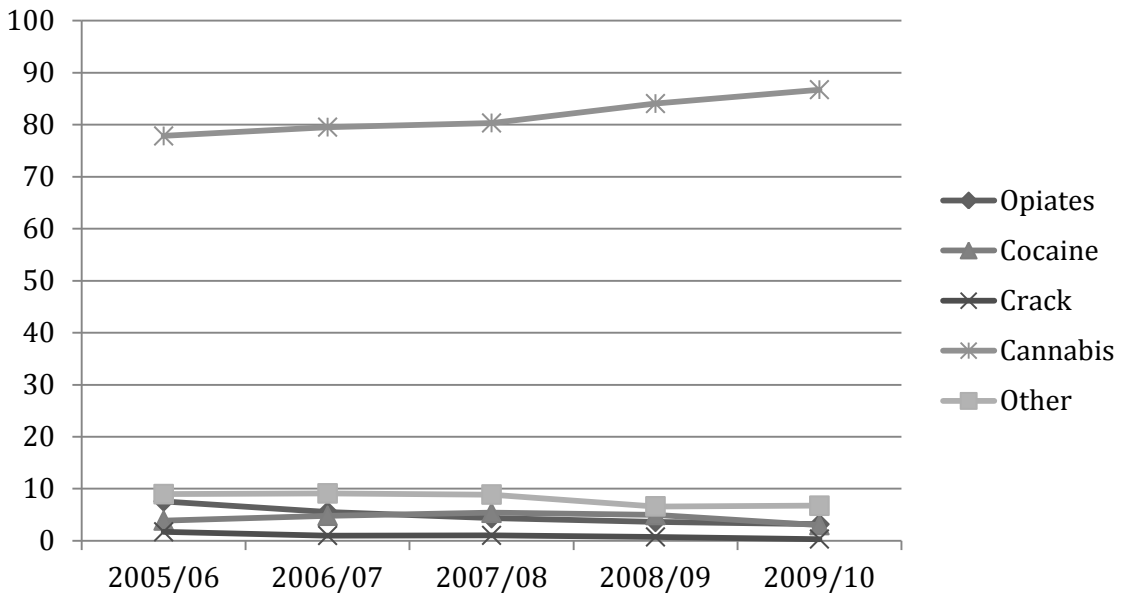


Figure 2.5.3 Young people (<18) in treatment by primary drug group - England
Source: *Statistics from the National Drug Treatment Monitoring System (NDTMS)*, various years

We now look at the situation in Wales, where data are collected by a different system and are expressed as *referrals* rather than individuals. Figure 2.5.4 reports the number of referrals in the years between 2005/06 and 2009/10. The figure shows an increase from about 6,700 referrals (corresponding to 5,700 individuals circa) in 2005/06 to more than 11,200 referrals (corresponding to almost 8,000 individuals) in 2009/10. This would correspond to a 67% increase in the number of referrals in 5 years (40% increase in the number of individuals), which seems unlikely. It is more plausible that the jump between 2005/06 and 2006/07 is due to problems with data collection in 2005/06 and that the number of referrals for drug treatment has been generally stable between 10,500 and 11,500 in the last period. Similarly to Figure 2.5.1, we see that the majority of referrals pertain to the 'adult population', here represented by individuals aged 20 or above. In this case the proportion oscillates between 12.5% and 14.5% in the last few years.

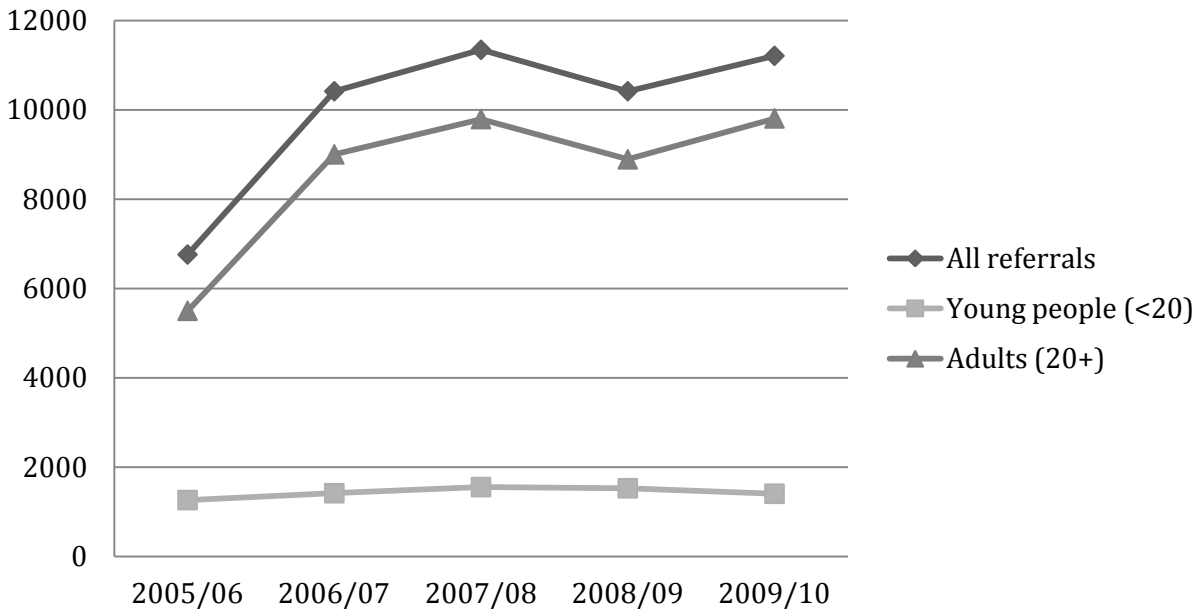


Figure 2.5.4 Number of referrals to treatment for drug misuse by age group - Wales
Source: Welsh National Database for Substance Misuse, online reports, available at http://wales.gov.uk/topics/housingandcommunity/safety/substancemisuse/stats/?lang=en

Figures 2.5.5 and 2.5.6 report the distribution of adults and young people referrals, respectively, by main drug. As we saw for England, the main problem drug is opiates (here specifically heroin) in the adult population and cannabis in the young population. Here, like in the case of England, the proportion of young people whose main problem drug is represented by cannabis has been increasing in the last few years. However, by contrast with the previous analysis, the proportion of people below 20 years who report other problem drugs is non-negligible, particularly when considering heroin.

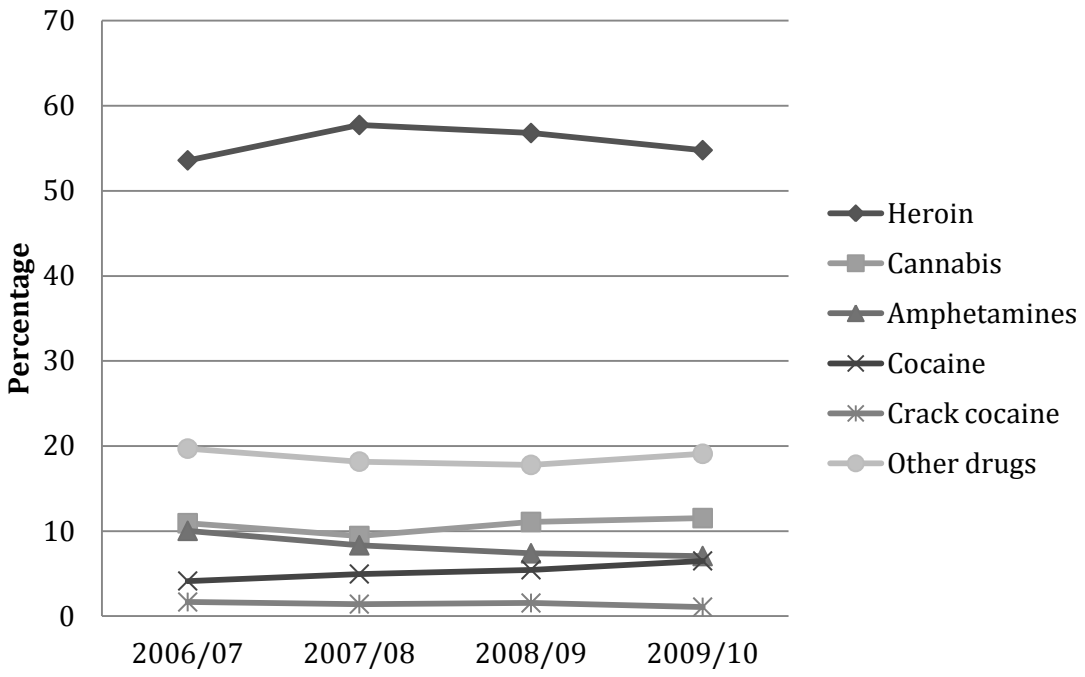


Figure 2.5.5 Adults referrals (20+) by main drug - Wales

Source: Welsh National Database for Substance Misuse, online reports, available at http://wales.gov.uk/topics/housingandcommunity/safety/substancemisuse/stats/?lang=en

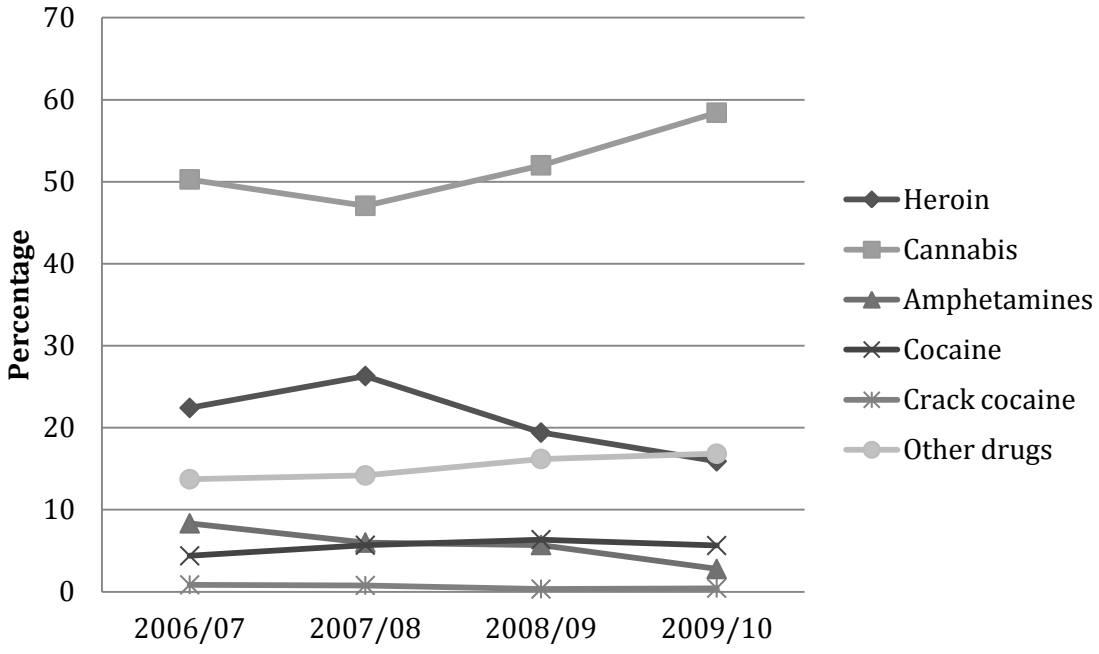


Figure 2.5.5 Young people referrals (<20) by main drug - Wales

Source: Welsh National Database for Substance Misuse, online reports, available at http://wales.gov.uk/topics/housingandcommunity/safety/substancemisuse/stats/?lang=en

3 Licensing and regulation: a possible reform

At present, the UN conventions require the UK to maintain a formal prohibitionist stance on cannabis. We have argued elsewhere (Pudney 2010) that there is a strong case for removal of domestic production and sale of cannabis from these treaties to allow national governments greater freedom to develop alternative policies which might, in some cases, extend to licensing and regulation. We make a basic assumption that the ban on international trade in cannabis incorporated in the UN conventions would remain in place, so that importation and exportation of cannabis products stays prohibited. For purposes of measurement, our analysis relates to England and Wales, but we assume that an identical licensing and regulation framework is also implemented in Scotland, to avoid distortionary responses to cross-border tax differentials like those generated by the Northern Ireland/Irish Republic border. Apart from this, we can only speculate on the system that would be implemented.

More research attention has been paid to various forms of decriminalisation or depenalisation than to licensing and regulation. Most such reforms maintain formal illegality of production possession and supply, whilst removing penalties for possession of moderate amounts of the drug, or substituting them with informal warnings or other 'dissuasion' activity. The Portuguese reform of 2001 was of this type, with local *Commissions for the Dissuasion of Drug Addiction* given powers to summon offenders in possession small amounts of the drug (2.5g in the case of cannabis) for discussion and imposition of sanctions such as community service, fines and various forms of treatment and advisory action. Supply activity remains heavily penalised and possession of larger amounts may lead to criminal charges (Hughes and Stevens 2010). The celebrated Dutch 'experiment' goes further than this, by decriminalising retail (but not wholesale) supply activity through approved outlets. All reforms of this sort fall short of the licensing and regulation option considered here. There are four main differences. First, under the envisaged system of licensing, the fact of illegality is removed, with possible consequent changes to the image of the product. Second, licensing allows the possibility of direct regulation of the physical attributes of the product. Third, it removes the heavy penalties for suppliers (licensed suppliers, at least), with the associated reduction in criminal justice system costs to society at large and to the suppliers themselves. Fourth, licensed supply allows the possibility of taxation of the product, generating tax revenue for government. Given these major differences, it is important to avoid lumping together decriminalisation and licensed supply under a generic heading of liberalisation – they are quite different.

3.1 Three visions of a regulated market

There are many possible visions of what a regulated cannabis market might look like. If introduced in practice, a host of detailed decisions would have to be taken about the nature of

regulation, and the market outcome may depend critically on what those decisions were. Rolles (2009) provides a comprehensive discussion of the options for design of market institutions. Any detailed specification would be highly speculative so, instead, we contrast three broad approaches to licensing and regulation in quite general terms.

3.1.1 A medical market

Cannabis has been claimed to have valuable therapeutic properties in a number of medical settings, particularly as pain relief for sufferers of chronic serious diseases like multiple sclerosis and cancer. Many of the large number of cannabinoids (chemical constituents specific to cannabis) are currently under investigation by pharmaceutical companies as possibilities for future prescription drugs. A few countries (notably the Netherlands since 2003) and a number of states of the USA already license the supply of cannabis on doctor's prescription. It can be argued that the first steps towards such a system have already been taken in Britain, since a synthetic cannabinoid called nabilone (cesamet) is licensed for treatment of nausea during chemotherapy, and a cannabis extract called Sativex[10], is licensed for relief of pain and other symptoms in multiple sclerosis. As the NICE clinical guideline (NICE 2003) states: "the development of Sativex was a response to a government proposal, which recognised the undesirable health and social consequences for people who were obtaining illegal cannabis for purposes of symptom relief". However, it appears that few practitioners prescribe Sativex at present, and its planned NICE review is currently suspended.

We think it highly likely that medicinal prescription of cannabis derivatives will become routine in the foreseeable future, putting an end to the occasional distressing incidents of terminally-ill patients subjected to police searches and arrests for illicit cannabis use that occur today. However, we see the development of a medical market as a quite limited innovation in British cannabis policy because relatively few of the very large number of cannabis users would be likely to qualify for prescription. Note that medicines are zero-rated for VAT in the UK, so the medical market does not lend itself to market control through taxation, nor to the use of tax revenue to fund treatment and health information programmes.

We do not expect to see a medical market for cannabis-derived products to develop along the lines of the system that has operated in California following the 1996 referendum which introduced a liberal system in which a doctor's written opinion of the existence of a medical need for cannabis (but not a formal prescription) is sufficient to protect the cannabis user from a charge of possession and his or her supplier from a trafficking charge. This loose system of regulation has allowed many people without substantial health problems to gain access to

[10] Sativex is formulated as an oral spray containing 2.7 mg THC and 2.5 mg CBD.

cannabis, and has been criticised as "backdoor legalisation". Lacking both the tight product control that we see in the market for prescription pharmaceuticals and the indirect taxation applied to products like alcohol and tobacco, this policy seems to lack the potential benefits that regulation might bring.

3.1.2 Regulation with light product control

There are several models that might be used as indications of what a regulated non-medical cannabis market would look like. One is the referendum proposal for an amendment to the Swiss federal constitution introducing "*une politique raisonnable en matière de chanvre protégeant efficacement la jeunesse*" (which was defeated by 63% to 37% in November 2008). Another is the more detailed Proposition 19 in California (defeated by 54% to 46% in a ballot in November 2010). The latter proposal would have permitted possession of up to 1 oz. of cannabis for personal consumption, consumption in non-public or specially licensed public places, and cultivation of cannabis in a private residence for personal use. Local governments would have been allowed to authorise retail sales of up to 1 oz. to people aged over 21, with a responsibility for regulating location, trading hours and promotional material. Other provisions would have permitted larger-scale possession and commercial production subject to local government approval, and the collection of indirect taxes. These abortive reform initiatives would have produced a system with little regulatory control over the nature of the product. The outcome would almost certainly have been a market with a large number of heterogeneous suppliers offering a wide range of product varieties. Since Proposition 19, similar initiatives have been passed by referendum and are in process of implementation in Colorado and Washington State, but the constitutional issues raised by conflict with prohibitionist federal law are unclear.

The closest parallel among legal UK markets is probably the market for alcohol, where regulation is also light. Although the product is heavily taxed, advertising is allowed on national TV, controls on alcoholic content are mainly confined to differential tax rates and, apart from the age 18 limit, there are only modest restrictions on consumption. Production of alcoholic drink is subject to requirements for registration or licensing, which historically originated from concern for public order and wartime production, and currently appear to be motivated as much by a concern to protect tax revenue as to promote public health. For example, there is a basic requirement for all registered/licensed producers to provide financial guarantees covering projected tax liabilities. A major difference from any form of cannabis regulation is that cultivation of the crops required for producing alcohol (barley, grapes, hops, etc.) is essentially unrestricted. Production of beer and cider is subject to registration for taxation purposes, but market entry is relatively easy and there are few controls on the production process itself, while wines and spirits are subject to more stringent licensing involving approval of plant and

processes. Unlicensed production of certain alcoholic drinks (mainly beer and wine) for personal domestic consumption is permitted. The proliferation of micro-breweries in recent years shows that the requirements imposed by the revenue protection principle are not necessarily a barrier to market entry by small producers.

This type of market organisation has three significant disadvantages. First, the multiplicity and heterogeneity of suppliers makes regulation more difficult. Second, it is not clear that such a market would do anything to reduce the prevalence of high-THC low-CBD sinsemilla or of damaging smoking material, so health concerns may remain. Third, it seems unlikely that this relatively permissive form of market organisation would achieve sufficient public support to become a politically feasible reform.

3.1.3 Regulation with stringent product control

There is an instructive contrast between the alcohol and tobacco markets. Regulation is much tighter for tobacco: all advertising is illegal, smoking is banned in most public places, the product itself is subject to direct controls, and there is a very active programme of health education aiming at demand reduction. The third vision of a legal regulated market for cannabis would have much in common with the market for tobacco and seems to us the most plausible type of reform in the British context.[11] There is likely to be public demand for stringent controls (see Branson *et al.* 2012 for recent survey evidence on the public support for regulation of markets for potentially harmful consumption goods) and, to achieve public acceptance in Britain, we would expect regulations on a licensed cannabis market to be at least as strict as those on the tobacco market, despite the evidence of rather less social harm for cannabis than either alcohol or tobacco.

Consider the existing tobacco market: unlike cannabis, **t**here is no significant agricultural production of tobacco in the UK, but it is produced as a farm crop elsewhere in the EU, with no specific controls or licensing requirements relating to the location or form of cultivation.[12] The manufacture of products from imported tobacco leaf in the UK is subject to registration, which involves an assessment of the control of the manufacturing process, adequacy of record-keeping and security of the premises.

However, there are health-motivated controls on product constituents which go far beyond the regulation required by the revenue protection principle. Regulations for the UK tobacco market are specified in a 2002 statutory instrument (Department of Health 2002), which implements European Community Directive 2001/37/EC. There are four main provisions: (*i*) the prohibition

[11] A still more radical form of supply control is for a state monopoly, as currently proposed by the Uruguay government.
[12] Tobacco output was long subsidised under the Common Agricultural Policy, with those subsidies only now being phased out.

of certain forms of tobacco;[13] (*ii*) controls on the physical constituents of tobacco products;[14] (*iii*) a system of government testing of tobacco products;[15] and (*iv*) mandatory health warnings.[16] A significant omission from the regulations is any control on tar, nicotine and carbon monoxide yields of loose hand-rolling tobacco. However, there remains a concern about the ability to update regulations in response to the continuous development of additives by producers and to develop forms of regulation sufficiently flexible to cover new forms of consumption that may become important in the future.

Product controls like those applied to tobacco require a degree of process consistency and internal quality control that are difficult for small producers to achieve, and economies of scale in production and distribution also produce a tendency towards domination by large producers, each offering a relatively uniform product in mostly prepared form. We do not make any specific assumptions about the producers who would be involved in a licensed market for cannabis, but we would expect some existing tobacco companies to be major participants, unless specifically excluded. This makes product controls particularly important, since tobacco companies would have a strong incentive to produce a cannabis product with high nicotine content to create nicotine dependency among cannabis users and thus promote long-term demand for conventional tobacco products. There is anecdotal evidence of a causal effect of cannabis use on tobacco smoking, which is consistent with the complementarity in demand between cannabis and tobacco found by some researchers (Van Ours 2007a). Table 3.1.1 summarises the way we would expect to see production controls applied in a tightly-regulated cannabis market.

[13] Certain oral tobacco preparations ("*snus*") are banned in all EU countries except Sweden.
[14] There are maximum yields of tar (10mg), nicotine (1mg) and carbon monoxide (10mg) per cigarette; yields must be declared on packaging and there is a mandatory system of reporting and justification of chemical additives.
[15] Traceable production batch identifiers must be printed on the packaging. Government testing criteria are based on international standards ISO 4387, 8243, 8454 and 10315.
[16] Health warnings drawn from a specified list are required on the packaging, occupying at least 30% of the front and 40% of the back of the pack.

Table 3.1.1 Possible regulatory provisions under a system of tight control

Regulation	Provisions
Licensing	Mandatory licensing would be required for all commercial production, with controls to restrict participation to "fit and proper" persons. Possible exclusion of suppliers involved in the tobacco trade, to prevent exploitation of cannabis as a route into tobacco addiction.
Domestic production	Individuals are likely to be permitted some small-scale domestic production for personal use, in a private residence, inaccessible to the public. The appropriate limit on the scale of this type of production is not clear. The typical scale of production among "social" growers interviewed by Hough et al (2003) in Britain was around 10-12 plants. In the US, Colorado has adopted a 3-plant allowance for private individuals, while the Washington State reform has maintained the illegality of domestic production. Proposition 19 in California would have allowed domestic cultivation on a plot of up to 25 ft^2. South Australia's Cannabis Expiation Notice scheme and Western Australia's Cannabis Infringement Notice scheme imposed cultivation limits of 10 and 2 plants respectively to avoid prosecution on a charge of cannabis production. We envisage a relatively tight allowance, certainly under 5 plants in cultivation at any one time. Proposals for a license fee levied on domestic production pose significant problems of policing and we envisage no such licensing system.
Security	Minimum security standards on commercial production facilities, similar to those imposed on tobacco producers. These would include a ban on cultivation in open fields.
Financial procedures	As is the case for alcohol and tobacco at present, financial guarantees and adequate record-keeping procedures would be required by the tax authorities to ensure that projected indirect tax liabilities can be met by licensed suppliers.
Product controls	Limits on THC content, THC:CBD ratio, and yields of carbon monoxide, tar and nicotine

In our view, product control is a potential advantage of a regulated market. The primary psychoactive constituent of cannabis is Δ^9-tetrahydrocannabinol (THC) but there are many other chemical components, whose physical and psychological impacts are not well understood. However, there is evidence to suggest that a particular component, cannabidiol (CBD), has significant psychological effects such as reducing anxiety, and may attenuate the psychosis-like and memory-impairing effects of THC (Morgan et al 2010a, Morgan and Curran 2008). Some studies have suggested that the negative mental health consequences of cannabis use may only occur if there is a sufficiently high THC-CBD ratio in the product used. Cannabidiol may also suppress the self-reinforcing tendency of THC to build appetite for cannabis (Morgan et al 2010b). Further evidence from fMRI brain scans also suggests that CBD pre-treatment tends to counteract the effects of THC on brain functions in regions that may mediate psychotic illness (Bhattacharyya et al 2010).

There is worrying evidence of a recent change in the typical THC/CBD content of illicit cannabis in the UK and elsewhere. The chemical composition of police seizures of 'street' cannabis has been tested using gas chromatography analysis, with results reported by the ACMD (2008), Hardwick and King (2008) and Potter et al (2008). Although these seized samples are unlikely to be fully representative of the whole cannabis market, they do suggest a recent large increase in the market share of sinsemilla with high levels of THC and virtually no CBD content. Estimation of trends is problematic because of comparability problems over time, but Hardwick and King (2008) suggest a rise in the market share of sinsemilla from around 15% (by weight) in 2002 to over 80% in 2008, while the low CBD content of sinsemilla appears to be common to samples seized at different times. Results from an extensive analysis of 1,756 samples collected in 2008 are summarised in Table 3.2.1 and Figure 3.2.1. The contrast between the characteristics of sinsemilla and imported herb or resin is very striking indeed and shows clearly the strong tendency for high potency to be accompanied by low CBD content in the current illicit market.

Table 3.1.2 Market shares and median THC/CBD content of seized cannabis

Substance	Market share (%)	THC content (%)	CBD content (%)
Imported resin	14.6	5.9	3.5
(min, max)		[1.3 – 27.8]	[0.1 – 7.3]
Imported herbal	2.1	8.3	< 0.1
(min, max)		[0.3 – 22]	
Sinsemilla	80.8	16.1	< 0.1
(min, max)		[4.1 – 46]	

Source: Hardwick and King (2008) and ACMD (2008)

Recent research findings on the action of THC and CBD on brain function, together with evidence on the increasing prevalence of high-THC low-CBD sinsemilla, make a powerful case that regulation of cannabis products should focus on optimising the THC:CBD ratio, alongside controls on tar, nicotine and carbon monoxide yields. One of the potential advantages of a system of licensed supply is that it would give the authorities the opportunity to exert much greater control over the properties of cannabis available to users and, consequently, reduce the risk to users of exposure to unexpectedly potent samples. Seen in this way, the setting of permissible ranges for THC and CBD content would be as important a policy parameter for the authorities as is the excise tax rate to be applied to retail sales. There is some precedent for controls on THC, since the Dutch authorities are in the process of imposing a 15% THC limit on cannabis sales through coffee shops.

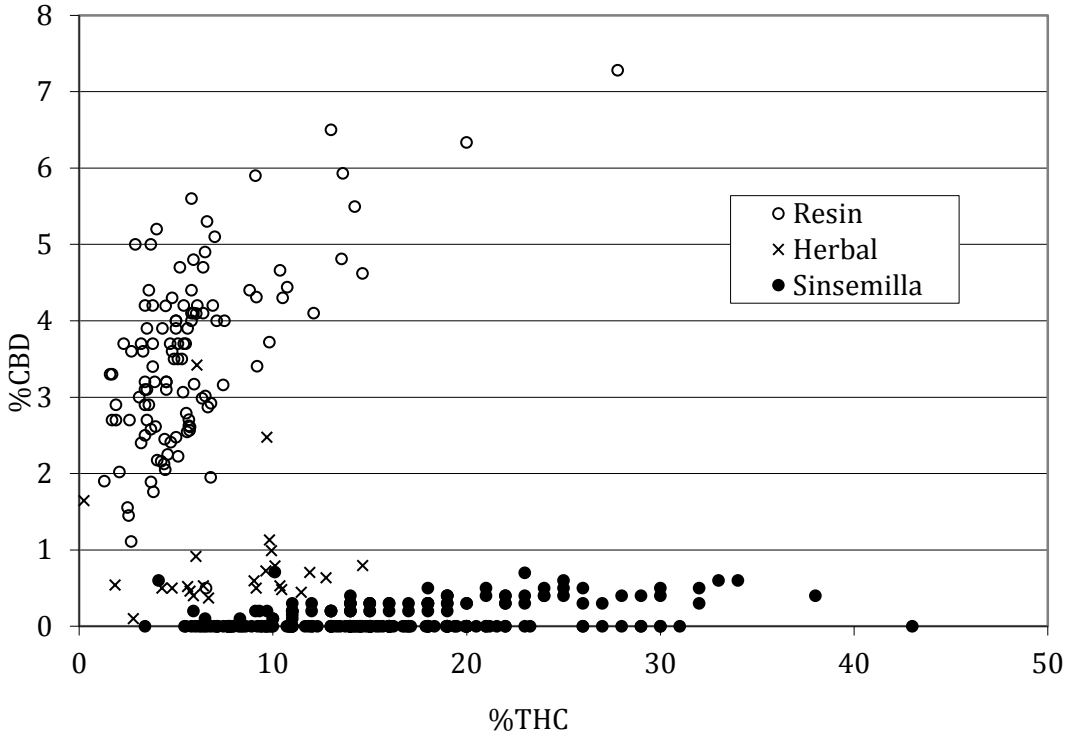


Figure 3.1.1 THC and CBD content in seized cannabis samples
(adapted from data reported in Hardwick and King 2008: with thanks to David Potter)

It is not possible to predict the effects on demand or on production costs of alternative choices for the limits on THC and CBD content, so there is no need for us to make a specific assumption about the limits that would be set in practice. However, we anticipate that the choice of tax rate and product controls would be set in attempt to drive out of the market imported herb and resin and to make large inroads into the market for illicit sinsemilla. For this to be achieved, we envisage that the THC limit would need to be significantly above the median level observed in imported herb and resin. For example, using the data on sinsemilla THC content underlying the Hardwick and King (2008) study, the bottom quartile point for THC content is around 10%, which might be a good candidate for the permissible limit on potency, being below the median level of 15% in seized samples but significantly above the median value for imported herb and resin which are around 5-9%. An upper limit of, say, 2.0 for the THC:CBD ratio might be realistic, although in the absence of detailed research on dose-response characteristics of THC and CBD effects, this is quite speculative.

In addition to controls on THC and CBD content, it is highly likely that the controls on nicotine, tar and carbon monoxide yields of tobacco products for smoking would be applied also to cannabis products for smoking, but we anticipate that they would be extended to loose material as well as prepared 'reefers'. In order to reduce nicotine dependence, it is important to

encourage smoke-free cannabis products or the smoking of cannabis without the addition of tobacco. Provisions for declaration of additives, government responsibility for testing and monitoring, and health warnings on retail packaging would be likely to apply to cannabis products in much the same way as they do to tobacco at present.

3.2 Curbs on consumption

There are two main reasons for direct controls on consumption: the protection of vulnerable young people who might be damaged by early initiation into cannabis use and curtailment of cannabis use among the adult population. These restrictions would relate to the age at which an individual could legally be supplied with cannabis and the locations and circumstances in which it could legally be used. The design of consumption controls is not straightforward: set too loosely, they would be ineffective in protecting young people; too restrictive and they would be evaded by resort to the illicit market, frustrating the objectives of reform. There is very little research to indicate what might be the optimal point on this trade-off.

Had it been adopted, Proposition 19 in California would have restricted sales of cannabis to over-21s, as is the case for alcohol throughout the USA. Instead, in the UK, tobacco and alcohol can both be bought legally at age 18. In our view, there are no completely reliable estimates of the impact of age of initiation on the health impairment caused by regular cannabis use, largely because of the difficulty of adequately accounting for confounding factors. However, there is a consensus that the risk declines appreciably for onset towards the end of the teenage years. If the age limit were set at 21, it would impose prohibition on people aged 18-20 who, in other respects, are treated as full adults by the law. Survey data indicate that the proportion of this group who report having used cannabis is currently around 35%,[17] so a ban on this large group could endanger the attempt to displace the illicit market, especially if imposed without compelling evidence of substantially greater harm for this age group than for over-21s. For that reason, we see 18 as the most plausible minimum age threshold under a system of licensing and regulation.

3.3 Retailing and advertising

Controls on retailing and advertising are likely to be similar to, or stricter than, those on either tobacco or alcohol at present. We do not envisage any licensing of sale for consumption on the premises, so there would be no parallel with the alcohol licensing laws that currently apply to bars and restaurants. It also seems unlikely that retailing of cannabis would be permitted as widely as are tobacco and (off-premises) alcohol at present. In our view, supermarkets, general stores, newsagents, etc. would be judged unsuitable as retail outlets because of the risk of access

[17] Authors' analysis of 2009/10 *British Crime Survey* data.

by under-18s. Instead, licensed retail outlets are likely to be confined to specialist shops and off-licences (liquor stores). There have been suggestions that cannabis might be supplied to consumers through pharmacies; we think this unlikely, since the supply of potentially harmful drugs to people without diagnosed medical need is in conflict with the ethical code that pharmacists and other health professionals are trained to comply with.

There is an interesting issue concerning limits on purchase amounts. For example, proposition 19 in California would have allowed purchases of up to 1 oz. In contrast, UK tobacco regulation currently imposes a *minimum* size on purchases of cigarettes by banning sales singly or in packs of less than ten. The upper limit reflects an assumption that large purchases will lead to binge consumption or secondary unlicensed supply, while the lower limit presumably reflects the assumption that children will be less likely to be able to afford larger transactions. There is some evidence from the Civil Infringement Notice experiment in Western Australia that the setting of a relatively high 30gm limit on allowable purchases changed behaviour in favour of larger purchases and thus (as a consequence of quantity discounts in the retail market) lower average prices. In view of this, an upper limit on the size of a single purchase seems a sensible precaution. An interesting possibility which could help reduce THC intake would be to specify this limit on purchase quantities in terms of THC content rather than weight of cannabis plant material.

Commercialisation and the promotional activity that accompanies it have been identified as a possible key factor in the growth of cannabis under the liberal Dutch policy regime (MacCoun and Reuter 2001) and there is evidence from the alcohol and tobacco markets in various countries that bans on advertising can have a significant impact on consumption (Saffer and Chaloupka 2000, Saffer and Dave 2002). Consequently, we expect policy on advertising within a regulated cannabis market to be the same complete ban on product display and public promotional activity that now applies to tobacco.

3.4 Monitoring and enforcement

The enforcement of regulatory controls is an important aspect of policy. It has been argued by Glaeser and Schleifer (2001) that prohibitionist policy has an advantage over taxation policy in terms of economic efficiency, since violations of prohibition are more easily detectable than violations of tax codes by legal suppliers. We doubt the plausibility of this assumption in the case of cannabis, but it does underline the importance of the effectiveness of taxation and other forms of regulation.

In Britain, monitoring and enforcement of the controls on retailing of alcohol and tobacco is the responsibility of local authorities and is carried out by local Trading Standards officers, with

support from the police. We expect that these responsibilities would be extended to cover retailing of cannabis products under a system of licensing and regulation, and that the penalties for breaches of the regulations on cannabis would be similar to those applying to alcohol at present. The maximum penalty for selling alcohol to under-18s is a fine of £5,000 (£2,500 for tobacco) and offenders may have their retail licence suspended or withdrawn. We would expect existing penalties for breach of tobacco advertising regulations to apply also to cannabis products: for example, there is at present a maximum fine of £1,000 for failure to display the required sign declaring the illegality of sales to under-18s.

Anti-smuggling and tax revenue protection policy is implemented at the UK level by HM Revenue and Customs (HMRC). All retailed tobacco products are currently required to bear a fiscal mark identifying it as legally produced and taxed, with a maximum fine of £5,000 and suspension of licence as a penalty for selling unmarked tobacco. We would expect this to apply to retail cannabis also. Although the incentive for illegal imports would be much reduced under a system of licensed domestic supply, we would expect smuggling to carry the same high maximum penalties that currently apply to tobacco: forfeit of the smuggled goods, up to seven years imprisonment and an unlimited fine. We envisage no penalties for possession of illicit cannabis, which would in any case be difficult to detect if home production for personal use were permitted.

Illegal export of legally-produced cannabis could become a significant problem, in terms of international relations with trading partners which maintain a prohibitionist policy on cannabis. We do not consider that issue explicitly, except to note that legal requirements for detailed recording of production and movement of goods would be an important element of policy, as it is with supply chain legislation for tobacco.

3.5 Information and health education

We share the widely-held view that the drug classification system introduced by the 1971 Misuse of Drugs Act inappropriately conflates two quite distinct functions. It disseminates information on the relative levels of potential harm from different substances and it simultaneously sets limits on the penalties to be applied by the criminal justice system. There is a common perception, particularly among the population groups most likely to become involved in drug use, that the criminal justice aspect of the classification system – reflecting the political judgements of legislators – has distorted the health messages sent out by the classification system. This, together with its omission of legal substances like alcohol and tobacco, tends to undermine the credibility of the classification system as a source of health information. It also makes it difficult for the authorities to issue specific guidelines on safer use similar to those that

have had some success in alcohol and diet.[18] In our view, it is quite plausible to argue that the creation of a licensed cannabis market would free health education on cannabis from political taint and thus improve the credibility of health information.

It is difficult to predict the extent of cannabis-related health education in a regulated system, and there are serious doubts about the effectiveness of mass-media health education programmes. We anticipate that existing publicly-funded drug-prevention work in schools and elsewhere would continue as at present, but we would expect an additional programme of mass media health campaigns similar to those that exist for alcohol and tobacco. The budgets for those programmes in 2009/10 were £17.6m and £14.8m respectively.[19]

4 The approach to evaluation

The evaluation presented here is a comparison of the potential outcomes under a new policy of licensed and regulated cannabis supply with the existing policy based on prohibition. It is important to realise that our analysis does not aim to give a prediction of the actual effects of policy reform in real time. Instead, we ask what the effects of policy reform would be if all external conditions except cannabis policy were held fixed at their 2010 configuration for a sufficiently long period of time to allow full adjustment to the new policy regime. Thus we are abstracting from a host of possible short-term effects and adjustment delays which would be extremely difficult to predict. Thus, for example, we are assuming that the cohort aged (say) 30 in 2010 would be identical to the 30-year-olds in our hypothetical future except for the changes induced by cannabis policy. We are therefore abstracting from background trends arising from technology, demography and past changes in policy on education, social security, etc., which have their long-term effects as each cohort ages through time.

Our analysis should be seen in the context of a wider policy review process. Ideally, policy reform involves four stages:

(*i*) *Background science*, in the form of continuous research activity, generates basic knowledge of relevant processes such as: the biological effects of drug use on the human body; the psycho-socio-economic processes which create and influence the demand for these drugs; and the effects of legal deterrents.

(*ii*) *Ex ante* policy analysis then attempts to project the range of likely outcomes of alternative feasible reforms, exploiting the background scientific knowledge that exists. The aim here is to

[18] See Fischer et al (2011) for a proposed set of "Lower Risk Cannabis Use Guidelines", covering frequency of use, age of use, driving, consumption practices, potency, and risks for special groups such as pregnant women and people with cardiovascular disease.
[19] Sources: House of Commons (2009, section 6) and ASH (2011).

identify whether reform is sufficiently promising to consider further and, if so, which variants appear preferable. This is the type of analysis presented in this study.

(*iii*) *Randomised controlled trials* (RCTs) of favoured policy options can then identify the impact of alternative reforms avoiding contamination from other extraneous influences on the outcomes on which policy is focused.

(*iv*) *Full-scale implementation* of the selected reform.

The difficulty we face in practice is that the RCTs of phase (*iii*) are completely infeasible for many of the most important policy decisions governments are called upon to make. That is certainly so for policies like the introduction of licensed and regulated cannabis supply. Although RCTs have been used for some of the relevant background science, the impossibility of controlling administration of cannabis in a realistic social setting and the long-term nature of many of the potential consequences of reform, make experimentally controlled trials of realistic policies completely infeasible. This means that we are forced to consider a leap from *ex ante* policy analysis to actual implementation. Inevitable, the consequence of this is that actual outcomes are highly uncertain.

4.1 Uncertainty and the precautionary principle

The largest volume of work on the problems of illicit drug use is in the medical literature and perhaps influenced by a basic precept of medical ethics, *primum non nocere* (first, do no harm) that creates a presumption in favour of cautious intervention, which often translates (questionably, in our view) into a bias towards the policy *status quo*. Among policy-makers, the precautionary principle is often used;[20] this states that, if a policy has a significant risk of causing substantial harm then, in the absence of scientific consensus on the level of harm, the burden of proof that it is *not* harmful should fall on those proposing the action. Again, this creates a presumption in favour of the *status quo*.

However, the precautionary principle should not be adopted without question. If policy effects are potentially damaging and irreversible then the principle clearly applies but, if the policy reform is unlikely to have large adverse effects and if it is also easily reversible, the precautionary principle places unnecessary constraints on policy-making. Evidence from Britain, the USA, Australia and several European countries suggests that moving away from punitive policy has remarkably little impact on cannabis use. The recent history of British policy on cannabis may not be a glorious one, but it does demonstrate conclusively that rapid reversals of policy are feasible. Consequently, in our view, the precautionary principle carries very little

[20] The precautionary principle is incorporated into Article 191 of the Treaty on the Functioning of the European Union (see European Commission 2000).

force in this context, and we see no compelling argument against moving directly to implementation of new policies which appear promising, even if there is considerable uncertainty about the projected policy impacts. Nevertheless, in carrying out our analysis, we have adopted a cautious approach which builds in a degree of inherent bias in favour of the *status quo*.

The *ex ante* policy analysis presented here is valuable for informing the policy debate, but it is subject to considerable uncertainty. In addition to a host of lesser uncertainties, we see four major sources of uncertainty which stand in the way of strong policy conclusions. First, there is no single obvious model for a licensed and regulated cannabis market. Second, in England and Wales since around 2002, there have been fundamental changes in the illicit cannabis market, with a large shift in favour of UK-produced high-potency forms of cannabis and a steady downward trend in cannabis use. The reasons for the trend in demand are not well understood. It is highly unlikely that falling demand is the result of policy changes or of price and income movements. Other explanations that have been put forward include: (*i*) the market domination of high-potency cannabis which some users find unpleasant; (*ii*) inconsistency of the effects of cannabis with the fast-paced life increasingly aspired to by many of the young; (*iii*) increasing health concerns which have been put in the public domain by the heated policy debate since the early 2000s. Without a good understanding of the determinants of demand, it is difficult to construct a convincing post reform scenario. Third, there is no consensus on the definition and consequent size of the group of people who should be regarded as vulnerable, in the sense that they are not judged to be mature, well-informed decision-makers able to balance personal risks against personal consumption benefits in deciding whether to use cannabis. Fourth, given the infeasibility of realistic randomised controlled trials, research on the long-term consequences of cannabis use has relied on observational data, analysed by statistical methods which are unavoidably vulnerable to bias from unobserved confounding factors. We believe that even the most sophisticated of these methods have a tendency to overestimate the causal impact of cannabis but, since the assumptions embedded in these methods are largely untestable, it is impossible to be certain.

It is difficult to give clear indications of the degree of uncertainty arising from these and other sources. Some components of the projections are purely statistical and we are able to construct conventional confidence intervals which indicate the likely range of error arising from purely random sources. However, conceptual uncertainty is likely to be much more important. Our approach is to provide a high-low range which gives a mainly subjective assessment of the degree of uncertainty from all sources. There is no 'scientific' way of producing these indicators of uncertainty, so they should be treated as no more than the authors' personal views about

where the major sources of uncertainty lie.

4.2 Elements of the evaluation

Opponents in the policy debate often seem to be fighting on different ground. Drugs policy 'doves' will point to the recurrent costs of policing and the criminal justice system (CJS) as a reason for decriminalisation, while 'hawks' often suggest the existence of large adverse long-term behavioural effects of drug use, using the "slippery slope" or "gateway" argument to oppose relaxation of policy. It seems unlikely that there will ever be a satisfactory outcome from a debate in which the two sides selectively highlight different issues. Drugs policy is difficult territory and any policy decision will have many distinct effects, all of which must be evaluated if we are to reach a fully considered view. Our aim here is to put all of the main issues together in one review and attempt to reach some conclusions about the likely importance of each element.

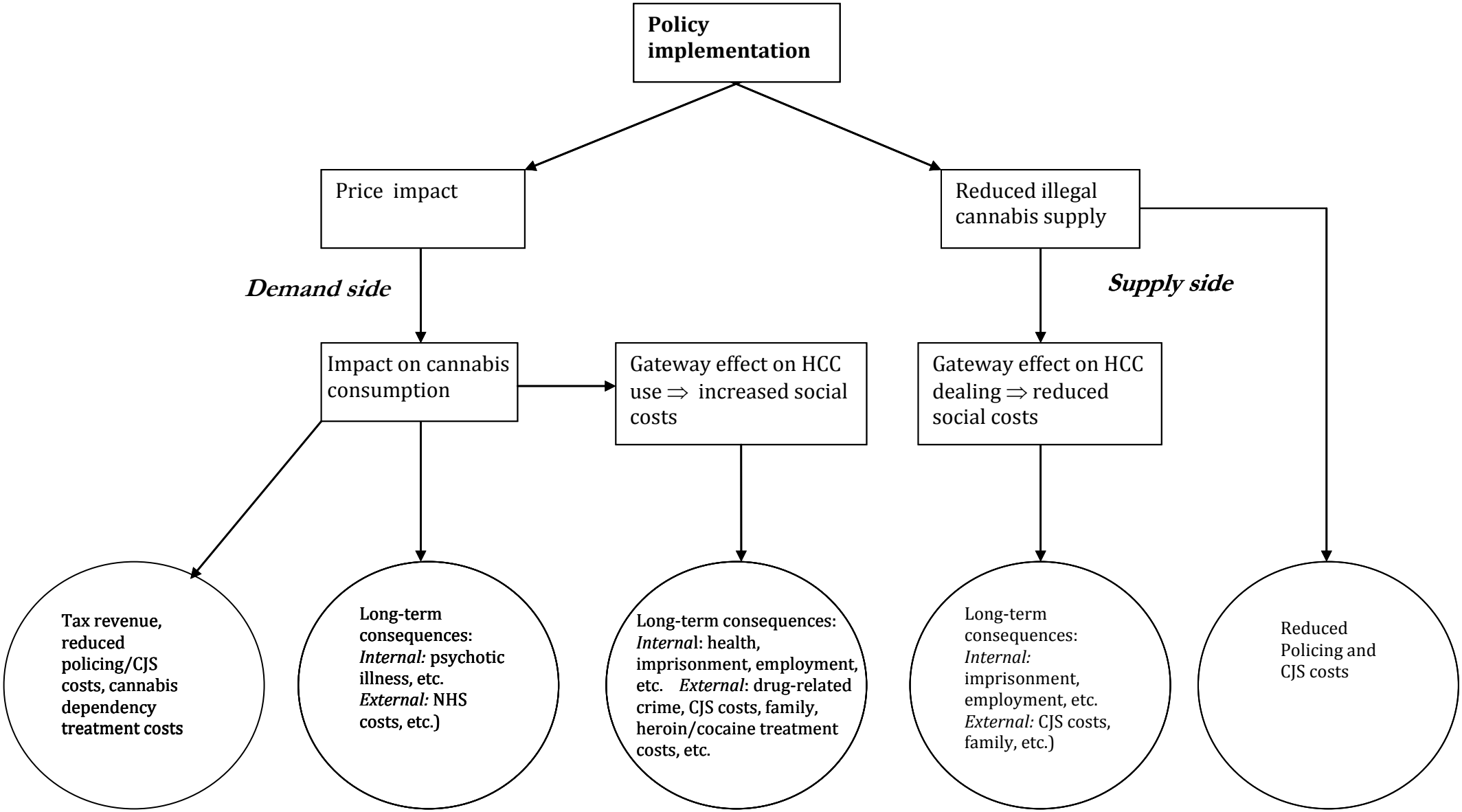
It is useful to classify costs and benefits into two groups: direct and indirect – although the distinction is inevitably blurred to some degree. *Direct costs/benefits* are those which are primarily related to the current operation of the cannabis market and its regulation and policing. They include things like policing and CJS costs, the costs of administering the system of regulation, etc. *Indirect costs/benefits* are only indirectly related to the way the cannabis market works and instead depend on long-term consequences produced by other behaviours triggered by the changed policy on cannabis. These indirect costs and benefits may be incurred long after the actions that caused them, and some stem from what is often known as the "gateway" effect.

The most widely discussed gateway hypothesis is that cannabis consumption in itself *causes* a rise in the risk of becoming a user of more damaging drugs such as cocaine, heroin and crack. If the causal gateway exists, a policy reform which induces a change in cannabis consumption patterns may, in turn, induce increased future costs of problematic hard drug use via a gateway effect. The gateway hypothesis as usually stated refers to demand behaviour, but causal gateways may exist on the supply side too, where they could generate benefits from reform instead of costs. For instance, if cannabis licensing and regulation has the effect of removing people from the illegal supply of cannabis, this may have the long-term effect of eliminating an entry point into hard drug supply, thus saving some people from a life blighted by imprisonment, damaged employment prospects and crime. Our aim is to bring direct and indirect effects into consideration and, as far as possible, to produce credible estimates of their magnitudes. Figure 4.1 gives a simple schematic overview of the primary issues involved.

There is a further important distinction to be made between the internal and external consequences of drug use. Internal consequences are experienced by users themselves; they include both enjoyment of cannabis consumption and the possible adverse impacts on health

and wellbeing. External consequences, such as the costs of medical treatment and criminal justice procedures are borne by society as a whole. This distinction has an important bearing on measurement and is discussed in the next section, together with the distinction between transfers (such as tax payments) and true social costs.

Figure 4.2.1 Schematic outline of an evaluation of cannabis licensing and regulation



4.3 What costs and benefits?

4.3.1 Internal and external costs and benefits

The effects of a move to a regulated market can be separated into internal costs and benefits experienced by drug users themselves and all other external costs and benefits. The reason for making this distinction comes from the standard microeconomic view of 'rational' consumption behaviour: a drug user who is fully-informed and has fully-developed decision-making faculties will balance the enjoyment from drug use against the costs, which include the purchase price and risk of personal harm. However, a self-interested consumer will not take into account costs imposed on others by his or her drug use. These external costs might include medical treatment costs, drug-induced crime, drug-induced accidental harm to others and distress to other family members. Consider a reform which relaxes external consumption constraints, leading to an expansion in cannabis consumption. This increases the risk to the consumer of cannabis-related harms (such as psychotic illness or respiratory disease) but, if the consumer has a full understanding of those risks and the capacity to use that information to make rational decisions, then the increase in potential harm must be at least offset by the enjoyment derived from increased consumption – since otherwise he or she would not have made the decision to consume more. Most discussions of drugs policy studiously avoid admitting any positive social value of consumers' enjoyment, which contrasts starkly with the important role of consumer benefit in almost every other application of cost-benefit analysis. One might not approve of users' enjoyment of cannabis in some moral sense, but it clearly exists.

In our view, it is impossible to give any credible estimate of the net consumption benefits accruing to cannabis users, in the absence of evidence on the nature of demand responses in the UK. Instead, our approach is to include only projected changes in external costs and benefits in our primary evaluation. By excluding the change in consumer surplus from consideration, our analysis will therefore tend to underestimate the social benefits flowing from the removal of distortionary constraints on consumption and this inherent bias in favour of prohibition should be borne in mind when interpreting our findings. Since we focus on the net external social costs and benefits (which are essentially the difference between two large figures for wellbeing in two policy regimes), our estimates are strikingly small in relation to the size of the market for cannabis and – particularly – legal drugs like alcohol. Appendix 4.2 outlines the theoretical argument underlying our approach in the context of consumers facing uncertain health and criminal justice costs of cannabis use.

There are three *caveats* to bear in mind when interpreting our results.

(*i*) *Imperfect information*

The revealed preference argument rests on one of two alternative assumptions: either consumers have full information about all the risks involved in consumption; or the consequences of consumption are reversible and realised quickly, so that consumers can learn from experience and modify their behaviour accordingly. The latter assumption is clearly not applicable to cannabis consumption: if there is a long-term risk of psychotic, respiratory or cardio-vascular illness, it is unlikely to occur quickly and extremely unlikely to be reversible. Consequently, the supply of accurate health information to young people is critically important.

(*ii*) *Failures of 'rationality'*

Behavioural economics challenges the view of rationality that underlies the revealed preference principle. Choices about risky consumption involve two issues: time (since the consequences may not be felt until far into the future) and risk (since adverse consequences are not perfectly predictable). The traditional economic model assumes consistent intertemporal discounting to handle situations where consumption consequences are distributed over time, and expected utility maximisation to handle unpredictability of outcomes. Experimental evidence has challenged both of these ideas. Consistent time-discounting has been rejected in favour of hyperbolic discounting (Laibson 1997), under which consumers may make choices today that their future self would prefer not to make. This pattern of behaviour has been observed in drug-dependent people but whether as a cause or consequence is uncertain (Madden et al 1997). Risk is equally problematic. Cannabis use involves a small risk of a few severe consequences, such as long-term illness and criminal penalties and there is experimental evidence of a tendency to over-react to small risks, leading to a proliferation of alternative theories of risky decision-making, notably prospect theory and its later developments (Kahneman and Tversky 1979). Problems of temporally-inconsistent decision-making and over-reaction to small risks work in opposite directions: the former leading people to use drugs, despite regretting it from a lifetime perspective; and the latter acting as a barrier to consumption.

(*iii*) *Undeveloped or impaired decision-making*

Decision-making abilities vary greatly between people and they also vary over time with personal development through childhood and adolescence. These abilities depend on cognitive skills and the process of learning from one's own experience and observation of the experience of others. Consequently, there are particular concerns about two population groups: those with impaired mental functioning, and the young. The rate of co-morbidity of drug dependence and other mental disorders is high (McManus et al 2009) and cannabis use is observed to be especially high among people in treatment for psychotic disorders, where it is associated with

particular poor prognosis. A particularly important concern is cannabis use by young people. The most recent school drug survey (NatCen 2011) found that as many as 21% of 15-year-olds had used cannabis during the previous year[21] and that, of those, about a third had used the drug once a month or more. The proportion of all current adult cannabis users who reported initiation into cannabis use at age 16 or below is 43% in the 2003 OCJS.[22] If this figure is combined with the Pudney et al (2006) estimates of the numbers of juvenile and adult cannabis users (Table 2.2.1 above), it suggests that in 2003 there were 2.77m (or 57%) cannabis users in England and Wales who had started at age 16 or earlier. This might be interpreted as a case for treating up to 57% of the internal harms experienced by cannabis users as elements of social cost. However, this would require very strong assumptions: that all damaging behaviour commencing by age 16 is purely the result of under-developed decision-making abilities and would not have occurred anyway if a later start were made; that every under-17 who chooses to use cannabis is a flawed decision-maker, while every under-17 who chooses otherwise is not; and that a course of behaviour commencing before age 17 is essentially irreversible by later, better-informed decisions.

Added to this conceptual uncertainty is the considerable practical problem of measuring internal harms, and there is a further difficulty in predicting how the introduction of a regulatory system would affect the rate of under-age cannabis use. Although one might expect cannabis to be more available to young people under a regulated system, this is far from certain. If licensing succeeds in eliminating much of the illicit supply from the market by removing profit opportunities and if policing of the retail system is effective, then it is just possible that availability to under-age consumers would be reduced. Note that it is important here to distinguish between consumption of cannabis material and consumption of its most problematic constituent, THC. With successful product regulation, it is quite possible that there could be a rise in under-age consumption of the former but a fall in consumption of the latter. We have very little evidence on this issue, and there is only weak evidence from the first analyses of the introduction of legal medical marijuana markets in a number of states in the USA, which have found no compelling evidence of leakage into the illicit under-age market (Anderson and Rees 2011).

4.3.2 Social costs and transfers

It is easy to confuse transfers of resources between members of society with a change in the total resources generated by society. A particular issue in the case of market regulation is

[21] This is just over half of the 39% who reported having been offered cannabis at some point.

[22] This relates to all respondents aged 10-60 reporting any cannabis use within the last year; the distribution of onset age is unlikely to have changed much since the survey year 2003. If the age range is restricted to cannabis-using respondents aged 17-30 at interview, the estimated proportion with onset at 16 or younger increases to 54%.

indirect tax revenue. Taxation of licensed cannabis supply generates revenue for government, but this is not a net social benefit, rather a transfer of resources from cannabis users to government, and should therefore not be included in measures of social cost or benefit. Evaluations of social cost do not always respect this principle. A good example is drug-related acquisitive crime. A 'pure' theft is simply a transfer from the legal owner of the property to a new illegal owner. We may deplore the transfer from a moral point of view but, strictly speaking, it is not a loss to society. In practice, thefts are never pure – the victim always incurs additional costs such as property damage, psychological distress, etc., but the common practice of treating stolen property as a total loss to society is not defensible unless we are prepared to admit moral weights to social welfare measurement.

An exception to this exclusion of transfers is the treatment of taxes and social security benefits related to earnings. If a drug policy reform changes an individual's earnings (for example through a spell of imprisonment), he or she experiences the loss of the post-tax part of those earnings. This is an internal cost, which should be excluded from our estimate of social cost. There is also an external cost which should be included in social cost: the rest of society loses its share of the output the individual would have produced, and delivered in the form of tax revenue.

As far as possible, we exclude the internal component of transfers from our analysis of social costs and benefits but, in section 7.3, we also present a parallel analysis of the impact of reform on transfers to and from government.

4.4 Production costs in a licensed market

We would expect the dominant form of commercial cannabis production in the UK to be under glass. As we have noted, cultivation in open fields would almost certainly be banned and would in any case probably be low yielding in the temperate UK climate. In order to estimate the likely costs of cannabis production in greenhouses, we adapt US work (Caulkins 2010) that was carried out against the background of the referendum in California in 2010 to introduce the Regulate, Control and Tax Cannabis Act (Proposition 19). Had it been passed, the Act would have allowed local governments some powers to authorise commercial cannabis production.

Compared to the small-scale home production methods, there is every reason to expect the (gross) cost of cannabis production to fall under a legal regime: there should be economies of scale from larger production units, innovation resulting from more open exchange of information, and more competition in the market for growing equipment. There should also be increases in labour productivity because workers could specialise full-time in cannabis production and those with particular skills in this area could sort more efficiently into the industry. Finally, labour costs should fall (to the extent that small-scale producers currently pay

themselves wages) because there would no longer be a need to pay a risk premium.

Nevertheless, as stressed by Caulkins (2010), estimating cannabis production costs is a speculative exercise because the commercial growing of cannabis for general use is illegal everywhere. Much of his information about production techniques and costs had to be taken from the grey literature or growing manuals aimed at enthusiasts (which may understate the difficulties). To allow for this uncertainty, we give high-low ranges for the costs that we use. We base our estimates on a hypothetical growing operation situated on a hectare of land that is 50% covered with greenhouses (the proportion of land covered is not critical, as rent turns out to be a tiny fraction of the final cost). Caulkins (2010) gives costs for a similar operation for California. We make various adjustments, mainly to allow for the UK cost of electricity, rent, labour inputs and wages. We also consider the amount of lighting likely to be needed at UK latitudes and look at the possible net benefits of adding two harvests in winter. The details of our projections of production cost are explained in Appendix A4.4.

Table 4.4.1 summarises the estimated costs, which are dominated by materials costs, labour, structure and lighting. Our final mid-range estimates are around £260 per kg under both scenarios because compared to summer harvests only, the additional lighting (and heating) costs during winter are offset by lower fixed costs (greenhouse structure and equipment) per unit of cannabis produced. Our high-low range of £180 to £360 per kg is wide, reflecting the accumulation of low and high range limits, but even our high estimate is only just over 10% of the wholesale price of a kilogram of skunk, £3,096, given by IDMU in 2009.[23]

Table 4.4.1 Estimated cost per kg of greenhouse-produced cannabis

	2 harvests per year			4 harvests per year		
	Mid range	Low cost	High cost	Mid range	Low cost	High cost
Materials	£142.43	£71.22	£213.65	£142.43	£71.22	£213.65
Lighting cost	£27.11	£27.11	£27.11	£42.18	£42.18	£42.18
Heating	£0.00	£0.00	£0.00	£4.06	£1.89	£5.67
Rent	£0.03	£0.02	£0.04	£0.02	£0.01	£0.02
Structure	£43.34	£34.67	£52.00	£21.67	£17.33	£26.00
Labour	£54.30	£47.00	£70.56	£54.30	£47.00	£70.56
Total	£267.21	£180.02	£363.37	£260.59	£177.74	£352.41

Production costs are only one component of the pre-tax price. Other elements include compliance costs, distribution costs, producer's profit margin and the retail mark-up.

[23] Cannabis prices in 2009 from http://www.idmu.co.uk/cannabis-prices-2009.htm

Compliance costs may be important. We would expect there to be some direct controls on the nature of the product, possibly covering tar, nicotine, CO, THC and CBD content and these controls introduce the need to undertake monitoring and exercise a high degree of control over product quality. We have no clear basis for estimating compliance costs, and they are largely dependent on the rigour of the monitoring system adopted by the authorities. Caulkins (2010) quotes experience of medical cannabis production in the Netherlands, where regulatory oversight is so rigorous that the legal product sells above the coffee shop price, and compares this with the low cost ($100) of testing an individual sample, which would add a negligible amount to costs if a light-touch random testing regime were adopted. For our mid-estimate, we assume that compliance costs are approximately equal to production costs, so that they are significant but not critical to the competitiveness of the licensed product. Distribution costs are assumed to be 50% of production costs and pre-tax producer profit is assumed to be 11%, which is the 5-year average for British American Tobacco.[24] Gross retail margins vary widely but a gross margin of 50% (implying a mark-up of 100%) might be a reasonable assumption. Table 4.4.2 illustrates a possible price configuration, leading to a pre-tax price of around £1.45 per gm. This would imply a ratio of the current illicit price to the projected price of licensed product of 4-5. This pre-tax ratio compares reasonably well with Miron's (2003) estimate of 200-400% for the ratio of illicit to (post-tax) legalised cocaine price. We now consider taxation.

Table 4.4.2 Illustrative pre-tax pricing of licensed cannabis

	Mid estimate	Low estimate	High estimate
Production cost	£0.26	£0.18	£0.35
Compliance cost	£0.26	£0.18	£0.53
Distribution cost	£0.13	£0.09	£0.18
Producer margin	£0.07	£0.05	£0.12
Total producer cost	£0.72	£0.50	£1.17
Retailer margin	£0.72	£0.50	£1.17
Total	£1.45	£1.00	£2.34

4.5 Tax policy and demand responses

As in the legal markets for alcohol and tobacco, we would expect the costs of production, distribution, compliance and profit margins to be modest components of the final market price of licensed cannabis.

[24] For 2006-2010, the 5-year average rate of pre-tax profit for Gallaher, BAT and Philip Morris were respectively 5.4%, 11.3% and 25.7% respectively; we use this to generate the high-low range.

Alcohol is subject to excise duty and VAT (at 20%). Excise duty is levied on alcohol content for beer and spirits and on product volume for wine and cider (with constant rates of duty within specified ranges of alcohol by volume (ABV)). Table 4.5.1 shows some examples. Note that the implied duty per litre of pure alcohol varies markedly across products, and total tax as a percentage of retail price varies between 31% (cider) and 72% (strong beer). Stronger products tend to be taxed at higher rates, although this is not uniform. Separate rates for high- and low-strength beers were introduced in the 2011 budget.

Table 4.5.1 Alcohol taxation in 2011

Product (ABV)	Duty per litre alcohol	Standard serving (litres)	Duty per Serving	Typical price per serving	VAT (20%)	% total tax
Beer (4.2%)	£18.57	0.568	£0.44	£1.40	£0.23	48%
Strong beer (7.5%)	£23.21	0.568	£0.99	£1.80	£0.30	72%
Low strength beer (2.8%)	£9.29	0.568	£0.15	£1.00	£0.17	31%
Wine (12.5%)	£19.30	0.175	£0.42	£1	£0.17	59%
Cider (4.5%)	£7.97	0.568	£0.20	£1.40	£0.23	31%
Spirits (37.5%)	£25.52	0.025	£0.24	£0.50	£0.08	65%

Tobacco attracts an ad valorem tax in addition to the specific excise duty and VAT, and the ad valorem tax and VAT interact in a complex way. The 2011 budget raised the specific duty on cigarettes and lowered the ad valorem tax so that economy cigarettes were taxed more heavily. As a percentage of retail price, tobacco is taxed more heavily than alcohol (Table 4.5.2).

Table 4.5.2 Tobacco taxation in 2011

Product	Pack size	Specific duty / pack	Ad valorem duty	Ad valorem duty / pack	Typical pack price	VAT (20%)	% total tax
Cigarettes	20 cigarettes	£3.10	16.5%	£1.02	£6.20	£1.03	83%
Loose tobacco	50g	£7.60	0	£0.00	£14	£2.33	71%

There are two striking features of these tax systems: taxes are high in comparison with suppliers' costs, and their structure is related to product characteristics in a complex way. The latter point suggests that a cannabis tax might in practice have multiple rates related to factors

like THC yield, perhaps with concessions for product forms that are tobacco-free or do not involve inhalation of smoke. With the very coarse evidence currently available on cannabis demand, it is not feasible for us to take account of such details. Instead, we assume – purely for clarity's sake – that there is a single licensed product with a fixed level of THC essentially dictated by the licensing authority.

What tax regime would be likely in a licensed cannabis market? In many respects, the government would be in the same position as an entrepreneur contemplating entry into an existing market: decisions have to be made about the design of the product and pricing. However, unlike the entrepreneur, government would only be able to influence product design and price through regulation and taxation, rather than setting them directly. In our view, the only practical approach to the analysis is to make assumptions about the government's strategic market objectives, then predict the price and product characteristics that would be required to achieve those objectives, and then finally to predict the indirect tax rate that would be required to generate that market price.

It is important to realise that, with product controls as part of the regulatory armoury, there is a tradeoff between price and potency that the government can choose from, if it seeks to make substantial inroads into the illicit market. The important insight here is that the demand for cannabis is a derived demand: although consumers purchase cannabis, they do so in order to gain access to the constituents of the good. From this viewpoint, cannabis is thought of as a bundle of components rather than a commodity in itself. Appendix A4.5 sets out a formal analysis from this viewpoint, using the Gorman-Lancaster characteristics model of demand (Gorman 1980, Lancaster 1966, Pudney 1981).

We consider two cases: version 1 assumes that cannabis users only care about a single characteristic, the primary psychoactive ingredient THC. With a single desirable characteristic available in the market, the characteristics model predicts that all competitively supplied varieties will offer the same price per unit of THC. Empirical evidence tends to contradict this: current market prices for standard herb/resin and sinsemilla are around £4 and £7 per gram (see Figure 2.3.1) and mean THC yields are around 6% and 15% (Table 2.3.1), so the price per gram of THC is £66.67 (herb/resin) and £46.67 (sinsemilla). The model predicts that, at these prices, sinsemilla will take the whole market – and the recent steep rise in its market share is possibly consistent with that view. The figure of £46.67 as the current implicit market price of THC suggests that, if the THC limit on the licensed product were set at (say) 10%, the corresponding maximum competitive price level for licensed cannabis would be £4.67, compared with £7 for illicit sinsemilla.

An alternative variant of the model assumes that consumers care about the volume of cannabis

they use (e.g. the number of joints smoked) as well as the total THC yield. Cannabis smoking is often a social activity and it is quite plausible that users derive some enjoyment from the act of consumption independently of the potency of the drug. Given the THC-price configurations observed in the market for sinsemilla and standard herb or resin, we can infer the implicit market valuation (or shadow price) of the two characteristics, product weight and THC (see Appendix A4.5 for details). For any projected level of THC potency in a new licensed product, these market valuations can be used to estimate the maximum competitive price that could be charged. Our assumption is that government would aim to choose the level of taxation so as to generate a price below this maximum competitive level and thus drive much of the illicit supply out of the market. Current market prices for standard herb/resin and sinsemilla of £4 and £7 per gram and THC yields of 6% and 15% imply that the current implicit valuation of THC is £33.33 per gram and of cannabis quantity is £2 per gram. So, from the consumer's point of view, the purchase of (say) 5gm of sinsemilla at £7 per gm is essentially a joint purchase of £10-worth of cannabis bulk and £25-worth of THC. This implies that, if government wishes the licensed product to make inroads into the illicit market, and sets a THC limit of (say) 10%, it would need to set the excise tax rate at a level which will generate a market price significantly below £5.33 per gram according to this 2-component model. The large difference between the maximum competitive prices (£4.67 and £5.33) predicted by these two perfectly reasonable views of demand means that there is a great deal of conceptual uncertainty around the setting of tax rates.

It is difficult to forecast demand, even for standardised commodities in legal markets, with access to high-quality data. To do so following a market intervention involving a new regulatory apparatus and the entry of a major new supplier is still more so. The conventional approach to demand forecasting is to use information on expected future price and income movements together with estimates of the response of demand to price, derived from statistical models fitted to recent survey or time-series data. There is only a limited literature on the responsiveness of cannabis consumption (and consumption of other related goods) to changes in price and legal status, mainly owing to a scarcity of high-quality data. The most suitable data come from the US or Australia, since those are the countries with best developed measurement of illicit drug prices. As we are not aware of any relevant UK studies, we base our assessment of likely demand responses on this international evidence.

Demand elasticities

The important concept here is that of a demand elasticity, which tells us the percent impact on the demand for a good of a 1% increase in the price of that (or some other) good. So, if the elasticity of cannabis demand is -0.8, then a 10% fall in the price of cannabis will increase

cannabis consumption by approximately 8%. There is an important distinction between the *participation elasticity*, which describes how responsive the number of new cannabis users is to price variations, and the *intensity elasticity*, which measures the responsiveness of the level of consumption by existing users. The total elasticity is the sum of the participation and intensity elasticities. Appendix A4.5 goes into technical detail and also summarises estimates of elasticities in the published research literature (Table A4.5.1). There is no clear consensus on the magnitude of demand elasticities for cannabis, but a reasonable assumption representative of the research literature is that the participation elasticity is around -0.4 an the intensity elasticity -0.3, giving an overall elasticity of -0.7.

A drawback of existing research on demand responses to price variation is that it largely ignores the issue of product quality. As outlined in the previous section and Appendix A4.5, if consumers value a range of product characteristics, variations in price will change the relative valuations of the underlying characteristics and produce both changes in the market shares of different product varieties and in the aggregate demands for cannabis quantity and components like THC.

Non-price influences on demand

As well as affecting the retail price of cannabis, the creation of a regulated market changes its legal status and may consequently cause a structural shift in demand. There is a possibility that the status of illegality has a direct effect in restraining demand, either through fear of legal penalties or through an indicative process by which the law emphasises social norms (Cooter 1998).[25] Because there are no examples of fully legal cannabis markets anywhere in the world it is very difficult to assess the impact of a move to legality and the best one can do is to try to draw inferences from the limited reforms which have been enacted at different times across the world. MacCoun (2010) reviews the evidence from reforms that have variously depenalised possession of small amounts of cannabis, decriminalised home cultivation, legalised consumption in coffee shops, and (for alcohol) raised the drinking age. Depenalisation of possession (in several US states, the Netherlands, Portugal and parts of Australia) seems to have had almost no effect on cannabis use. There is also no evidence that the decriminalisation of limited home cultivation in Alaska and South Australia substantially changed consumption trends.

MacCoun (2010) argues that the Dutch coffee shop experience represents the most realistic scenario for assessing the likely non-price effects of licensing cannabis supply, and concludes that legalisation could result in a 35% increase in past-month use. However, it appears that consumption may be quite sensitive to the increased restrictions introduced from the 1990s,

[25] See Pudney (2010) for a discussion of the role of law in relation to cannabis.

such as raising the minimum age of entry from 16 to 18 and limiting advertising. To the extent that the UK market would be strictly regulated from the start, we may expect the non-price effects to be substantially lower.

Given the considerable uncertainty about demand responses, the obvious way to proceed is to consider a range of possible market outcomes, corresponding to different views of demand responses. Appendix A4.5 contains a detailed technical discussion of the possible demand responses to a policy-induced price change in a setting where consumers are interested in cannabis both as a consumption good in itself and as source of THC; Table A4.5.3 gives a range of alternative predictions as illustrations of the possible outcomes of a reform. For simplicity, we assume here that the licensed product is subject to a 10% limit on THC content, with the indirect tax rate set at a level that generates a market price of £4.80 for the licensed product (which is 10% below the maximum competitive price). We consider three alternative scenarios, set out in Table 4.5.3, which have four appealing features: (*i*) they span a reasonable range of possibilities in view of the changes in implicit market valuations of THC and quantity that would be generated by a moderate undercutting of the illicit market by licensed supply; (*ii*) they allow for the possibility that the amount of THC and the volume of cannabis may change in different ways as users substitute between licensed and unlicensed varieties; (*iii*) they respect the identities connecting post-reform market shares and the proportional demand changes induced by the reform; and (*iv*) they imply a wide range of possibilities in terms of market shares of unlicensed product. Appendix A4.5 gives the technical details.

The low-response scenario is consistent with low elasticities of demand for THC and cannabis quantity and substitutability between them, with reform leading to a modest increase in demand for cannabis quantity and decrease in intake of THC. The mid-response scenario involves a substantial increase in cannabis quantity but little increase in THC intake. The high-response scenario, which we regard as less plausible, involves a large rise in THC consumption and still larger rise in cannabis quantity, and could be consistent with a significant role for illegality *per se* as a restraining factor on pre-reform demand.

Table 4.5.3 Three market response scenarios

	Low response	Mid response	High response
Change in THC demand	-10%	+5%	+25%
Change in cannabis quantity	+15%	+20%	+40%
Unlicensed share (quantity)	20%	30%	35%
Unlicensed share (THC)	25%	39%	45%

We use these scenarios to produce alternative estimates of those elements of social cost which are related either to the level of consumption of THC (for example, the costs of psychotic illness) or the quantity of cannabis (for example, the costs of respiratory disease).

5 Direct costs and benefits

The available evidence on policing and criminal justice system costs is surprisingly sparse, and the few unit cost figures that appear in the research literature are remarkably divergent. Enforcement costs can be separated into the costs arising from three phases of the enforcement process: (*i*) policing; (*ii*) criminal justice procedures; and (*iii*) implementation of sentences imposed by the justice system. We consider these in turn. For each, we first review the available evidence about costs and make judgements about the plausible range of unit costs for relevant types of action. We then summarise the available data on caseloads and consider the change in aggregate social costs that would be brought about by projected caseload changes as a result of the policy reform.

5.1 Enforcement costs

5.1.1 Policing

Unit costs for a given police action (such as a cannabis warning or a supply arrest) are generally calculated in one of two ways. The first, used by Godfrey et al (2004) and May et al (2002), is based on an estimate by Brand and Price (2000) of the aggregate costs of policing drug offences in financial year 1999/2000. Brand and Price (2000) did not describe their estimation procedure in detail, but it involved the adaptation of an activity sampling exercise carried out by Humberside police to estimate the proportion of police activity that is devoted to dealing with crime.[26] The resulting aggregate figure (£516m) for policing costs arising from drug offences is then divided by the number of drug offences recorded to produce an average cost per offence. Surprisingly, although both Godfrey et al (2004) and May et al (2002) appear to have used the same method and the same aggregate cost figure, the former arrived at a figure of £3,551 per drug offence, while the latter quoted a figure of £4,605 per offence. The Brand and Price (2000) aggregate cost estimate is acknowledged to be quite crude and it is not an ideal basis for policy costing. Their study was updated by DuBourg et al (2005) for a subset of offence groups (excluding drug offences, unfortunately) and their more extensive analysis of police activity

[26] The details of the Humberside study and the way in which it was adapted are not documented.

data suggested that the Brand-Price method tended to understate the costs of non-violent crime and overstate the costs of most violent crime. In a study of the costs of class A drug use, Godfrey et al (2002) used a reduced figure of £1,346 per arrest for possession, which appears to be based on an alternative to the Brand and Price calculation, although the method of calculation is not made clear.

A second approach to costing any particular type of police action is to make an estimate of the average number of hours of police time required for that action to be completed and multiply it by the average cost of an hour of police time. This approach has been used by May et al (2002) and May et al (2007) in two conflicting ways. The earlier study calculated the hourly cost of an officer's time as the ratio of total police expenditure to the number of police constables, converted to an hourly rate by dividing by an assumed 1,500 working hours per officer per year. This concept of an hourly rate therefore includes all support and overhead costs, apportioned pro rata. In this way, May et al (2002) arrive at a figure of £50 per hour. An arrest for cannabis possession was assumed to take 10 hours of a constable's time – a figure based on analysis of a sample of custody records and on police evidence given to the Home Affairs Select Committee on Drugs Policy. Thus an average cannabis arrest was estimated to have a unit cost of £500. In the later study, May et al (2007) use a completely different approach, with no explanation for the change of methodology. They assume an arbitrary £13 per hour as the cost of a constable's time, based on the observation that the starting salary was £9.22 but the average constable would have some years of experience. Note that this concept of an hourly rate excludes any support and overhead costs and is likely to give a gross underestimate of true policing costs. At 10 hours of police time per arrest and 80 minutes per warning, this latter approach implies £130 as the average cost of an arrest for possession and £17.33 as the average cost of a police warning.

As far as we are aware, these are the only recent attempts to estimate the costs of police action on drug offences and they are not very encouraging. Estimates spanning a range from £130 to £4,605 per arrest do not provide a good basis for cost-benefit analysis. However, both extremes of this range are subject to methodological objection, so it is possible to narrow the range of plausible estimates considerably.

We have no new basis for estimating the time required to deal with particular types of case, and the available estimates in the research literature are almost anecdotal in nature, so there is a great deal of uncertainty involved here. The literature also has little to say about the magnitude of the seniority effect – that more serious crimes tend to involve more senior officers, thus raising the unit cost. Again, comparison of figures used in different studies generates a very wide range. Using a (non-representative) sample of custody records, May et al (2002) found

that the time from arrest to return to the beat was 3.5 hours. This excludes additional activities that might be required, so a figure of 5 hours was used, in line with earlier police evidence given to the Home Affairs Select Committee on Drugs Policy. On grounds that patrol officers typically work in pairs, a total of ten hours was assumed for an average arrest for drugs possession. At the other extreme, the Godfrey et al (2002) figure of £1,346 would imply, at our rate of £68.46 per hour of police time, 19.7 constable-hours per arrest. Even allowing for the fact that Godfrey et al (2002) were considering arrests for class A possession rather than cannabis, this is a very large difference.

Given the uncertain basis of the latter estimate and its questionable outcome, we follow the May et al (2002) approach, but modify it slightly. Our concern is with the assumption that all aspects of the arrest involve two constables, so that the 5 hours of elapsed time is equivalent to 10 hours of police resource. Some of the work involved in an arrest (report-writing, etc) does not require two people and some will also be spread across offences where multiple charges are involved.[27] For this reason, we assume that the 3.5 hours reported by May et al (2002) as the interruption to patrol time required to process a cannabis arrest involves both officers, while the additional time required is 2 hours of a custody sergeant and a further hour of one of the constables, so that our assumption for the total time for a cannabis arrest is 8 constable-hours plus 2 sergeant hours. May et al (2002) do not distinguish between arrest leading to a caution and arrest leading to a court appearance. In the latter case, we assume arbitrarily that the additional preparatory work increases the average time to 12 constable-hours plus 4 sergeant-hours.

For the formal cannabis warnings which have been in operation since 2004, May et al (2007) assume an average time of 80 minutes to carry out eight steps, including the stop-and-search, police checks, completing a stop-and-search form, inputting details to various information systems and transferring the seizure to the property store. It appears that the 80 minutes time was not increased to allow for involvement of two officers in the action. To allow for this, we have increased the assumed time to 140 minutes. We assume the same time for the use of a Penalty Notice for Disorder (PND), which involves on-the-spot imposition of a fine.

For the time required to deal with an arrest for supply offences, we are in the realms of guesswork, since we have found no relevant evidence in the research literature. We assume that all arrests for supply and production offences involve preparation for a possible court case and that, on average, the process involves costs equivalent to 24 hours of constables' time, 12 sergeant-hours and 10 inspector hours. These figures should be seen as an arbitrary illustration

[27] Analysis of custody records by May et al (2002) found that 15% of cannabis possession arrests involved other non-drug offences.

only: they have been chosen to give a unit cost figure close to the Brand and Price (2000) estimate of over £3000 per case.

Table 5.1.2 gives the resulting unit cost estimates, which range from £150 for a warning or PND, to £3,420 for an arrest for a supply offence. Since these figures are so uncertain, we also provide a judgemental high-low range for each unit cost, which we are confident will contain the true figure.

Table 5.1.2 Assumed times and unit costs for police actions

Activity	Illustrative calculation of police time	Unit cost (mid estimate)	High-low range
Cannabis possession: formal warning or PND	140 constable minutes	£150	£100-200
Cannabis possession: arrest and caution	8 constable hours + 2 sergeant hours	£660	£400-£1000
Cannabis possession: arrest and preparation for court	12 constable hours + 4 sergeant hour	£1060	£700-£1,500
Cannabis supply or production: arrest and preparation for court	20 constable hours + 8 sergeant hours + 8 inspector hours	£3,420	£2,000-£4,800

Note: calculations rounded to the nearest £10.

Official statistics on the volumes of drugs offences dealt with in various ways lack some of the detail we would like for analysis of drugs policy. In particular, the specific substance (or substances) involved in a particular detected drug offence is not recorded in a proportion of cases, and published data are often aggregated within the three official drug classes, so that individual drugs cannot be separated.

Table 5.1.3 gives our best estimate of the police caseloads for cannabis offences in the two years post-reclassification for which data are available. The residual possession category is the difference between the number of recorded cannabis possession offences and the total number of warnings, PNDs and court convictions. This residual thus covers cases not proceeded with, not guilty verdicts and an error arising from the mismatch between financial years used for criminal statistics and calendar years used for sentencing statistics.

Table 5.1.3 Police caseloads for cannabis offences post-reclassification

Activity	2009	2010
Cannabis possession: formal warning or PND[a]	99,833	93,023
Cannabis possession: arrest and caution[a]	20,609	18,870
Cannabis possession: arrest and preparation for court		
leading to conviction[b]	21,457	25,188
leading to other outcome[c]	2,045	2,400
Other cannabis possession arrest outcomes[d]	18,666	-
Cannabis supply or production: arrest and preparation for court		
leading to conviction[b]	8,701	12,319
leading to other outcome[c]	829	1,174

Note: [a]Tables 1.4 and 2.1 of *Criminal Justice Statistics, Quarterly Update to December 2010*; [b] Table A4.10 of "annual tables" appendix to *Criminal Justice Statistics, Quarterly Update to December 2010*; [c] Estimated from number of convictions, assuming an average 2005-10 conviction rate of 91.3% for drugs offences; [d] Difference between number of recorded possession offences (*Recorded Crime Statistics 2009/10*) and sum of warnings, PNDs, cautions and court convictions; recorded offences not available for 2009/10.

We use the unit cost estimates from Table 5.1.2 and caseload figures from Table 5.1.3 to construct estimates of the financial cost of cannabis policing for 2009 and 2010. In doing so, we make two further assumptions. First, the average proceeds from PNDs are assumed to be £43.20 per PND. Although cannabis possession is an upper-tier offence carrying an £80 penalty, only 54% were paid in full in the two years 2009-10.[28] We assume that, for the remainder, any eventual proceeds of consequent fines are offset exactly by recovery costs. Second, we assume that the 2010 residual "other possession outcomes" volume is identical to the 2009 figure, and use the warning/PND unit cost figure to compute the corresponding cost element.

The resulting aggregate cost figures are presented in Table 5.1.4. Our central estimate is that the total financial cost of cannabis policing in England and Wales is currently around £100 million. However, the range of uncertainty associated with this estimate is very large. If, instead, we adopt the low or high estimate for all of the unit costs, we would instead have a range of possibilities from around £65m to £105m.

Table 5.1.4 Estimated total current cost of cannabis policing (£million per annum)

	2009	2010
Mid estimate	£88.9m	£104.6m
(low, high range)	(£55.6 – 125.3m)	(£65.0 – 147.4m)

There are three further points to bear in mind here. First, the supply/production component of

[28] Table A2.1, *Criminal Justice Statistics, England and Wales 2010*.

these sums would be the saving in terms of police resources only if the licensing of cannabis supply were to remove the need for policing supply and production activity completely. In practice that is not the case – there will always exist a black market, just as there does for tobacco. As with tobacco, the black market will generate some policing activity, so that total savings will be less than the figures in Table 5.1.4 suggest; we consider these regulation costs in section 5.6 below.

Second, our estimates exclude all policing costs associated with importation and exportation of cannabis. Under the hypothesised system of licensing and regulation, international trade in cannabis would continue to be illegal. We assume that these policing (and associated criminal justice system) costs would remain unaffected, in spite of the likely fall in the volume of imported cannabis that would ensue. We make this assumption principally because we have no data on the caseload classified by drug type; in practice, this means we will underestimate the enforcement cost saving to some degree.

Third, note that our estimates are considerably larger than the £3.5m saving estimated by May et al (2007) for the 2004 switch to policing of cannabis as a class C drug. There are three main reasons for this difference: May et al used a very low figure of £13 per hour for police time, which ignored all support costs; their calculation relates to 2004 and does not allow for cost increases since then; and supply offences were excluded from consideration.

5.1.2 Criminal justice procedures

The statistical evidence on the costs of criminal justice procedures relating to drug offences is still more limited than the evidence on policing costs. The widely-cited study by Brand and Price (2000) uses cost data for 1997/8 reported by Harries (1999), which was produced from a Home Office simulation model of aggregate costs and flows through the criminal justice system. These figures were subsequently revised by Dubourg et al (2005) to allow for sentence costs spanning multiple years but the court proceedings component of unit costs was left essentially unchanged. As far as we are aware, the Harries (1999) unit cost estimates, reproduced in Table 5.1.5, remain the most up-to-date available estimates of the average costs of court proceedings for drug offences, despite the fact that they relate to a period fourteen years in the past. A further difficulty is that there is no official index of court costs for public prosecutions that can be used to uprate Harries' estimated unit costs. In Table 5.1.5, we show the effect of uprating the 1997/8 unit costs by RPI or median earnings growth. Alternative assumptions about cost inflation make a large difference to the result; in our view, the option of uprating in relation to earnings growth is preferable, since court processes are highly labour-intensive and legal costs are known to have grown strongly over the last decade or so.

Table 5.1.5 Estimated unit cost of court proceedings for drug offences by court type

	Crown court	Magistrates court
1997/8 estimate (Harries 1999)	£7,700	£700
Uprated to 2009/10 by RPI[a]	£10,448	£950
Uprated to 2009/10 by median earnings index[b]	£14,002	£1,273

[a] Uprated using all-items RPI growth between 1997 and 2009; [b] Uprated using growth in median weekly earnings (ASHE) for full-time workers between April 1997 and April 2009

Table 5.1.6 summarises the most recent available data on the breakdown of cannabis convictions for possession and supply/production across the two types of court. There is a strong tendency for magistrates courts to deal with cases of possession rather than supply.

Table 5.1.6 Distribution of cannabis possession and supply convictions by court type in 2010 (%)

Cannabis offence	Crown court	Magistrates court	Total
Possession	2.32	71.62	73.94
Production/supply	10.93	15.13	26.06
Total	13.25	86.75	100

Source: *Criminal Justice Statistics England and Wales 2010*, analysis of supplementary computer file *Court level sentencing* (downloaded from www.justice.gov.uk/publications/statistics-and-data/criminal-justice/criminal-justice-statistics.htm on 15 August 2011)

Under the assumption that all variations in average cost of court proceedings are captured fully by the type of court, we can use Tables 5.1.5 and 5.1.6 to construct unit costs for each of the four types of drug offence. The results are given in Table 5.1.7, for the two alternative uprating methods. We adopt the earnings-uprated costs as our mid-estimate, and adopt a wide range of uncertainty around each.

Table 5.1.7 Estimated unit cost of court proceedings for cannabis offences

Offence	RPI uprating	Median earnings uprating (mid-estimate)	High-low range
Possession, cannabis	£1,240	£1,680	£1,000-2,400
Production/supply, cannabis	£4,940	£6,620	£4,000-10,000

Note: weighted averages calculated from Tables 5.1.5 and 5.1.6, rounded to nearest £20

Cannabis-related convictions totalled 26,716 for England and Wales in 2009 and 33,430 for 2010; their distribution across offence and court types is given by Table 5.1.6. The aggregate costs implied by these caseloads and our estimated unit values are summarised in Table 5.1.8.

Table 5.1.8 Estimated total current cost of cannabis court proceedings (£million per annum)

	2009	2010
Mid estimate	£ 70.9m	£ 96.9m
Low-high range	£ 42.5-104.1m	£ 58.2-142.9m

On these estimates, the annual cost of court proceedings is approximately £100m, which is roughly comparable to policing costs. However, they are likely to be underestimates, since they exclude any of the costs involved in court proceedings which end with a not guilty verdict or which are initiated but not pursued to verdict; such cases involve costs which we are unable to estimate.

5.1.3 Custodial sentences

Unfortunately data are not available on custodial sentence length by specific drug type. In 2009, the first year after cannabis was restored to class B, there were 1,526 custodial sentences in England and Wales for offences recorded as involving class B drugs. Just under a quarter of these were for possession, the remainder for production or trafficking offences. Mean sentence lengths for class B possession and supply/production offences are 2.2 and 19.3 months respectively. Their distributions are shown in Figure 5.1.1: almost 90% of all possession sentences were 3 months or less while, for supply offences, the median was between 12 and 18 months, with just under 90% of sentences being 36 months or less. We might expect cannabis offences to be seen by the courts as less serious than those involving other class B substances, so these distributions may overstate the severity of cannabis penalties to some degree.

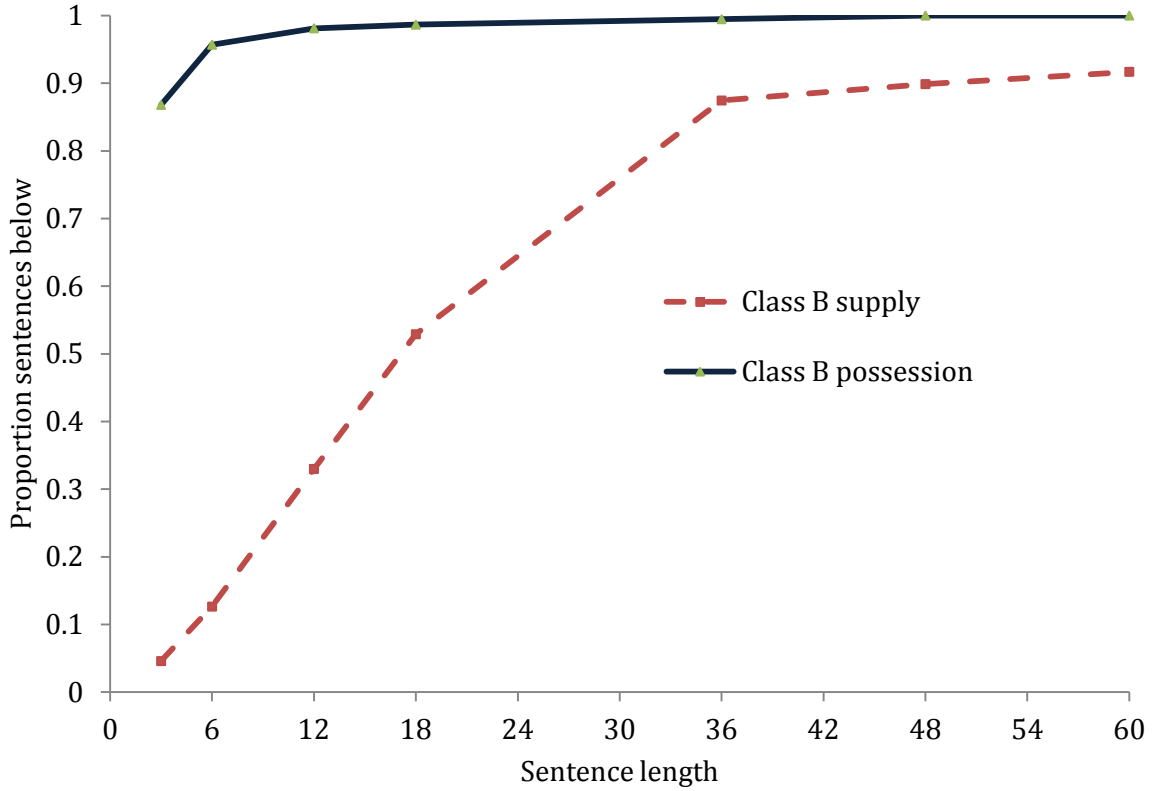


Figure 5.1.1 Distributions of sentence lengths for possession and supply/production offences involving class B drugs
(Source: *Sentencing Statistics 2009*, supplementary table S5.8)

Formal sentences are not a good guide to the true resource cost of custodial penalties. Overall, for all sentences discharged in 2009, the total time served was only 59% of total sentence length.[29] These proportions relate to all offences but no separate figures are available for drug offences, so we assume a uniform implementation rate of 59% for possession and supply offences.

The most recent official estimate of the average cost of a prison place is £45,000 for financial year 2008/9, equivalent to £3,750 per month. The average cost of a prison place for a specific type of drug offender will depend on the system for allocating such offenders to specific types of institution. Unfortunately there is no available information on the variation of prison costs across offence categories. The overall average cost will over-estimate the cost of places in low-security facilities where some drug offenders are held but, against this, some will occupy places in Young Offenders Institutions, where costs are higher – approximately £4,920 per month on

[29] Source MoJ (2010c, Table 9.1a); the proportion is lower (50%) for 6-12 month sentences and higher (62%) for sentences of 48 months and over.

average.[30] In the absence of better information, we assume a flat average cost of £3,750 per month for all prison places.

Table 5.1.9 sets out the cost calculation, which leads to a mid-estimate of £84m in 2010 as the public cost of custodial sentences for cannabis possession, production and supply offences. This figure is almost certainly an underestimate, since it excludes the costs of monitoring by the probation service post-release. It also does not include follow-on costs, such as the potential output lost during the period of imprisonment and as a consequence of unemployment induced by the scarring effect of a spell of imprisonment; we consider these in sections 5.2 and 6.1. Note that the cost of imprisonment for people convicted of international trade in cannabis is excluded from the calculation in Table 5.1.9.

Table 5.1.9 Estimated unit cost of custodial sentences for cannabis offences, 2010

Offence	Mean sentence (all class B offences, months)	Cost per sentence served	Number of custodial cannabis sentences	Aggregate cost
Possession	2.2	£4,868	346	£ 1.7m
Production/supply	19.3	£42,701	1,927	£ 82.3m
Aggregate cost of sentences for cannabis possession/production/supply offences		Mid-estimate: £84.0m	Low: £50m	High: £125m

Note: Calculations assume: mean sentence lengths uniform across class B drugs; time served is 59% of nominal sentence; no post-release costs such as parole monitoring. Estimates do not include costs of exportation/ importation offences.

5.1.4 Costs of community sentences and fines

The vast majority of cannabis convictions lead to fines or community sentences of various kinds. Community sentences are extremely diverse in character and may involve a combination of requirements imposed on the offender. There are twelve specific requirements, defined by the 2003 Criminal Justice Act, that can be imposed on offenders, including[31]: supervision by the probation service; unpaid work for the community; compulsory training or behavioural change programmes; reparation activities; bans on specified activities; curfew; exclusion from specified locations; treatment for mental health problems or drug/alcohol dependency; attendance at an Attendance Centre; restrictions on residence. The majority of Community Orders (COs) impose only a single requirement and the most common are for stand-alone supervision and for unpaid community work, each accounting for around a third of the total community sentence caseload.

[30] See *Official Report* written answers: 3rd March 2010, c1251W and 18 January 2011, c865-867W. The latter source suggests that costs have been stable since 2008, so we do not uprate these averages to a current cost basis.
[31] See National Audit Office (2008, Appendix 7).

There is no information available on the distribution of CO requirements or durations across offence types, but we assume that most cannabis-related cases are relatively short and uncomplicated.

There is little available information on the costs of implementing community sentences or the value of the output that is produced by those that impose a requirement for unpaid community work. However, the National Audit Office (2008) commissioned a costing study that gives some basis for estimating the public cost of community sentences. They estimated average costs incurred by the probation service of £650 and £780 respectively for orders made in 2006, involving supervision and unpaid work respectively. However, the underlying costing exercise also produced indicative costs for the specific example of a first offender sentenced to 60 hours of unpaid community work, where the cost was estimated to be £323. This is quite a typical sentence for cannabis possession. In the absence of better evidence, we uprate these figures to a 2010 basis in line with median earnings growth and assume that COs for cannabis supply offences entail an average unit cost of £1,000 per case, while possession offences cost half that figure. We also assume that 50% of these COs require unpaid community work (150 hours for supply offences and 60 hours for possession), which generates output valued at £3.69 per hour, calculated as 75% of the National Minimum Wage for 18-21 year-olds from October 2010. Thus the average community sentences for cannabis supply and possession offences are assumed to generate £277 and £111 in social benefit from unpaid work, which can be offset against the costs of implementing the sentences.[32] The results of this calculation are summarised in Table 5.1.10. The estimated aggregate cost (assuming 2009 caseloads but 2010 cost levels) is the relatively small figure of £3.2m.

Table 5.1.10 Costs of community sentences

Offence	No. community sentences 2010	Unit cost	Aggregate cost	Unit social value of output produced	Aggregate social value of output produced
Cannabis possession	4,532	£500	£2.3m	£111	£0.5m
Cannabis supply/production	2,942	£1,000	£2.9m	£277	£0.8m
All cannabis cases	7,474	£697	£5.2m	£176	£1.3m

Source: http://sentencing.justice.gov.uk/?id=2&id2=19

The introduction of Community Orders by the 2003 Criminal Justice Act was partly intended to encourage the courts to substitute community sentences for short custodial sentences. Instead,

[32] We ignore costs to the offender of providing the effort required as unpaid work, since we are concerned here only with external net public costs.

there was a large switch from the use of fines to community sentences, so the proportion of sentences for drug offences which involve a fine declined from 47% in 1999 to 37% ten years later (MoJ 2010a, Table 4(iii)). Among indictable offences, cannabis possession generates the second largest volume of fines (over 13,500 in 2010), the average level being £101. We assume that this figure results from an average fine of £90 for cannabis possession and £250 for cannabis production or supply.[33] There is little reliable evidence on the collection of fines and apparently no usable data on the associated recovery costs[34] but the National audit Office (2006) found a payment rate within 6 months of only 52% in its analysis of a sample of fines imposed in 2005. We assume that there has been some improvement in payment rates to 60% since 2005, but we also assume that the value of all fines not paid within 6 months but eventually recovered is exactly offset by aggregate fine recovery costs. As Table 5.1.11 shows, the aggregate revenue from fines is estimated to be negligible in comparison with aggregate enforcement costs, and unlikely to exceed £1m.

Table 5.1.11 Estimated net revenue from fines for cannabis offences, 2010

Offence	No. of fines in 2009	Average fine	Assumed proportion paid within 12 months	Net unit revenue from fines	Aggregate net revenue
Possession	13,554	£90	60%	£54	£0.7m
Production/supply	1,131	£250	60%	£150	£0.2m
Aggregate net cost of fines for cannabis possession/production/supply offences			Mid: £0.9m	Low: £0.5m	High: £1.4m

Note: Source: MoJ (2010a) and analysis of supplementary files. Calculations assume recovery of fines paid after 6 months are exactly offset by collection costs

5.2 Output lost through incarceration

In addition to the direct cost of maintaining a prisoner in jail, the incarceration of a person who would otherwise be employed has a further cost in terms of the loss of earnings (and thus output) that would otherwise have been produced by that person. To the extent that this is a fully understood risk and that the offender was capable of taking that risk into account when making his or her decision to consume or supply cannabis, the greater part of this is an internal cost and (as discussed in Appendix A4.2), only the lost tax revenue should be included in a conservative evaluation restricted to external social costs and benefits. However, there is at least anecdotal evidence to suggest that many low-level cannabis suppliers become involved in drug dealing essentially as part of their social activity and may not think of this as drug dealing

[33] This assumption is roughly consistent with the fact that the modal fine is £100 and the median is £75.
[34] See MoJ (2010b, pages 210-211) for an explanation of the process of redeveloping information on fines recovery.

subject to severe criminal justice penalties.

One can value the loss of output as the (gross) earnings that would have been earned, had employment continued. A simple valuation method would be to multiply the time spent in prison by the average level of earnings, but this would overlook the fact that people arrested for drugs offences have a relatively low probability of being in employment at the time of arrest, and below-average earnings levels if they are employed. Table 5.2.1 illustrates this with data from the 2003-6 Arrestee Survey, comparing people arrested for suspected drugs offences with other arrestees. Note that (uprated) average pay for employed drug arrestees is only around 70% of the average earnings level (of £488) for all employees in 2010. The higher average pay of people arrested for supply, rather than possession, offences reflects their greater average age.

It is likely that people imprisoned for drug offences have weaker labour market attachment than the average for people arrested on suspicion of drug offences. The Arrestee Survey does not observe the outcome of the arrest, but it gives some indicators of a high risk of imprisonment. Table 5.2.1 shows that arrestees with a previous history of arrest have (significantly) lower than average employment rates (around 36-37% rather than 40-42%), and that with a previous spell in prison have a still lower employment rate of around one quarter. In contrast, a previous arrest or prison history has no statistically significant influence on the average level of pay for arrestees who are in employment.

Table 5.2.1 Arrestee Survey 2003-6: economic activity and earnings by reason for arrest

	Possession	Supply or production	Non-drug offence
% economically active [a] (all arrestees)	42.1 (2.3)	40.4 (3.3)	47.2 (1.0)
% economically active [a] (arrestees with at least 1 previous arrest)	36.7 (2.5)	35.6 (3.7)	41.1 (1.0)
% economically active [a] (arrestees with prison record)	24.6 (3.1)	25.9 (4.5)	28.5 (1.0)
Average weekly net earnings at time of arrest [b]	£317 (14.2)	£343 (34.9)	£469 (42.3)
Average weekly gross earnings at time of arrest [c]	£405 (371 , 439)	£443 (359 , 528)	£629 (526 , 731)

Means weighted to allow for survey design, non-response and arrest frequency; standard errors in parentheses adjusted for complex survey design. [a] Employed, self-employed, in training or education; [b] Most recent pay (uprated to 2010 levels by growth in median weekly earnings) for all arrestees in employment at time of arrest; [c] Net-to-gross conversion using the personal tax and NI allowances and basic tax and NI rates for 2010)

On the basis of this evidence, it seems reasonable to assume that between 24% and 36% of people imprisoned for cannabis possession and supply offences would be in productive

employment if they were not incarcerated[35] and that their productive contribution to society would have been approximately £405 and £443 per week respectively. Taking the mean sentence length and aggregate number of sentences from Table 5.1.9 above (and assuming that 59% of the sentence is spent in prison), the estimated value of lost production is in the range £4.6m-£10.2m. Compared to the cost of maintaining these people in prison (£35m-£80m), the value of lost output caused by their removal from the labour market while in prison is modest. Of course, the longer-term costs of damaged future employment prospects may also be substantial. We deal with that issue in section 6.1.

Table 5.2.2 Assumed average levels of production lost through imprisonment, 2010

	Possession	Supply
Assumed % economically active	30% [24% , 36%]	30% [24% , 36%]
Average gross earnings per month	£1,755 (1606 , 1904)	£1,921 (1555 , 2287)
Average no. months served in prison	1.3	11.4
Number of sentences	346	1,927
Total value of lost production	£12.9m [£10.3m , £15.5m]	

90% confidence intervals in parentheses; Subjective high-low range in square brackets

5.3 Cannabis dependency costs

Cannabis dependency may involve a range of external costs both intangible (such as public treatment costs) and intangible (such as the distress caused to members of the drug user's family). If cannabis users' perceptions of the risk of dependency are too low, there will also be part of the internal cost to the user that should in principle be included in the calculation of net social cost. Given the extreme difficulty of assigning a value to all but tangible treatment costs, we exclude from the analysis intangible costs and all costs internal to the user, but assign a high upper limit to the range of uncertainty to our estimates to reflect this omission.

Like policing, the level of drug treatment costs is, to a large extent, a choice made by society. In the last decade or so there has been a deliberate policy decision to expand the provision of drug treatment services and to embed them in criminal justice procedures. Thus, the cost of drug treatment programmes has increased, in part because policy-makers have chosen to increase them. Any attempt to estimate the change in treatment costs induced by a reform of cannabis

[35] In a stationary multi-state transition process, the proportion of time spent in a given state equals the probability of observing that state at any point in time. Consequently, the proportion of a sentence that would have been spent in employment is the same as the probability of observing employment immediately before the sentence begins.

policy must therefore entail some assumption about policy on the provision of treatment services. We make the assumption here that the treatment system continues to run on current principles, except where the switch to licensing and regulation of the cannabis market necessitates some change. The difficulty here is the link between the criminal justice system and drug treatment. Although self-referrals are currently the most common form of entry to drug treatment programmes (40% in 2010), almost a third (29%) of entries into treatment are initiated by the criminal justice system (NDTMS 2011). This may happen through a variety of routes, including the probation or prison services, drug rehabilitation requirements in Community Orders and the Drug Interventions Programme.

We have no way of knowing how many of the referrals triggered by the criminal justice system are the result of cannabis offences alone – probably rather few, but we cannot be sure. If legal, licensed cannabis supply were to become available, at least some of the possession and supply offences which could trigger referrals would be eliminated, so we would expect referrals to fall, together with the associated treatment costs. On the other hand, it is likely that any policy intervention which runs the risk of increasing cannabis consumption would be accompanied by some expansion in the provision of treatment services for cannabis dependency. We sidestep the dual problems of (*i*) estimating the impact on treatment caseloads of removing a class of offences from the criminal justice system and (*ii*) anticipating revisions to treatment policy, by assuming that these two effects offset each other. We thus maintain the assumption that the caseload of cannabis dependency treatment programmes varies only in proportion to some measure of the size of the cannabis market.

There is no available data on the unit costs of providing treatment places linked to specific drugs, nor is there any breakdown of drug treatment budgets by substance of abuse. We also have no information on the duration of spells in treatment by substance of abuse, so there is little alternative but to use a single expenditure per case figure, calculated for the treatment system as a whole, as our estimate of the unit cost of a treatment episode for cannabis dependency. Table 5.3.1 shows the total treatment budgets and caseloads for adults and young people for England in the most recent year for which data are available, 2008/9. There are substantial differences between the types of intervention covered. The treatment budget for young people includes treatment for alcohol dependency, whereas the adult budget covers drug treatment alone; there are relatively few cases of heroin and cocaine dependency in the youth caseload, whereas adult treatment is strongly focused on those drugs; and there is almost no pharmacological treatment (such as methadone maintenance) within the youth treatment system. Despite these differences, the estimated unit cost is between £2,700 and £2,800 for both adults and young people.

Table 5.3.1 Estimated unit costs of drug treatment (England, 2008/9)

	Adults [a]	Young people [b]
Caseload (all substances)	210,815	22,382
Total treatment budget	£ 581m	£ 62.2m
Unit cost	£ 2,756	£ 2,779

[a] Age 18 and over; excludes alcohol dependency; [b] Age under 18; includes alcohol dependency

Although the treatment budget is not broken down by substance of abuse, caseloads are available classified by primary substance of abuse. There are potential difficulties in cases where multiple drug types are involved, but we have no way of dealing with those complications using available data. Our cost calculations are based on a unit cost of £2,750 per case, arrived at by using the (rounded) adult cost per case figure in Table 5.32.1. We regard this figure as a probable over-estimate, given that the treatment of cases of heroin and cocaine dependency is typically more difficult (and consequently more expensive) than treatment for cannabis dependency. Our indicative range of uncertainty for the unit cost takes account of this (Table 5.3.2). Caseloads by drug type are available separately for England and Wales and we combine these in Table 5.3.2 to give a total number of 16,255 cannabis treatment cases in 2009/10, or approximately 7% of the total drug treatment caseload. This volume implies a mid-estimate of £44.7m for the total cost of cannabis treatment in England and Wales. Under the proportionality assumption, these estimates suggest that even an increase in the cannabis market as large as 50% would only increase treatment costs by somewhere between £12m and £24m, which is small in comparison to policing and criminal justice costs.

Table 5.3.2 Estimated total cost of treatment for cannabis dependency in England and Wales 2009/10

England: cannabis treatment	14,306
Wales: cannabis treatment	1,949
Estimated unit cost	£ 2,750
[High-low range]	[£1,500-£4,000]
Total cost in England and Wales	£ 44.7m
[High-low range]	[£24.4m-£65.0m]

Table 5.3.2 tells us the approximate cost of the existing volume of treatment for cannabis dependency, but it does not immediately tell us the implications of a switch to a system of licensed regulated cannabis supply. Under our simple assumptions, a 10% increase in the number of regular cannabis users would increase treatment costs by around £2.2m and a 50%

expansion might increase costs by roughly £22m. Even a doubling of the size of the at-risk group of cannabis users could be expected to increase treatment costs by under £50m, which is less than half the costs of policing cannabis, or of the CJS procedures associated with cannabis possession and supply.

5.4 Drug-related crime

Drug-related crime undoubtedly accounts for a large part of the external costs of illicit drug use. For example, Godfrey et al (2002) estimated that around 88% of the economic and social costs of class A drug use in England and Wales in 2000 was attributable to crime and policing costs, while the UK Drug Harm Index (MacDonald et al. 2005, 2006), which attempts to measure the trend over time in drug-related social harms, assigns over two-thirds of its weight to property crime. Consumption of illicit drugs might influence crime in a number of ways. It might create a need for additional income to fund drug purchases – Goldstein's (1985) "economic-compulsive" mechanism. There may be direct "psychopharmacological" causes of drug-related crime: for instance, through weakening of self-control or decision-making capacity, or provoking violent responses to external provocation. Violence is also sometimes a feature of the working of illicit markets, where legal enforcement of contracts is impossible (Goldstein's concept of "systemic" drug-related crime). However, research on drug-related crime is limited by the difficulty of establishing the level of crime that would have been committed by drug users or suppliers had they been free of drugs (the "counterfactual"), and there have been few attempts to use controlled experiments or estimate causal behavioural models as a basis for simulating crime in a counterfactual world characterised by a different configuration of drug markets. This lack of evidence is particularly striking in relation to cannabis, despite the widespread belief among the general public that cannabis use contributes to criminal activity (Advisory Council on the Misuse of Drugs 2008, Table 8).

In a companion paper (Bryan et al 2011), we have used statistical matching methods and data on self-assessed motivation to produce separate estimates of the amount of violent and acquisitive crime which is causally related to cannabis use. That study uses a combination of data from the Arrestee Survey and Offending Crime and Justice Survey to give adequate coverage of prolific offenders and drug-users. The central conclusion is that, in contrast to public perceptions, there is essentially no statistically significant evidence of criminal activity induced by cannabis use and only weak evidence of a small amount of crime linked to cannabis supply activity (Bryan et al 2011, Table 7). The study also estimated the aggregate social costs, both tangible and intangible, associated with drug-related crime. Table 5.4.1 reproduces their results for two population groups: cannabis consumers (defined as those who have used cannabis but no hard drug within the last month); and cannabis suppliers (defined as those who

have sold cannabis but no hard drug in the last month).

There are several important points to note about these estimates. First, there is some overlap between the sets of cannabis consumers and suppliers (since many suppliers also consume) and also between acquisitive and violent crime (since robbery involves both acquisition and actual or threatened violence). Second, social costs include the value of stolen goods, implying that theft constitutes a total loss to society. This is standard practice in the research literature, but it over-estimates the loss to society as a whole by ignoring the benefit generated by stolen property which remains in existence after the theft. Part of the loss to victims of acquisitive crime is in fact a transfer from the legal owner to the thief, rather than a total loss to society. It may be distasteful to include the benefit to wrong-doers in a measure of social welfare, but it is logically appropriate to do so, at least under conventional welfare measures. Third, the aggregate estimates for violent crime are large and the associated range of uncertainty very wide. This happens, despite the fact that estimated individual rates of cannabis-related crime are small, because the number of cannabis users is large and because the estimated levels of intangible unit social costs of psychological distress are potentially high and conceptually very uncertain (see Bryan et al 2011, section 8). Fourth, the estimates in Table 5.4.1 exclude crime committed by people aged 16 or under. It is perhaps more likely for juveniles than adults to commit petty crime to fund cannabis purchases, so there may be some under-estimation of the costs of cannabis-induced acquisitive crime, but the relatively small size of the cannabis-using under-17 population means that this bias will be modest in size.

Table 5.4.1 Estimated aggregate external social cost of drug-related crime in 2003 (2003 prices)

Crime measure	Indicator of drug use	
	Cannabis-only user	Cannabis-only supplier
Group size (millions)	2.47 (2.34 , 2.59)	0.21 (0.18 , 0.25)
Aggregate social cost: acquisitive crime (£bn)	0.747 [-0.024 , 1.518]	0.829 [0.318 , 1.341]
Aggregate social cost: violent crime (£bn)	6.346 [-0.345 , 13.037]	2.710 [1.273 , 4.148]

Source: Bryan et al (2011), Table 15; 90% confidence intervals in parentheses; ranges of uncertainty in square brackets are partly subjective and should not be interpreted as conventional confidence intervals.

Licensing of cannabis is likely to have two primary effects: an expansion in the number of cannabis users and a reduction in the number of illicit cannabis suppliers. To the extent that cannabis-induced crime does exist, we would therefore expect there to be an increase in crime generated by cannabis use, but a reduction in crime causally related to cannabis supply; these

may be offsetting to a large degree. To illustrate this, suppose that the number of cannabis users expands by 25% while the number of illicit cannabis suppliers falls by 75%. Under a simple assumption of proportionality, the net result would be *falls* in the aggregate social cost of acquisitive and violent crime of £435m and £446m respectively.[36]

In practice, the situation is more complex than these simple calculations suggest, since a fall in the price of cannabis and an increase in its availability would have implications for other related markets. For example, there might be substitution of cannabis for other forms of consumption such as alcohol, with a consequent fall in the volume of alcohol-related crime and disease. These indirect benefits of reform could be very large (see Caulkins et al 2012, pp. 133-135) but, in our view, evidence on demand interactions with other problematic goods is far too weak to allow credible estimates to be made for Britain (or, probably, anywhere else).

On the supply side, there may be some substitution of other illicit supply activity (such as cocaine dealing) for cannabis, with a corresponding rise in the volume of crime related to this new supply activity. These indirect effects could attenuate the direct effects on drug-related crime, although the degree to which this happens is impossible to estimate convincingly with currently available evidence. To illustrate the magnitudes involved, we make the following simple assumptions: (i) 12% of current illicit suppliers of cannabis would continue illicit cannabis supply activity post-reform (the same proportion as the estimated market share of smuggled cigarettes in the tobacco market); (*ii*) among those who move out of cannabis supply there would be an average 25% reduction in their criminal activity – a low figure that allows for considerable substitution of other harmful activity for cannabis supply.

The Bryan et al (2011) figures are based on 2003 prices and relate to the subsets of cannabis-only consumers and suppliers. We use the CPI to convert to 2009/10 prices and make assumptions about the numbers of cannabis suppliers and consumers pre-reform based respectively on the combined-sample proportion of OCJS and AS respondents who self-report any current or past cannabis supply activity and on the estimate of market size by Pudney et al (2006). Both supplier and consumer numbers are scaled down by 39%, to reflect the reduction in measured cannabis prevalence recorded in the BCS since 2003/4. This gives estimated numbers of suppliers and users as 0.139m and 3.374m respectively in 2009/10: a supplier-consumer ratio of 4.1%. For the change in cannabis prevalence induced by reform, we use the three scenarios set out in Table 4.5.3. Since a neuroscience-based demand gateway would depend primarily on THC consumption, while a social influence-based demand gateway would depend primarily on the number of purchase transactions, we use an average of the THC and

[36] The indicative ranges of uncertainty associated with these illustrative figures would be -£245 to -£626m (acquisitive) and -£1,041m to +£148m (violent).

volume changes characterising each scenario, so the low, mid and high-response scenarios imply demand increases of 2.5%, 12.5% and 32.5% respectively. Table 5.4.2 gives the results of these calculations. The projected net benefit is small and positive if the demand response to reform is low, but this declines to a net social cost and the associated range of uncertainty increases sharply as we admit the possibility of a larger demand response to reform. In the high-response scenario, there is a large projected net social cost of over £0.5bn, but with such a large range of uncertainty that no useful conclusion can be drawn.

Table 5.4.2 Projected net external benefit from reform-induced change in drug-related crime

	Market response scenario		
	Low-response	Mid-response	High-response
Cannabis-induced crime	+ £17m [£6m, £28m]	- £15m [-£145m, £114m]	- £569m [-£1.4bn, £256m]

Note: subjective ranges of uncertainty in brackets; figures may not sum to totals because of rounding.

5.5 Drug-related accidents

Our knowledge of the contribution of illicit drug use to accidents is very limited. There is a small body of quantitative research on drug-related road accidents but very little on the role of drugs in accidents at work or in the home, and we therefore restrict attention to road accidents. The recent North report (North 2010, chapter 6) reviewed the state of evidence on drug-induced road accidents and found alarming shortcomings. It is well-established that cannabis and other drugs (both illicit and prescribed) cause some impairment of drivers' performance. However, the system for identifying drug use as a contributory factor in accidents is limited and there are concerns about the low priority attached by police investigators to drugs other than alcohol as possible factors in accident investigations. There is also enormous difficulty in determining whether drugs found to be present in the system of a person involved in an accident played any part in causing the accident – particularly when both drugs and alcohol are present.

When the police investigate a road accident, they use a formal procedure (STAT19) for recording contributory factors, which is part of the national road accident reporting system. This procedure is essentially subjective and it is partial, since some accidents do not involve police assessment in person. Drugs are likely to be under-recorded as a contributory factor, since there is no systematic testing for evidence of drug use by those involved. On the other hand, while the system records the existence of possible contributory factors (2.4 factors per

accident on average) it does not assign any estimate of their "share" of causation, so there is a countervailing tendency towards over-estimation through multiple counting. Table 5.5.1 summarises the latest available data, relating to the whole of Great Britain in 2009. It is interesting that, of the 2,094 road deaths in which the police reported one or more contributory factors, 3.1% involved drugs – a figure which is very close to the causal impact of 2.5% estimated by Laumon et al (2010) for France, which has similar drug prevalence to Britain.

Table 5.5.1 Proportions of road accident victims involved in accidents where drugs were judged to be a contributory factor

	Deaths	Serious injury	Slight injury	All casualties
Drug-related	64	314	924	1,302
All accidents	2,094	22,146	155,407	179,647
Drug-related share	3.1%	1.4%	0.6%	0.7%
Cannabis-related share	2.0%	0.9%	0.4%	0.5%
[Low-high range]	[1.5, 2.4]	[0.7, 1.1]	[0.3, 0.5]	[0.4, 0.6]

Note: includes only casualties in accidents where a police officer attended the scene and a contributory factor was reported. Computed from Table 4h of DfT (2010).

We adopt the drug-related shares of road casualties from Table 5.5.1 as our central estimate of the causal impact of drug use on road casualties. It is not possible to break this down by drug type, so we convert these shares to cannabis-specific form by multiplying by a factor defined as the number of cannabis users as a proportion of those reporting any illicit drug. Estimates for this proportion range from 57%, using the prevalence estimates underlying the Pudney et al (2006) analysis of market size, to 79% from the last-month prevalence figures from the 2010/11 British Crime Survey. In view of this uncertainty, we use a figure of 65% for our central estimate and [50%, 80%] as the low-high range. We then apply these rates to the numbers of recorded road casualties in England and Wales, after making allowance for under-reporting of injuries (using also the confidence intervals provided by DfT 2010, Table 5c). The resulting numbers of drug-induced road casualties is presented in Table 5.5.2, together with estimated numbers of the corresponding accidents, classified by seriousness.

To estimate the aggregate social cost of these casualties, we multiply the numbers of casualties and accidents by the estimated average unit social cost for each category of casualty and accident. These unit costs are taken from the Department for Transport's annual analysis (DfT 2011, section 3.4), which provides a standard basis for the evaluation of transport projects. The casualty-specific unit costs include human costs (such as grief and suffering), estimated using a willingness-to-pay methodology; the value of lost output; and medical costs. Accident-specific costs include police and insurance costs and damage to property. The unit costs over-estimate

external social costs to some extent, since some of their components are foreseeable internal costs to the drug user. Total cannabis-related road accident costs calculated in this way turn out to be substantial, ranging in total from £117m to £316m, with £192m as a central estimate.

Table 5.5.2 Estimated cannabis-induced road casualties: England & Wales 2010

	Deaths	Serious injury	Slight injury	All casualties
Number of reported casualties	1,642	20,700	155,407	179,647
Casualties adjusted for under-reporting	1,642	63,692	523,165	588,499
Estimated cannabis-related casualties:				
Mid estimate	33	587	2,022	2,641
Low	25	282	1,555	1,863
High	40	1,084	3,331	4,455
Estimated number of accidents by seriousness:				
Mid estimate	30	506	1,616	1,945
Low	23	243	1,243	1,371
High	37	935	2,663	3,280
Casualty-related unit cost (£)	1,585,510	178,160	13,740	
Accident-related unit cost (£)	12,813	5,333	3,070	
Estimated aggregate social cost of cannabis-related accidents:				
Mid estimate	£52.1m	£107.3m	£32.7m	£192.1m
Low	£40.1m	£51.6m	£25.2m	£116.8m
High	£64.1m	£198.1m	£53.9m	£316.1m

Note: includes only casualties in accidents where a police officer attended the scene and a contributory factor was reported. Computed from Table 4h of DfT (2010).

5.6 Market regulation costs

The licensing of cannabis supply would introduce a need for regulation activity similar to that already in place for tobacco and alcohol. It is difficult to estimate the costs of regulation activity because, in practice, regulation takes many forms, involves a large number of local and national agencies and is difficult to distinguish clearly from the other functions of those agencies. We interpret regulation to cover four areas:

(*i*) *Retail*: including monitoring and control of advertising, mandatory health warnings, sale to under-age people, purchase quantities;

(*ii*) *Production*: including monitoring of production locations and methods and control of product characteristics;

(*iii*) *Illicit supply*: enforcement of bans on unlicensed production, and importation and exportation of cannabis.

(*iv*) *Information and education*: provision of information about the law and health consequences of cannabis consumption.

As with treatment for drug dependency, the cost of regulation depends on a set of decisions

made by the authorities about the appropriate level of regulation activity. This in turn has important implications for the outcome of the policy as a whole. For example, the large investment in anti-smuggling activity made in the last ten years is believed to have led to a large fall in the market share of illicit tobacco and, consequently, a significant increase in revenue from the indirect taxes on tobacco (APPGSH 2010, Annexe 2).

In addition to the uncertainty about the regulation activity that would be undertaken, we have no reliable information on the unit costs of that activity. As far as we are aware, there are no published data on aggregate expenditure on regulation activity directed at the alcohol and tobacco markets. Most of this work is local, involves multiple agencies and is not easily separated from the other work of those agencies, so it is not feasible for us to attempt a detailed costing exercise for alternative assumptions about the intensity of regulation. Instead, we make two convenient assumptions: that the setting up of a system of licensed supply would reduce the incentive for illegal importation of cannabis, thus freeing some of the resources currently devoted to intercepting imported cannabis for other uses; and that those resources would be redeployed to local authorities for monitoring and enforcement of the new cannabis market. In addition, we assume that new funding would be provided to local authorities, which we estimate by analogy with the additional funding provided to support the introduction of the Welsh and English smoking bans in April and July 2007. In total, this funding package amounted to £29.5m for 2007/8 as a one-off payment to local authorities.[37] We assume that the same sum is paid on an annual basis, in addition to any funding redeployed from the customs service. This is a relatively generous scale of funding, intended to reflect the health concerns which have been consistently expressed by UK governments.

There is better information available on the costs of public health education and information initiatives. For alcohol and tobacco in 2009/10, these programmes cost £17.6m and £14.8m respectively, and we assume that there would be a new initiative (in addition to existing school-based and other drug-prevention programmes) of similar scale: say £16m per year. Thus, in total, we envisage an increase in spending on market regulation and health education of £45m annually.

6 Long-term and indirect costs and benefits

The indirect consequences of policy reform are particularly difficult to evaluate. They include long-term effects on a range of outcomes including mental and physical health, education and employment trajectories, and the risk of transition to more serious drug abuse and crime, with

[37] Local Authority Circular LAC(2006)17, Department of Health, 21 December 2006.

their adverse social consequences. There are two large problems here. The first concerns the distinction between internal and external costs and the extent to which the potential long-term costs are understood by cannabis users. External costs such as health service costs and the distress caused to family members are borne by others who have no say in the decision to use cannabis. Internal costs are borne only by the user himself or herself. Under simple assumptions, if the user makes a fully informed decision, the expected internal costs are offset by the pleasure derived from cannabis consumption and should thus be excluded from the cost-benefit calculation. But, if trained researchers with access to large data resources and scientific research methods are uncertain about the magnitude of potential future internal costs, how can we assume that the ordinary drug user has a good understanding of them?

The second major difficulty lies in the process of establishing causality linking cannabis use to the various long-term outcomes that are hypothesised to follow from it. A particular problem here stems from *confounding*, which is one form of what is often referred to as *endogeneity*. Consider the much-discussed link between cannabis consumption and schizophrenia. There is a clear statistical association between cannabis use and schizophrenia in the sense that average prevalence and intensity of cannabis use is significantly higher among people who suffer from the disease than among non-sufferers. Moreover, cannabis use is generally observed to precede the (detected) onset of schizophrenia. This pattern of association may arise because cannabis use causes schizophrenia in some people, or it may occur because there are deeper underlying factors which predispose people to become cannabis users and also to suffer the disease. If these underlying confounding factors are responsible for all of the association between cannabis use and schizophrenia, then there is no true causal connection, so policy-induced changes in the pattern of cannabis use will have no impact on the incidence of schizophrenia (unless the confounding factors also change for some reason). Researchers face a dual problem: the behavioural/biological processes are not sufficiently well-understood to identify clearly what the relevant confounding factors are, so they cannot be fully observed; and it is not feasible or ethical to conduct randomised controlled trials in which human subjects receive long-term cannabis exposure. There are several empirical approaches that have been developed to overcome these difficulties, none of which can be relied upon alone to give absolutely reliable results. These approaches are reviewed in Appendix A6.1.

6.1 Long-term direct health costs

6.1.1 Mental illness

Anyone who has ever witnessed a friend or family member with serious prolonged psychiatric illness will understand the enormous – mostly intangible – social cost of mental illness and the difficulty of the diagnostic process. Diagnosis is particularly hard in the case of drug users, for

whom the symptoms of intoxication and drug dependency can be difficult to separate from those of mental illness itself. This is one of the most important areas of concern for policy on cannabis, but also one of the most difficult areas for research.

The evidence for a link between cannabis use and mental illness or impairment comes from three sources. First, a short-term connection with impairment of brain function has been demonstrated using randomised experimental methods to examine the effects of oral THC on cognitive test outcomes (Curran et al 2002) and fMRI images of brain activity (Bhattacharyya et al 2009). It is unclear whether these short-term impacts on the brain are directly connected with long-term mental illnesses such as schizophrenia. Second, trend analysis of the connection between cannabis prevalence and onset and the incidence of schizophrenia has produced little evidence of a causal link. The UK does not have a full register of diagnoses of mental illness, so research of this kind is difficult, but analysis of the Australian register (Degenhardt et al 2003) suggests no causal link. So far, there is little national evidence of the significant rise in schizophrenia incidence projected by Hickman et al (2007) under the hypothesis of a causal effect, although Boydell et al (2003) do report a two-fold increase in incidence between 1965 and 1997 in Camberwell. Practising clinical psychiatrists have expressed growing alarm about cannabis-related psychotic illness (Murray 2007).

The third source of evidence is a large body of observational studies examining the statistical association between cannabis use and subsequent symptoms of mental illness. Moore et al (2007) provide a systematic review of this literature, with some assessment of study quality in respect of vulnerability to bias caused by reverse causation and transient intoxication effects. However, the majority of the studies reviewed relied on the use of proxy covariates to adjust for effects of unobserved confounders – a procedure which we have shown to be potentially unreliable (Appendix 6.1). The Moore et al (2007) pooled analysis of published findings suggests a 40% increase in the risk of psychosis for people with occasional use of cannabis, with a larger (50-200%) increase in risk for heavy users. Because of the confounding problem and the lack so far of any clear trend in schizophrenia incidence, we view estimates of this magnitude as an upper bound on the true causal effect, with zero as the lower bound. Moore et al (2007) also review the smaller literature on other mental disorders, including depression and anxiety. The findings of these studies are not very coherent and give little evidence of any effect. For this reason, we focus entirely on psychotic illness.

The total annual cost of psychotic illness is based on the following identity:

$$C = np\,[\pi_0 + \pi_L(1+\lambda_L) + \pi_H(1+\lambda_H)]\,c \qquad (6.1.1)$$

where: n is the size of the population; p is the prevalence of illness among non-cannabis users;

π_0, π_L and π_H are the pre-reform prevalence rates of non-use, low- and high-intensity cannabis use in the population (where $\pi_0 = 1 - \pi_L - \pi_H$); λ_L and λ_H are the proportionate increases in prevalence of psychosis caused by the two levels of cannabis use; and c is the annual unit cost of a case of psychotic illness. Let $\bar{p} = p[\pi_0 + \pi_L(1 + \lambda_L) + \pi_H(1 + \lambda_H)]$ be the pre-reform prevalence of psychosis in the population, and assume that reform increases the prevalence of light and heavy drug use by a uniform proportion g. Then the increase in aggregate cost is:

$$\Delta C = \frac{ng\bar{p}\,[\pi_L\lambda_L + \pi_H\lambda_H]\,c}{1 + \pi_L\lambda_L + \pi_H\lambda_H} \tag{6.1.2}$$

We estimate π_L and π_H from OCJS survey data for 2003-6 as 11.25% and 5.72% respectively, where heavy use is defined as consumption at least once a week and light use is any lower rate of cannabis use (including current abstinence with any history of past use). McCrone et al (2008) estimate the prevalence of psychotic illness in England in 2007 as 0.5% and we take this figure to be applicable to England and Wales. The most recent estimates of prevalence and unit social costs are also provided by McCrone et al (2008), who quote a unit service cost of £10,687 in 2007 prices, with a further £8,391 as the cost of lost employment. Uprating these to 2010 prices in line with median weekly earnings, gives a total unit cost of c = £20,804. This figure includes elements for inpatient and other NHS care, medication, supported accommodation, criminal justice services, day care and other social services, informal care and lost output, but it does not include the "human" costs of distress to the victim and his or her family.[38]

Calculations using expression (6.1.2) are presented in Table 6.1.1, where we show both service costs and loss of earnings under three alternative assumptions about causality. The first assumption is that there is no effect at all. The second is that there is no impact of occasional cannabis use on the prevalence of psychosis, but a doubling of prevalence among long-term regular users. The alternative stronger assumption is that prevalence is raised by 40% for occasional users and tripled for regular users. Given the likely over-estimation of causal effects, we regard the last of these as implausible and use it as an upper bound.

The cost of services for patients with psychotic illness is clearly an external social cost which should be included in a cost-benefit analysis. Loss of earnings or output is an internal cost and arguably should be excluded from the cost-benefit picture if we are also excluding the user's perceived enjoyment of cannabis. Following this line, we adopt an estimate of £26m (range: £0m-£52m) for our central demand-response assumption and £53m (£0m-£134m) for the high-response case.

[38] Estimates produced by SCMH (2003) for mental illness as a whole suggest that human costs may be as large as service and lost output costs.

Table 6.1.1 Projected aggregate costs of additional policy-induced psychotic illness

	Low-response	Mid-response	High-response
Moderate causal impact [a]			
No. cannabis-induced cases ('000)	- 1.1	0.5	2.7
Service costs	- £13.7m	£6.8m	£34.1m
Lost output:			
Internal share [c]	- £8.0m	£4.0m	£20.1m
External share [c]	- £2.7m	£1.3m	£6.7m
Total external cost	- £16m	£8m	£41m
Strong causal impact [b]			
No. cannabis-induced cases ('000)	-3.0	1.5	7.6
Service costs	- £35.5m	£17.8m	£88.8m
Lost output:			
Internal share [c]	- £20.9m	£10.5m	£52.3m
External share [c]	- £7.0m	£3.5m	£17.4m
Total external cost	- £43m	£21m	£106m

[a] $\lambda_L = 0; \lambda_H = 1$; [b] $\lambda_L = 0.4; \lambda_H = 2$; [c] assuming an average tax/NI rate of 25%.

6.1.2 Physical disease

Cannabis is generally smoked, often in combination with tobacco because of its tendency to burn unreliably. Commercially-produced cannabis products would be likely to have better combustion properties and we assume that smoking will continue to be the primary means of consumption. We assume that, despite product controls, smoked cannabis remains at least as damaging to the respiratory and cardiovascular systems as tobacco, so that reform of cannabis policy has potential implications for physical as well as mental health.

The relationship between tobacco and cannabis consumption plays a key role in determining the costs of physical disease. If someone is a tobacco smoker and also a regular user of cannabis, then it becomes very difficult to identify the damage to health caused by each substance. We 'solve' this problem by assuming that each substance is equally damaging. The relationship between the demands for cannabis and tobacco is also important. A majority of the research on the issue has concluded that the two substances are complements, so that a reform leading to expansion of cannabis use would be expected to increase tobacco use also. However, most of this evidence does not separate prevalence and incidence. It is quite possible that initiation of someone into cannabis use might induce a demand for tobacco while, for someone who is already a smoker, an increase in cannabis use might be a substitute for cigarette smoking. A further complication is that product development within a licensed system might change the relationship between cannabis and tobacco demand.

There is a vast research literature on the health consequences of tobacco smoking, but there remains a great deal of uncertainty about the associated treatment costs. For the NHS in England, these were estimated as £1.4-1.7bn in 1996 (Department of Health 1998), and there are divergent estimates of £2.7bn (Callum et al 2011) and £5.2bn (Allender et al 2009) for 2006. Costs for Wales were estimated as £386m in 2007/8 by Phillips and Bloodworth 2009. The methods used to construct these estimates make use of survey data on the prevalence of current (and ex-) smoking, without adjustment for the overlap of this group with the group of cannabis smokers. Consequently, the estimates contain a (presumably small) upward bias to the extent that some cannabis-induced illness is misattributed to tobacco.

The interrelationship between cannabis and tobacco is not known in sufficient detail to allow any but the crudest estimate of the possible health effects. This crude estimate is derived as follows. Define n_s, n_c and n_{sc} to be the numbers of people who are respectively smokers of tobacco only, smokers of cannabis only and smokers of both. The co-consumption rate among smokers, $\lambda = n_{sc}/(n_s + n_{sc})$, and among cannabis users, $\mu = n_{sc}/(n_c + n_{sc})$, can be estimated from OCJS survey data as 10.4% and 82.1% respectively, where we define cannabis users as those who report use at least once a week.

The Callum et al (2011) and Phillips and Bloodworth (2009) estimates can be uprated to 2010 terms to give a figure of £3.46bn as our central estimate of the aggregate cost of treatment for diseases attributed to smoking in England and Wales. The estimation procedure used in those studies attributes all the disease suffered by co-smokers of cannabis and tobacco to tobacco. The result can therefore be considered as an estimate of $S = [n_s + (1 + \theta)n_{sc}]c$, where c is the mean cost of smoking-related disease for a cigarette smoker and θ is the increase in risk for an average co-smoker relative to a cigarette-only smoker. We assume also that the average cannabis-only smoker has a level of risk equal to θ. It is likely that $\theta < 1$, since the typical frequency and duration of cannabis smoking is less than that of cigarette smoking, and we assume a central value of 0.5 (high-low range: 0.25-0.75). Under these rough assumptions, the cost of disease caused by cannabis is $\theta[n_c + n_{sc}]c = \theta\lambda S/\mu(1 + \theta\lambda)$, which gives £208m as the implied central estimate, with a high-low range [£107m, £587m].[39] Under our three alternative assumptions about the expansion of demand in response to reform, this gives the net social costs induced by reform which are presented in Table 6.1.2. Remarkably, these costs are potentially larger than those of cannabis-induced psychotic illness, which have received far more attention in the cannabis policy debate.

[39] The high estimate uses the higher Allender et al (2009) estimate of aggregate cost and $\theta = 0.75$.

Table 6.1.2 Projected increase in aggregate treatment costs of cannabis-induced physical illness

	Low-response	Mid-response	High-response
Mid-estimate	£16m	£21m	£43m
High-low range	[£8m, £31m]	[£11m, £41m]	[£21m, £82m]

6.2 Scarring effect of a criminal record

A 'criminal record' is not a completely unambiguous term, although it is usually interpreted as referring only to unspent court convictions. Under the 1974 Rehabilitation of Offenders Act (ROA), most convictions become spent after a specified rehabilitation period elapses. A conviction never becomes spent if it carries a custodial sentence of more than 30 months, it is spent after 10 years for a sentence of 7-30 months, and after 7 years for a sentence of 6 months or less. Fines and community sentences become spent after 5 years.[40] Conditional and absolute discharges are spent after 1 year and 6 months, respectively, while cautions, warnings and reprimands are spent as soon as they are issued.

Job applicants do not have a legal obligation to reveal unspent convictions but they might be asked to do so by their employer at the time of the job application or interview, or when signing the employment contract. Failure to disclose unspent convictions could result in dismissal. It is illegal for an employer to ask about spent convictions unless the job is listed as an exception under the 1974 ROA. Most of these exceptions are professions, offices and occupations in the finance, health and public sectors.[41]

There are two types of Criminal Records Bureau (CRB) checks in England and Wales, known as *Standard* and *Enhanced* checks.[42] Both Standard and Enhanced CRB checks will reveal details of spent and unspent convictions, cautions, reprimands, and warnings held on Police National Computer (PNC) records. In addition, if the job involves working with vulnerable adults and children, the checks will reveal information held by the Independent Safeguarding Authority.[43] Enhanced CRB checks are usually asked for people applying for jobs that involve very frequent contact with vulnerable children and adults (such as a teacher or a Scout guide). They contain the same information as Standard checks but with the addition of local police force information considered relevant by Chief Police Officer(s).

[40] These rehabilitation periods are halved for under-18s.
[41] For more details see: http://www.homeoffice.gov.uk/publications/agencies-public-bodies/CRB/about-the-crb/eligible-positions-guide?view=Binary
[42] A third type of check, called Basic Disclosure is available in Scotland from Disclosure Scotland and can only reveal unspent convictions. This is accessible to applicants from England and Wales. Just under a million applications were handled by Disclosure Scotland in 2010.
[43] Notice that the Coalition Government has announced that the Independent Safeguarding Authority will be soon merged with the Criminal Records Bureau.

The CRB was established under Part V of the Police Act 1997 and was launched in March 2002 (CRB 2010). As Table 6.2.1 shows, since 2002 the number of CRB checks has increased steadily. In 2010 there were more than 4.3 million checks in England and Wales, more than a three-fold increase since 2002. About 95% of the total were enhanced checks, involving the highest level of disclosure and 7-8% of these checks revealed one or more offences. Research has suggested that, at least in the early days of the CRB, as many as 11% of CRB checks may have been illegal under the 1974 ROA (Suff 2005). It appears that criminal justice penalties are increasingly visible to employers and may be a significant influence on their hiring decisions and, consequently, in the job search behaviour of people with criminal records.

Table 6.2.1 Number of CRB checks by type and year since 2002

Period	Standard	Enhanced	Enhanced as % of total	Total
2002 (Apr-Dec)	117,917	805,752	87.23%	923,669
2003	267,819	1,881,653	87.54%	2,149,472
2004	284,232	2,184,291	88.49%	2,468,523
2005	294,381	2,361,547	88.92%	2,655,928
2006	342,171	2,800,938	89.11%	3,143,109
2007	302,892	3,050,148	90.97%	3,353,040
2008	358,456	3,345,015	90.32%	3,703,471
2009	349,438	3,848,836	91.68%	4,198,277
2010	189,158	4,119,250	95.61%	4,308,408

Source: Freedom of information requests 17194 and 17270. [44]

The number of people whose jobs are potentially vulnerable to a criminal record is large. In the 2003 OCJS sample, 9% of respondents employed in the education, health, legal and financial sectors (where a criminal record may be visible to employers and potentially sensitive) reported having used cannabis within the last year and 3% reported a current rate of consumption of at least once a month.[45] From the viewpoint of people acquiring a drug-related criminal record, employment rates among 2003/6 Arrestee Survey respondents on a charge of drug possession or supply were 42% and 40% respectively.

There is no direct evidence on the long-term effect of a drug-related criminal record, but there is reason to believe that it might be an important factor in employers' decision-making. The most thorough study of this issue in the UK by Metcalf et al (2001) was based on a survey of

[44] Accessed at: www.homeoffice.gov.uk/publications/agencies-public-bodies/CRB/Freedom-of-information/all-foi-responses/17194-number-of-checks?view=Standard&pubID=881971 and http://www.homeoffice.gov.uk/publications/agencies-public-bodies/CRB/Freedom-of-information/all-foi-responses/17270-checks-issued/?view=Standard&pubID=856072

[45] Comparable figures for other sectors are 16% and 8%.

employers and founds that 26% automatically reject, or view less favourably, applicants with any form of criminal record.[46] Drugs offences would "count a lot against" the applicant in 56% of cases. [47]

This finding is supported by an experimental audit study conducted in Milwaukee (Pager 2003), using closely matched pairs of people applying in person for entry-level jobs. For each vacancy audited, one applicant was randomly assigned to declare a criminal record, allowing the causal impact of the criminal record to be estimated. The callback rate among white applicants declaring a criminal record (17%) was half that for applicants with no record (34%). Among black applicants, the proportionate difference was still greater: a 5% callback rate compared to 14% for the non-criminal group.

We use a simple theoretical model of job search as a guide for our speculation on the costs generated by a criminal record. We assume there are two employment sectors. In sector 1, comprising mainly education, health, legal and financial services, employers have a high probability of checking criminal records and acting on the results. In sector 2, past criminality is a less sensitive issue and the risk from a criminal record check is negligible. In line with the evidence from Metcalf et al (2001) and Pager (2003), we assume that the probability of a job offer is halved in sector 1 but left unchanged in sector 2 for applicants with a criminal record.

In appendix A6.2, we set out a very simple economic model of two-sector job search which allows us to explore the possible effects of criminal record scarring. The model is calibrated using data from the British Household Panel Survey and Labour Force Survey, matched to Arrestee Survey data. It should be emphasised that this model has only the very modest objective of providing a framework for thinking about the possible order of magnitude of the scarring effect; it should not be treated as a serious predictive model.

In applying the model, we assume that every drug offence that involves arrest and interview at a police station leads to a criminal record, but we ignore cannabis warnings and PNDs. There are errors in both of these assumptions: some arrests do not result in a conviction or caution and many warnings and PNDs may be visible to some employers with negative consequences for the individual. These errors are offsetting to some degree and we expect any bias to be in the direction of understatement of the scarring effect, so that our estimates should be seen as conservative.

Table 6.2.2 shows the elements of the calculation. The assumption that employment probabilities are halved in sector 1 translates into an estimated 19% reduction of average

[46] Metcalf et al (2001, Table 4.6).
[47] Metcalf et al (2001, Table 4.7).

earnings for all people convicted on cannabis charges. Of the twenty-eight thousand cannabis arrestees (with average annual earnings of roughly £21,500), 16.5% are first-time arrestees who are at risk of scarring. The total loss of earnings through this scarring effect is therefore estimated to be just over £100m. The component of this sum which is external to the cannabis user is the total tax/contribution yield of £23m.

Table 6.2.2 Estimated scarring costs

Parameter	Estimate
Proportional loss of earnings due to scarring [1]	18.6%
Number of cannabis possession and supply convictions in 2010	28,048
Proportion of cannabis-arrestees who are first-time arrestees	16.5%
Average gross annual earnings [2]	£21,520
Aggregate earnings lost through criminal record scarring	£101.9m
External cost component of earnings	£23.0m

[1] Weighted average over individuals who are not users of opiates or cocaine. [2] Weighted mean average for Arrestee Survey cannabis-only users arrested on suspicion of a drugs offence

6.3 Long-term effects on human capital and earnings

Experimental evidence demonstrates convincingly that THC has an impact on brain function which results in at least a temporary impairment of cognitive function and memory. Although there is considerable doubt about whether sustained use causes these impairments to persist in later life, even temporary impairments may cause significant difficulties in learning and in negotiating the educational system. If cannabis consumption does have an adverse causal effect on human capital accumulation, it follows that there is a stream of lost returns to human capital in later life, at least until experience and on-the-job training make good the initial losses. In addition to this, continued use of cannabis might further decrease an individual's productivity while in work, in addition to its effect through educational achievement. To evaluate these losses, we need to combine evidence from three areas of the research literature: one dealing with the impact of cannabis use on educational attainment; the second dealing with the long-term returns to that attainment; the third investigating the impact of current cannabis use on productivity when in work. The last two of these effects in principle involve both the expected level of earnings when in employment and the incidence of unemployment spells interrupting the earnings stream. Appendix A6.3 sets out a highly stylised method of generating a range of plausible long-term earnings impacts. To make this method operational, we need to use a range of alternative assumptions about the causal impact of early cannabis use on school attainment and of adult cannabis use on earnings.

The research literature on cannabis and schooling contains a great diversity of findings,

complicated by different authors using different measures of cannabis use and schooling outcomes. In our view, none of the available studies is able to deal with the problem of unobservable confounding factors in a fully satisfactory way, and many of the results rely on quite weak strategies for identifying true causal effects. Some, like Engberg and Morral (2006), are based on selected samples which are unrepresentative of the general population that is our concern. Examples of studies which find quite large causal effects include Yamada et al (1996), Bray et al (2001), Register et al (2001), Engberg and Morral (2006) for the US and Van Ours and Williams (2009) for Australia. Studies which find smaller effects or which give reason to suspect that unobserved confounding factors are the dominant reason for the empirical association between cannabis use and school dropout include Chatterji (2006), Pacula (2003) and Roebuck et al (2004) for the US and Fergusson and Horwood (1997) for New Zealand. Observational studies of this kind rely on strategies for identifying true causal effects which are questionable to some extent and, in our view, it is extremely difficult to avoid a chronic tendency for over-estimation of causal effects through a failure to account fully for unobservable confounding factors and reverse causation (see Appendix 6.3). This means that any attempt to estimate the social costs and benefits flowing from the human capital consequences of reform will be subject to a large range of uncertainty.

The biggest policy concern is the possible link between early cannabis use and the failure to achieve any recognised qualifications from school. Table 6.3.1 gives some idea of the size of the empirical association between the two, using data on respondents aged under 35 from the 2010/11 BCS. The probability of leaving school without any qualification is 22% lower (2.4 percentage points) for early-onset cannabis users than for others.[48] The unconditional earnings premium associated with any form of school qualification is large: almost £10,000, or 71% of unqualified career average earnings.[49] This premium allows for differences in the incidence of interruptions to earnings through unemployment, but not for personal characteristics other than education or unobservable characteristics such as cognitive and non-cognitive abilities. The relatively small difference in basic qualification rates means that the difference in average annual earnings between early-onset cannabis users and others is much less than the earnings difference between groups classified by school qualification.

To span a wide range of assumptions about the causal impact of early cannabis use, we assume for our central estimate that half of the empirical difference in qualification rates between early onset users and others is causal; for the low and high estimates we assume respectively that

[48] The difference is statistically significant ($P = 0.048$) and comparable but slightly larger than the corresponding estimate from the 2003 OCJS.
[49] These earnings estimates are averages over all age groups in the 17-59 2010 population, weighted by age group size, and therefore abstract from cohort differences.

none and all of the difference is causal.[50]

Table 6.3.1 The empirical association between early cannabis use, educational achievement and average career earnings: British Crime Survey and Labour Force Survey, 2010/11

School qualifications	BCS 2010/11 data (all aged 17-34)		LFS 2010 Mean annual earnings, by qualification level
	Cannabis onset before age 16	Later or no cannabis onset	
No qualifications	10.82% (8.40, 13.24)	8.46% (7.03, 9.90)	£13,516
At least GCSE or equivalent	89.18% (86.76, 91.60)	91.54% (90.10, 92.97)	£23,159

The relationship between adult drug use and earnings when in work has been studied extensively and there is a greater degree of consensus in the research literature. Research based on UK and US data from the 1980s and 1990s is near-unanimous in finding an insignificant (often positive) association between cannabis use and earnings, after allowing for the effects of individual differences in personal characteristics and education attainment. See Kaestner (1991, 1994), Gill and Michaels (1992), Register and Williams (1992), Kandel et al (1995) and MacDonald and Pudney (2000, 2001) for leading examples of this literature. These findings are robust with respect to the type of data (cross-section or longitudinal) and the strategy for establishing causality. They are also in line with Conti's (2010) finding, based on data from the 1970 British Birth Cohort Study, that experimentation with cannabis is positively associated with measures of cognitive ability and that, when the wage analysis takes account of IQ test scores alongside other personal characteristics, the empirical (positive) association between cannabis use and wages disappears.

However, the analysis by Van Ours (2007b) conflicts with this body of research. Using longitudinal data from Amsterdam, he found evidence of a large negative association, with recent cannabis use accounting for a roughly 10% reduction in the average wage of cannabis users. We find it hard to reconcile this study with the large body of work reaching quite different conclusions, but the differences may be linked to the fact that Van Ours' data come from a specific location known as a centre of drug culture, and from a later period when the typical THC/CBD ratio of purchased cannabis was much higher. There are also identification issues and methodological differences that may account for some of the difference from earlier findings. We take account of the lack of complete unanimity by using Van Ours' estimate in the

[50] Note that the relationship between qualification rates and age of onset of cannabis use is not a simple one. For example, in BCS data, the qualification rate among people who first used cannabis at age 16-18 is higher than that among people who have never used cannabis.

construction of the upper limit of the range of uncertainty attached to our estimate (see Appendix A6.3).

Few studies have much to say about the link between drug use and earnings through the course of a whole career. Kandel et al's (1995) finding of a zero effect at age 35 is the combination of a positive association early on and subsequent slower wage growth, but their findings are based on a small US panel of individuals in continuous employment. In the absence of clear results on the time profile of impacts on wages, we assume that any earnings effects that exist act proportionately throughout the career. Recent work by Hyggen (2012) based on Norwegian survey data linked to administrative records finds a link between long-term cannabis use and an subjective index of work commitment, but we are sceptical about the causal significance of this link, given that work commitment and cannabis may both be consequences of the same underlying psychological process.

Most of this literature confines attention to the impact of cannabis use on the earnings of people in employment, overlooking the possible effects on the risk of unemployment. MacDonald and Pudney (2001) looked at the latter and concluded that, in contrast to heroin and cocaine, there was no evidence of an impact for cannabis. For our central estimate, we assume again that there is no direct effect on unemployment risk, but only an indirect effect through the human capital route. For our worst-case assumption, we use a 10% impact by analogy with Van Ours' (2007b) estimates for wages.

The results we arrive at, following the method set out in Appendix 6.3, are shown in Table 6.3.2. None of these figures should be regarded as reliable estimates, since the uncertainties in the basic research literature are too great to allow us much confidence. While we think that the extreme estimate of a £3bn loss of aggregate earnings from cannabis-induced loss of human capital is highly unlikely to be accurate, because its neglect of the self-selected nature of the early-onset group, it is consistent with a pessimistic reading of the evidence. Our aim in presenting these figures is primarily to demonstrate the importance of these uncertainties, underlining the need for more robust evidence on the link between cannabis use and school achievement.

Table 6.3.2 Estimated impact of reform on aggregate total earnings

	Low market response (ΔTHC = -10%)	Mid market response (ΔTHC = +5%)	High market response (ΔTHC = +25%)
Total annual earnings loss	+£24m [-£2,900m, £0m]	-£12m [-£3,000m, £0m]	-£60m [-£3,100m, £0m]
External component	+£6m [-£720m, £0m]	-£3m [-£740m, £0m]	-£15m [-£760m, £0m]

6.4 Behavioural gateways and their long-term costs

The "gateway" hypothesis has attracted a great deal of attention in the debate on cannabis policy. The hypothesis asserts a causal link between cannabis use and an increase in the risk of subsequent hard drug use,[51] and it is generally seen as a demand-side phenomenon, implying that any reform which increases consumption of cannabis would induce additional long-term social costs. There is some, highly contested, evidence in favour of a gateway effect for consumers of cannabis. Some animal experiments have found evidence of a "chemical gateway" in experiments involving self-administration of opiates by THC-exposed rats, but some other experimental work has found no effect of THC on the self-reinforcing character of opiates or cocaine (Ellgren et al 2007, Solinas et al 2004, Panlilio et al 2007). The vast difference between rats in an experimental laboratory setting and human beings in the social world makes this ambiguous evidence very difficult to interpret.

Naive interpretations of survey data suggest a large gateway effect, since there are few hard drug users who did not use cannabis before taking hard drugs. However, more sophisticated analysis allowing for confounding factors tends to result in a much smaller, but still positive residual gateway effect. Building on past work (Pudney 2003, Hernandez and Pudney 2011), we now believe it is essentially impossible to generate robust evidence of a gateway effect free of the upward bias caused by unobserved confounding factors, through observational studies of this kind, and it is our view that any true causal gateway facing individual cannabis users is likely to be very small.[52]

For our purposes, it is important to broaden the scope of the gateway hypothesis and consider it

[51] Many different mechanisms could be responsible for such an effect, ranging from neurological processes in the brain to social pressure from suppliers but the empirical research literature has made little progress in distinguishing these causal paths. See MacCoun and Reuter (2001), Kandel (2002) and Pudney (2010) for discussion of the elusive gateway effect. The policy implications of the gateway effect would depend on the mechanism involved. For example, if it has neurobiological roots, harm will be related to the change in THC consumption; if it is generated by contact with suppliers, harm is related to the number of transactions made.

[52] Recent work using genetic instrumental variable methods (Mendelian randomisation) has looked at a possible causal gateway operating from alcohol consumption to cannabis use and other adverse outcomes (Irons et al 2007), using as an instrumental variable a genetic variant linked to ALDH2 enzyme deficiency, and finding no evidence of a gateway. As yet, no genetic variant linked unambiguously to the probability of cannabis use has been identified, so the same technique is not available for gateway effects of, rather than on, cannabis use.

as a possibility on the supply side of the cannabis market also. The processes by which people become involved in drug supply are varied and complex, and social networks involving family and friendship ties are particularly important. For example, in a qualitative study of young active cannabis users, Duffy et al (2008) found that well over 90% either bought cannabis from a seller they knew socially or were given it by friends or had it bought on their behalf by a friend. This view is confirmed by large-scale survey data on young people (National Centre for Social Research 2011).[53] Thus, among social groups where cannabis use is prevalent, supply at the lowest market level seems to be more a by-product of social engagement than deliberate commercial activity. The predatory profit-motivated drug-pushers so often portrayed in the news and entertainment media appear hardly to exist at all at the lowest level of the cannabis market. Instead, there is a large group of young people, not otherwise involved in criminality, who are vulnerable to sliding into serious trouble as an unintended consequence of something they regard as a part of their social life rather than a considered income-generating activity. A supply-side gateway theory would predict that this low-level cannabis supply activity generates contact with 'professional' drug supply, creating pressure or temptation for informal supply activity to be extended to harder drugs, with consequent long term risks of incarceration, damage to employment prospects and hard drug dependence. This is at least as plausible as the demand-side gateway, but has quite different implications: it is the people supplying, rather than using, cannabis who are at risk; and the risk in question is one of involvement in hard drug supply rather than in hard drug use. By reducing the number of illicit cannabis suppliers, the reform we are considering would reduce, rather than increase, social cost.

The 2003-6 Arrestee Survey (AS) is one of the few surveys containing usable information on supply behaviour. Apart from the usual difficulty of establishing a causal link, the AS has the further disadvantage that it only contains two questions about supply of each of a few specific drugs: whether the respondent has ever sold it and, if so, when he or she last sold it. This question design makes it impossible to observe the sequencing of initiation into cannabis and hard drug supply for those who have supplied both and, consequently, it is not possible to estimate a statistical model of the causal link between them. Instead, we do two things. First, we show evidence from the AS, in the form of crude statistical associations between hard drug and cannabis supply and between hard drug and cannabis consumption, to demonstrate that the scope for an individual-level causal gateway effect is at least as large on the supply side of the market as it is on the demand side. Second, we explore the implications of alternative assumptions about the relative strength of supplier and consumer gateways for the aggregate

[53] The same pattern is common in other countries: for example in a large quantitative survey in New Zealand, Wilkins and Sweetsur (2006) found that a high proportion of cannabis users were provided with the drug by friends in a process of barter and gift exchange, and that most low- and middle-level dealers earned rather little cash income from their supply activity.

welfare outcomes of a move to a regulated market.

The AS was an annual repeated cross-section survey of arrestees aged 17 and over, in police custody in England and Wales (see Boreham et al 2006 for further details). The sample itself was designed to be representative of the population of arrest events flowing through police custody suites above a minimum size thresholds (those with at least one interview room and processing at least 2,000 arrests a year). The design of the AS randomised the timing and location of interviewer shifts within custody suites, and interviewers were required to attempt interviews with all arrestees in custody during the shift. A stratified random sample of 72 police custody suites was used and interviews were conducted while respondents were in police custody, using computer-assisted self-interviewing (CASI) for the sensitive subjects of crime and drug use. Survey weights are used to adjust for three possible sources of non-representativeness: (*i*) the oversampling of larger custody suites where cost per interview is low; (*ii*) non-response, caused by a number of process-related factors as well as refusals; (*iii*) the higher sample inclusion probability of prolific offenders. Weighting for frequency of arrest is particularly important, to avoid over-representation of prolific offenders with high frequency of arrest. The AS weights are based on predicted frequency of arrest estimated from reported actual frequency in the year preceding interview.

The last two waves of the AS give some detail on drug dealing activity by drug type. In 2004/5, the questionnaire asked when the most recent episode of selling occurred for each of cannabis, heroin, crack and powder cocaine. In 2005/6, the list was extended to include ecstasy. Table 6.4.1 is based entirely on the AS sample for 2005/6 and shows the most common combinations of co-supply of different drugs within the group of five drugs covered by the AS questionnaire. By far the most common is cannabis alone: using a one-month or one-year observation window to define dealing status, this accounts for 40-50% of those who are active in supply. There is a clear empirical distinction between two dealer "types". One is a supplier of the more socially-accepted recreational drugs, cannabis, ecstasy and powder cocaine. The various combinations of these three drugs account for around three-quarters of supplier prevalence in total. The second distinct type is the supplier of heroin and crack cocaine, accounting for almost 15% of dealers.

Table 6.4.1 Most common combinations of co-supply (Arrestee Survey, 2005/6)

Combination of drugs supplied within observation window	Observation window		
	Last month	Last year	Ever
Sample percentage of each supply combination within observation window			
Cannabis only	51.3 (3.5)	41.7 (2.2)	37.9 (1.7)
Ecstasy only	5.0 (1.1)	5.7 (1.0)	5.8 (0.9)
Cocaine only	5.7 (1.4)	5.1 (1.0)	2.1 (0.4)
Cannabis + ecstasy	5.3 (1.6)	9.6 (1.8)	14.2 (1.3)
Cannabis + cocaine	4.4 (1.5)	4.0 (1.0)	3.5 (0.6)
Ecstasy + cocaine	1.2 (0.6)	1.4 (0.5)	0.7 (0.2)
Cannabis+ ecstasy + cocaine	3.6 (1.2)	6.8 (1.2)	6.6 (0.9)
Heroin only	7.6 (1.7)	6.5 (1.4)	4.5 (0.7)
Crack only	1.3 (0.4)	2.3 (0.6)	1.3 (0.4)
Heroin + crack	5.3 (1.2)	5.2 (1.2)	1.8 (0.4)
Other combinations	9.4 (1.5)	11.6 (1.0)	21.6 (1.4)
Number reporting supplying drugs within observation window	488	918	1,733

Note: Proportions calculated within subsample of respondents reporting any drug dealing within the observation period. Weights are used to adjust for sample design, non-response and arrest frequency. Standard errors in parentheses, calculated allowing for stratified and clustered sample design.

Table 6.4.2 shows the empirical associations between involvement with cannabis and involvement with hard drugs in terms of supplier and consumer behaviour and the associations after adjustment for personal characteristics.[54] These associations are severely afflicted with bias arising from underlying confounding factors and should not be interpreted in a causal sense, but the comparison between the demand side and supply side is suggestive. In each case, the association between cannabis supply and dealing in hard drugs (especially cocaine) is particularly strong, and considerably stronger in proportionate terms than the analogous association for consumption. Note that the high rate of hard drug use among AS respondents is quite atypical of cannabis users in the general population, since users of hard drugs are greatly over-represented in the criminally-active part of the population.

[54] Adjusted using a logit model with covariates: gender, age, age^2, whether first arrested as a juvenile, whether left school prematurely, whether excluded from school.

Table 6.4.2 Crude gateway measures: Arrestee Survey 2004-6

Sample proportions	Supply		Consumption	
	Powder cocaine	Cocaine, heroin or crack	Powder cocaine	Cocaine, heroin or crack
Unadjusted for personal characteristics				
Proportion supplying/using hard drugs: if no supply/use of cannabis at any time	1.0% (0.10)	3.7% (0.25)	6.5% (0.55)	7.9% (0.61)
Proportion supplying/using hard drugs: if some supply/use of cannabis at any time	20.5% (0.85)	36.9% (1.03)	56.0 (1.04)	61.8 (0.92)
Ratio	20.91 (2.37)	10.03 (0.73)	8.57 (0.74)	7.82 (0.62)
Adjusted for personal characteristics				
Proportion supplying/using hard drugs: if no supply/use of cannabis at any time	1.3% (0.14)	4.6% (0.28)	10.4% (0.68)	13.1% (0.70)
Proportion supplying/using hard drugs: if some supply/use of cannabis at any time	17.4% (0.95)	33.9% (1.24)	54.5% (1.08)	60.7% (1.04)
Ratio	13.64 (2.54)	7.31 (0.93)	5.25 (0.82)	4.65 (0.70)

Note: Weighted estimates adjusting for over-sampling of prolific arrestees. Standard errors in parentheses, calculated allowing for stratified and clustered sample design.

The potential for large supply-side gateway effects at the individual level is striking, but it is only one of the factors determining the outcome of gateway processes in aggregate welfare terms. Since the number of cannabis users is much larger than the number of cannabis suppliers, even a small demand-side gateway effect may be sufficient to outweigh a larger supply-side effect in terms of aggregate net social benefit. In fact, the aggregate gateway impacts depend on: (*i*) the numbers of cannabis suppliers and users, pre and post-reform; (*ii*) the magnitudes of the relative individual-level gateway effects; (*iii*) the proportions of people who supply or use hard drugs without supplying or using cannabis; and (*iv*) the long-term external social cost of a life involving supply or use of hard drugs compared to a life that does not.

To see this, suppose that, prior to the projected policy change, there were n_s cannabis suppliers and n_c cannabis users. The new policy has the effect of increasing the prevalence of cannabis use to n_c^* and reducing the number of illicit cannabis suppliers to n_s^*. Suppose also that there is a probability p_s of someone who is not a cannabis supplier being a supplier of hard drugs, while p_c is the probability of someone who is not a cannabis user being a user of hard drugs. The corresponding probabilities for someone who has supplied or used cannabis are p_s^* and p_c^*, so

the proportional gateway effects for the supply side and demand side are $g_s = (p_s^* - p_s)/p_s$ and $g_c = (p_c^* - p_c)/p_c$. The long-term average social cost of becoming a hard drug user is S_c, while the social cost of becoming a hard drug supplier is S_s.

The net social benefit of the move to a regulated cannabis market is therefore:

$$B = (n_s^* - n_s)(p_s^* - p_s)S_s \; + \; (n_c^* - n_c)(p_c^* - p_c)S_c \tag{6.4.1}$$

which we compute as:

$$B = n_s(1 - \iota)g_s p_s S_s \; + \; n_c r g_c p_c S_c \tag{6.4.2}$$

where ι is the assumed proportion of current cannabis suppliers who would continue to engage in illegal supply post-reform and r is the assumed increase in cannabis (or THC) demand following reform.

Definition (6.4.2) is used to make three illustrative calculations, set out in Table 6.4.3 below, based on the following assumptions.

(*i*) The number of cannabis suppliers and consumers pre-reform are based respectively on the combined-sample proportion of OCJS and AS respondents who self-report any current or past cannabis supply activity and on the estimate by Pudney et al (2006). Both supplier and consumer numbers are scaled down by 39%, to reflect the reduction in measured cannabis prevalence recorded in the BCS since 2003/4. This gives estimated numbers of suppliers and users as 0.139m and 3.374m respectively in 2009/10: a supplier-consumer ratio of 4.1%. For the purpose of these illustrative calculations, we assume that 12% of current illicit suppliers of cannabis would continue illicit supply activity post-reform: the same proportion as the estimated market share of smuggled cigarettes in the tobacco market. For the change in cannabis prevalence induced by reform, we use the three scenarios set out in Table A4.5.3. Since a neuroscience-based demand gateway would depend primarily on THC consumption, while a social influence-based demand gateway would depend primarily on the number of purchase transactions, we use an average of the THC and volume changes characterising each scenario, so the low, mid and high-response scenarios imply demand increases of 2.5%, 12.5% and 32.5% respectively.

(*ii*) There are three alternative variants of the gateway. The 'weak gateway' case assumes that causal gateways are responsible only for a 10% increase in risk on both the demand and supply sides of the market. The 'plausible gateway' case reflects our view that there is at most a modest true demand-side gateway, but possibly a significant supply-side gateway. Thus we assume that cannabis is responsible for a 20% increase in risk on the demand side, but a doubling of risk on the supply side. The 'strong gateway' case – which we see as the least

plausible of the three – assumes that there is a causal gateway which doubles the risk of initiation into hard drugs for cannabis users and triples the risk of hard drug dealing for cannabis suppliers.

(*iii*) The probabilities of hard drug supply or consumption without cannabis supply or consumption are estimated from a combination of AS and OCJS data as 0.17% and 0.34% respectively.

(*iv*) The assumed long-term average social costs of an individual becoming involved in hard drug supply or consumption are very difficult to measure. Work by Cohen (1998) and Cohen and Piquero (2009) for the US leads to social costs as high as $1.7-2.3 million discounted over a whole career.[55] These estimates are certainly too high for our purposes, for two main reasons. First, they relate to an individual who follows a "delinquent" trajectory, whereas not all individuals who slip into hard drug use or supply through a causal gateway will follow such a trajectory – for many, it will be a transient phase generating much less social cost. Second, these evaluation exercises assume implicitly a non-delinquent counterfactual, whereas it is likely that someone who slips into delinquency through a causal gateway would not have led a blameless life in the absence of that gateway. Estimation of unit social costs in a way that addresses these concerns is virtually impossible with currently available evidence. Instead, we make illustrative calculations based on an estimate by Gordon et al (2006) of £44,231 as the annual social cost of class A drug use per user. For the gateway into hard drug supply, we use this figure and assume that such costs are, on average, incurred over a 5-year period, giving a result of approximately £221,000 per person. For hard drug use rather than supply, a lower figure is appropriate, since the majority of people who use heroin crack or cocaine at some point do not become sustained problem drug users. Consequently, we assume the average cost is equivalent to that for a 2-year drug-use career: roughly £88,500. These are purely illustrative figures, not serious predictions.

[55] However, discounting is not appropriate in our context because we are evaluating the current cost of a group of people at different stages of their lifecycles. In a stationary environment the 10 year of social cost generated by one new cannabis-induced hard drug dealer is representative of the first year's cost arising from that person plus 9 similar people who began their 10-year hard drug dealing careers 1-9 years earlier. To calculate aggregate current social cost, we sum them without discounting.

Table 6.4.3 Aggregate net social benefit resulting from demand- and supply-side gateways

	Aggregate net social benefit (£m)	Low demand response (-10% THC, +15% volume)	Mid demand response (+5% THC, +20% volume)	High demand response (+25% THC, +40% volume)
Weak gateway effects (10% risk increase for cannabis users and suppliers)	Demand side	- £3m	- £13m	- £33m
	Supply side	+ £5m	+ £5m	+ £5m
	Total	+ £2m	- £8m	- £28m
Plausible gateway effects (20% risk increase for cannabis users; 100% for suppliers)	Demand side	- £5m	- £25m	- £65m
	Supply side	+ £53m	+ £53m	+ £53m
	Total	+ £48m	+ £28m	- £13m
Strong gateway effects (Risk doubled for cannabis users and tripled for suppliers)	Demand side	- £25m	- £126m	- £326m
	Supply side	+ £105m	+ £105m	+ £105m
	Total	+ £80m	- £20m	- £221m

The estimates in Table 6.4.3 are subject to very great conceptual and statistical uncertainty and should only be seen as illustrations of the way in which the costs and benefits of reform would arise. However, there are two important – and reasonably clear – conclusions to be drawn from these calculations.

The magnitude of the aggregate gateway effect is not huge. Although the social cost of a life "lost to drugs and crime" may be very high at the individual level, the number of individuals involved through any plausible gateway mechanism is small, so the aggregate gateway effect appears to be moderate, compared with current enforcement costs.

The combined demand and supply gateway effect may favour regulation over prohibition. Unless policy reform leads to a very large expansion in cannabis consumption, the beneficial effect of the supply side gateway tends to offset the costs induced by the demand-side gateway, and it is quite plausible to argue that gateway mechanisms – if they exist at all – act in favour of regulation and against prohibition, rather than the reverse as argued by many opponents of reform. Even if we change our cost assumptions considerably (for example by increasing the assumed unit social cost of hard drug use), it is difficult to generate an outcome in which negative gateway effects on the demand side of the market grossly outweigh the positive gateway effects on the supply side and become a dominant factor in the cost-benefit balance. Consequently, it is hard to justify the central position that "the gateway effect" has occupied in the policy debate.

6.5 Other indirect effects

There are many other possible indirect effects of policy-induced change in the cannabis market.

Given the state of available evidence, we do think it possible to construct any meaningful estimate of these effects, so we leave them as further unquantifiable source of uncertainty in the cost-benefit calculation.

6.5.1 Consumption of other substances

For people who use cannabis alongside other substances, changes in the price (and physical properties) of cannabis arising from policy reform are likely to cause some changes in the demands for those other substances. If the substance in question is a substitute for cannabis, its consumption will fall if cannabis demand rises in response to a policy-induced price fall. There is therefore a positive cross-price elasticity between the two. Conversely, if it is a complement to cannabis, the cross-elasticity is negative, and its demand will increase together with consumption of cannabis in response to the price change. Note that these effects are distinct from the "gateway" effects of the previous section, which relate to changes in preferences induced by consumption of cannabis. Instead, cross-price effects relate only to economic responses to changes in the relative prices of consumption goods.

Appendix Tables A4.5.3-A4.5.5 survey the published literature on cross-elasticities of demand between cannabis and, respectively, tobacco, alcohol and other illicit drugs. A majority of these studies have concluded that cross-elasticities are negative, suggesting that tobacco, alcohol and other drugs are complements to cannabis, and that consumption will increase along with any policy-induced rise in cannabis consumption. Unfortunately, this body of evidence is of very little use to us. Most published research has investigated the effect on cannabis demand of changes in the prices of other goods, rather than the reverse, and the few studies that have looked at the impact of cannabis price changes on consumption of other goods have produced no clear conclusion. In general, the estimates cover a wide range of numerical values and there is a great deal of uncertainty associated with them. Moreover, none of them relates to the UK and none comes from a model of demand that accommodates the qualitative difference between high- and low-potency varieties of cannabis and the shift in their market shares that has been seen in recent years. Our view is that the direction of these cross-commodity effects is uncertain, but their magnitude is unlikely to be large.

6.5.2 Failures of decision-making

Our use of net external benefit as the evaluation criterion rests on the assumption that any individual who chooses to consume a good expects the personal consumption benefit he or she derives from it to outweigh the harm they expect to suffer. After the event, some may regret the outcome, but the assumption is that, beforehand, consumption appeared to be a risk worth taking. There is nothing special about cannabis in this respect: many forms of consumption or

personal activity entail some short- or long-term risk which people willingly accept.[56] Cost-benefit analysis usually allows individuals to be the best judges of their own welfare, and assume that observed choices reflect those welfare judgements. Under this assumption, the net external benefit criterion biases the analysis in favour of the *status quo* to some degree.

There is only good reason to depart from the revealed preference assumption if there are grounds for believing that a significant number of consumers are making irrational decisions (i.e. decisions which would conflict with their own 'true' evaluation of their welfare). This could arise either because of flaws in the decision-making process through an inability to envisage and compare potential outcomes or through a lack of the information required for efficient decision-making. For such individuals, it is possible that the net external benefit criterion would be biased against the *status quo* rather than in favour of it.

Two population groups are of most concern in this respect: young people whose decision-making capacities are not yet fully developed, and people with capacities impaired by mental illness (a group known to have a relatively high prevalence of cannabis use). While it is possible to measure population size by age group and to estimate the prevalence of various kinds of mental illness, it is much more difficult to define the idea of impairment as it affects decisions in relation to cannabis and to estimate the prevalence of impairment and its consequences. A further source of uncertainty is the effect of market regulation on the choices made by these groups.

One might expect that an expansion of the market would increase the number of 'irrational' consumption decisions, particularly if the legal status of licensed cannabis encourages more adults to continue consumption into the parenthood stage. However, it is not impossible that regulation of the retail trade, better control of product quality, and clearer health messages would be more effective as a curb on consumption by the very young than the current illicit but widespread market.

Overall, our view is that this is likely to be a net source of social cost rather than benefit, but potentially large only if there is a very large market response to policy reform.

6.5.3 Credibility of health information

At present, official information about health risks from drug use are linked to the Misuse of Drugs Act and thus tied to the prohibitionist legal provisions of that Act. Distrust of government in general and drugs policy in particular is widespread among the groups most at risk of becoming involved in drug use, and it is plausible to suggest that the health information

[56] David Nutt's famous or infamous example of horse riding is only one of many that could be given – including smoking, drinking, driving, eating junk food, TV watching and other sedentary habits.

originating from government loses credibility by being linked to the law in this way. If this argument is correct, one possible benefit of regulating rather than prohibiting the cannabis market is that consumers would become better-informed and more likely to conform to the economist's idea of a rational decision-maker.

We know of no evidence bearing on this issue, and we take the view that there may be some positive net benefit from this source, but probably of modest size.

6.5.4 Drug tourism

If the UK were to introduce a licensed cannabis market, and do so alone, there is little doubt that it would generate "drug tourism" in the same way that liberalisation has in the Netherlands, although a ban on all smoking in public places such as bars and cafés would presumably reduce this considerably. Although the Dutch have found drug tourism to be a nuisance and have considered controls on tourists' access to cannabis, there may be benefits (in terms of employment and income from overseas) as well as costs involved.

Overall, we see increased drug tourism as a potential net social cost, but probably not on a large scale.

7 Overall results: aggregate net benefits and their distribution

We have made a distinction between those costs and benefits which are directly related to the current working of the cannabis market and costs/benefits which are more indirectly related, through uncertain long-term causal mechanisms such as disease processes and behavioural gateways. Although not completely clear-cut in practice, this is a useful distinction, because it separates (relatively) straightforward issues, where there is clear scope for further research to clarify the picture considerably, from difficult issues relating to long-term impacts which involve questions of causality that are unlikely ever to be settled unambiguously.

We summarise the net benefit estimates under three alternative assumptions about the increase in consumption generated by the switch to a licensed regulated cannabis market; these scenarios are set out in Table 4.5.3 above. Remember that the estimates are not predictions of what would happen in any future period. They are estimates of the net aggregate effect of a hypothetical reform implemented in 2009/10, abstracting from any transitional adjustments (and any accompanying transitional cost), assuming that the full potential savings are realised. For instance, this would mean that potential savings in police time are realised either through a corresponding reduction in police funding or by the reallocation of those resources to other socially beneficial uses. A positive figure represents a net saving to society from the reform,

negative figures represent net losses. All figures are expressed in 2009 prices.

7.1 Direct costs and benefits

The results for direct net benefits are given in Table 7.1.1. Drug-related crime plays a critical role here. The figures for crime are based on an individual-level study by Bryan et al (2011) which found no statistically significant evidence of crime caused by cannabis use and only modest amounts of crime caused by involvement in cannabis supply. If we were to assume that the former is exactly zero and the latter small but positive, the conclusion would be that licensing and regulation would have positive net benefits in terms of crime in all market response scenarios. However, there are wide confidence intervals around these estimated individual-level mean crime effects, which must be multiplied by very large numbers of suppliers and (especially) users of cannabis to generate aggregate estimates. The assumed mean unit social costs of (especially violent) crime are high and the result is an extremely wide range of possible values for the net benefit of reform through the impact on crime.

If we were to exclude cannabis-related crime, our conclusion would be that reform would generate a modest direct net benefit, probably between £200m and £300m, irrespective of the scale of market response. When we include crime in the picture, the estimate of the total direct impact of reform varies much more across market response scenarios and the range of uncertainty becomes much larger. The fall in net benefit with the degree of market response is largely driven by the (statistically insignificant) estimate of violent crime caused by cannabis use because of the very large number of cannabis users.

Allowing for the uncertainty introduced by estimation of drug-related crime, we can be confident of a positive total direct net benefit in the low- and mid-response scenarios. In the other projection which envisages a much greater demand response, the central estimate is large and negative, but largely swamped by statistical uncertainty.

Table 7.1.1 Summary of aggregate direct external net benefits from cannabis licensing in England and Wales (2009 prices)

	Market response scenario		
	Low-response	Mid-response	High-response
Policing	+ £105m [£65m, £147m]	+ £105m [£65m, £147m]	+ £105m [£65m, £147m]
Court procedures	+ £97m [£58m, £143m]	+ £97m [£58m, £143m]	+ £97m [£58m, £143m]
Custodial sentences	+ £84m [£50m, £125m]	+ £84m [£50m, £125m]	+ £84m [£50m, £125m]
Community sentences	+ £5m [£3m, £8m]	+ £5m [£3m, £8m]	+ £5m [£3m, £8m]
Tax on earnings lost during incarceration	+ £10m [£8m, £12m]	+ £10m [£8m, £12m]	+ £10m [£8m, £12m]
Market regulation / health promotion costs	- £45m	- £45m	- £45m
Cost of cannabis-related accidents	+ £13m [£8m, £21m]	- £6m [-£11m, -£4m]	- £32m [-£53m, -£20m]
Cannabis dependency treatment costs	+ £5m [£2m, £7m]	- £2m [-£3m, -£1m]	- £11m [-£16m, -£6m]
Cannabis-induced crime	+ £17m [£6m, £28m]	- £15m [-£145m, £114m]	- £569m [-£1.4bn, £256m]
Total	+ £290m [£224m, £366m]	+ £231m [£86m, £381m]	- £356m [-£1.2bn, £472m]

Note: subjective ranges of uncertainty in brackets; figures may not sum to totals because of rounding.

7.2 Indirect costs and benefits

Effects of reform which are less directly related to outcomes in the cannabis market often involve long-term processes which are not easily analysed statistically. This means that the overall net benefit-cost balance becomes more uncertain still when indirect consequences are brought into consideration. Our attempts to evaluate the mental and physical health consequences, the costs of scarring in the labour market and gateway effects do not lead to any substantial change in the overall picture: an overall net external benefit from reform of around £280-460m for the low-response scenario and £100-400m for the moderate assumption about market response. Only for the high-response scenario do we find a risk of large net social costs, with the range of uncertainty running from a £1.3bn loss to a £400m net benefit.

This neglects further potential impacts which we do not see as quantifiable with currently available evidence. However, in our view, the unquantifiable effects probably do not change the picture greatly, except to add further uncertainty and to increase the possible extent of net social loss in the high-response scenario.

Table 7.2.1 Summary of aggregate indirect net external benefits from cannabis licensing in England and Wales

	Market response scenario		
	Low-response	Mid-response	High-response
Quantified effects			
Mental illness treatment costs	+ £16m [+£8m, +£43m]	- £8m [-£21m, -£4m]	-£41m [-£106m, -£20m]
Physical illness treatment costs	- £16m [-£31m, -£8m]	- £21m [-£41m, -£11m]	- £43m [-£82m, -£21m]
Criminal record scarring	+ £23m [+£11m, +£57m]	+ £23m [+£11m, +£57m]	+ £23m [+£11m, +£57m]
Gateway consequences	+ £48 [£0m, +£96m]	+ £28 [-£20m, +£80m]	- £13m [-£220m, £0m]
Unquantified effects			
Consumption of other substances	**?**	**?**	**?**
Failures of decision-making	**?**	**-**	**--**
Credibility of health information	**+**	**+**	**+**
Drug tourism	**-**	**-**	**-**
Total quantifiable indirect effects	+ £71m [+£19m, +£136m]	+ £22m [-£33m, +£82m]	-£74m [-£295m, -£18m]
Total quantifiable direct and indirect effects	**+ £361m [£277m, £461m]**	**+ £253m [+£98m, +£415m]**	**-£430m [-£1.3bn, +£400m]**

Note: subjective ranges of uncertainty in brackets; figures may not sum to totals because of rounding. **?** = direction of effect uncertain; **-** = probable net cost of modest size; **--** = probable net cost, possibly large; **+** = probable net benefit of modest size.

7.3 Government budget implications

The impact of a policy reform on the government's budgetary position is not a measure of social cost, but it is important, since all policy changes need to be integrated in the government's overall funding strategy. The budgetary impact is the sum of net savings in expenditure (on policing and criminal justice procedures, health care costs, etc.) and net increases in revenue from taxes and other receipts. We summarise these impacts in Table 7.3.2.

Any net savings in government expenditure should be seen as potential savings until a strategy for realising them is in place. For example, our central estimate of a saving of £105m on policing costs represents the estimated value of police time freed by the removal of the requirement for policing of cannabis possession and domestic supply. Government could choose to realise it as a budgetary saving by reducing the police budget accordingly, or it could allow the corresponding resources of police time to be redeployed to meet other policing objectives. The estimates

presented in Table 7.3.2 assume that potential savings are realised in cash terms.

The largest single element of the budgetary picture is the net indirect tax revenue from the taxation of licensed cannabis production. This is difficult to predict since, to do so, we need to know: (*i*) the baseline volume of demand pre-reform; (*ii*) the effect of reform on demand; and (*iii*) the share of market captured by licensed production. All three of these are uncertain, but (*ii*) and (*iii*) are fixed by our three market response scenarios set out in Table 4.5.3.

Our starting point for (*i*) is the analysis of market size for England and Wales in 2003/4 by Pudney et al (2006), which resulted in an estimate of cannabis volume of approximately 360 tonnes at a retail value of around £900m. Note that 2003/4 represents a low point in cannabis prices, with an average price of around £2.50 per gram according to Law Enforcement Agency sources (see Figure 2.3.1 above). Since that time, the available survey data suggests that there has been a fall in prevalence to around 60% of the 2003/4 level and that the fall has been approximately uniform across regular and occasional users, so that total consumption will have followed the same trend. However, we know that there has also been a pronounced shift in market share of the more expensive sinsemilla varieties. There is no completely reliable data on the sinsemilla market share, but we can use evidence from police seizures which suggests that the share had reached 80% by 2010, implying an average cannabis price of around £6.40 per gram. If we assume that there has been no change in the volume of cannabis per episode of use (in other words no change in titration), then the 2010 market value can be estimated as £900m × 60% × 6.40/2.50, giving a baseline market size of £1.38bn in 2010.

Our reform scenarios assume a licensed product limited to 10% THC content, with a tax rate set in such a way that licensed supply is retailed at the price of £4.80, which is 90% of the competitive price predicted by the 2-component Gorman-Lancaster model for a product with 10% THC.[57] Using the range of estimated production costs set out in Table 4.3.2, the required taxation system is as shown in Table 7.3.1. The tax rate on licensed cannabis would be around 70%, which is considerably lower than the 83% total tax rate on cigarettes and close to the 72% rate on high-alcohol beer. Since we envisage the existence of a substantial residual illicit market, the share of taxation in total market turnover would be significantly lower, in the range 30-63%. Note that the unlicensed market shares we envisage are considerably greater than the shares of illicit supply in the alcohol and tobacco markets.

If there is significant change in consumption of tobacco and alcohol as a consequence of cannabis market reform, this would have further implications for tax revenue. We do not believe it is possible to estimate these secondary tax effects with any degree of confidence.

[57] Note that this calculation of the competitive price ignores the cost of risk associated with illicit purchases, so the licensed product would in fact undercut the illicit market by rather more than this margin.

Table 7.3.1 Projected indirect tax regime

	Market response scenario		
	Low-response	Mid-response	High-response
Tax rate on licensed cannabis	70% [51%, 79%]	70% [51%, 79%]	70% [51%, 79%]
Share of tax in total market value	56% [41%, 63%]	43% [32%, 49%]	39% [29%, 44%]
Total tax revenue	£768m [£564m, £871m]	£594m [£436m, £674m]	£541m [£397m, 614m]

The overall impact of the policy innovation on the government budget is summarised in Table 7.3.2. We would expect the government to gain in budgetary terms by something approaching £1bn per year, roughly three-quarters of which would come from tax revenue rather than expenditure savings.

Table 7.3.2 Summary of aggregate government budget implications of cannabis licensing in England and Wales

	Market response scenario		
	Low-response	Mid-response	High-response
Commodity taxes			
Taxes on licensed cannabis	+ £768m [£564m, £871m]	+ £594m [£436m, £674m]	+ £541m [£397m, £614m]
Other indirect taxes	?	?	?
Taxes on earnings			
Tax lost during incarceration	+ £10m [+£8m, +£12m]	+ £10m [+£8m, +£12m]	+ £10m [+£8m, +£12m]
Tax lost due to scarring	+ £23m [£11m, £57m]	+ £23m [£11m, £57m]	+ £23m [£11m, £57m]
Public expenditure			
Enforcement costs	+ £291m [£176m, £423m]	+ £291m [£176m, £423m]	+ £291m [£176m, £423m]
Health information and dependency treatment	- £41m [-£43m, -£39m]	- £47m [-£48, -£46m]	- £58m [-£61m, -£51m]
Mental illness treatment	+ £16m [-£0m-£53m]	- £21m [£0m-£53m]	- £43m [£0m-£107m]
Physical illness treatment	- £16m [-£31m, -£8m]	- £21m [-£41m, -£11m]	- £43m [-£82m, -£21m]
Total	+ £1,051m [£816m, £1,225m]	+ £841m [£645m, £1,000m]	+ £724m [£525m, £882m]

8 Conclusions and recommendations

Our main conclusions and recommendations are as follows.

[1] The heated public debate on cannabis policy is much too limited in scope. We have identified seventeen distinct sources of social cost or benefit that might contribute to the outcome of a comprehensive market reform and attempted to quantify thirteen of them. The relative importance of these sources depends critically on the form of regulation and the nature of market responses to reform. Consequently, any considered view on the question of reform needs to take account of a large number of factors and be contingent on a specific view about the detailed nature of the reform. Few of the most vocal participants in the debate on drug policy reform take a sufficiently broad perspective.

[2] At present, there is so much uncertainty about some of the important issues involved in the introduction of a licensed and regulated cannabis market that a clear conclusion is not possible. In particular we lack a good understanding of the demand behaviour which underlies the steady fall in cannabis prevalence over the last decade or so, and the degree to which the association between cannabis use and long-term adverse outcomes is truly causal. In our view, all unambiguous claims for or against radical policy options should be treated with caution.

[3] Psychopharmacological research suggests that harm from cannabis use is related to the chemical composition of the drug, so tight product regulation similar to that in the tobacco market would have some advantages. Several alternative forms of regulation that could be used in a licensed market and policy designers need to bear in mind the different consequences each might have for the harmfulness of consumption. Relatively *laisser faire* reforms which encourage large numbers of small producers make it difficult to control product characteristics and may lead to higher levels of average potency and thus more harmful long-term outcomes.

[4] Cost benefit evaluations should not assume that there are zero personal benefits from consumption: such an assumption would be unthinkable in any other application of cost benefit analysis. Our use of a net external benefit criterion is based on the view that the consumer necessarily perceives at least as great a personal benefit from consumption as there is personal cost and risk from consumption. It is a conservative approach, producing results biased in favour of the status quo under the assumption of competent well-informed decision-makers. However, we need a much better understanding of the vulnerable groups who may be making poor consumption decisions because of inadequate information or imperfectly developed decision-making capacity.

[5] Given the lack of a convincing empirical model of market demand for high- and low-potency forms of cannabis and the uncertainty about the form that product regulation would

take, there is a wide range of plausible market responses to reform. It is likely that consumption in overall volume terms will rise significantly as a consequence of the switch to legal status and the lower price that results. But it is possible that, for some forms of product regulation, average potency would fall, so that average consumption of the psychoactive ingredient THC would rise much less than consumption of the good itself, and might even fall.

[6] Our results are set out in the Table below. The direct impacts of reform in terms of potential changes in aggregate policing, criminal justice and drug treatment costs appear to be modest and largely insensitive to the nature of regulation and the market response to it. We estimate an annual aggregate net benefit of roughly £200-300m from this source as a consequence of a move to a regulated market.

[7] Another direct effect of reform will come through its impact on drug-related crime. One might expect crime related to cannabis consumption to increase if reform reduces price and increases demand, while crime related to cannabis supply would be reduced as illicit supply is driven out of the market. At the individual level, we have found no statistically significant evidence of a causal link between cannabis use and acquisitive or violent crime, but a modest significant link with supply activity – suggesting an overall net saving on crime costs from reform. However, the large size of the cannabis market, the potentially high personal costs for the victims of violent crime, and the substantial statistical uncertainty around the estimates imply that, at the aggregate level, projected net social benefit of reform is highly uncertain. We can be confident of a substantial additional net benefit from reform through a reduction in drug-related crime if we assume that the demand response is low or moderate. However, if very large demand responses to market reform are envisaged, it is not possible to draw any definite conclusions about the cost-benefit balance for the impact on crime.

[8] The indirect effects of policy reform include the social costs of long-term impacts on physical and mental health, the impact on labour market outcomes through the scarring effect of a criminal record, and the 'gateway' effect on the risk of involvement with harder drugs. For all of these, we estimate the external costs and benefits to the rest of society, excluding the internal costs and benefits borne by the cannabis user. These indirect impacts of reform are hard to estimate with any confidence because of the difficulty of isolating the effect of unobserved confounding factors that produce spurious correlation between cannabis use and observed outcomes. The public debate about cannabis policy has focused heavily on mental health costs, but we find these to be modest, because of the relatively small number of individuals involved and the modest effect size suggested by the research literature. In total, we expect net external costs of the impact on physical and mental health to range from zero for the low demand response scenario to around £85m in the case of a strong demand response to reform. Even in

the worst case, these costs are modest in relation to projected savings on policing and criminal justice costs.

[9] We estimate modest external net benefits from reform through the avoidance of scarring effects of criminal records in the labour market of roughly the same magnitude as the external cost to society of the impact on metal health.

[10] Another greatly exaggerated focus of the public debate on cannabis policy is the "gateway effect" – the possible increase in risk of involvement in hard drugs caused by exposure to cannabis. In our view, the evidence for a large gateway effect among cannabis consumers is weak, and there is an often-overlooked offsetting gateway on the supply side, drawing cannabis users into drug dealing. Licensing of supply might lead to a rise in demand and thus harm through the demand gateway, but it would also remove many people from illicit cannabis supply and thus reduce harm through the supply gateway. We estimate that reform could generate a net external *benefit* in the range £20-80m under the most plausible assumption of a moderate demand increase. Only a large demand response would be likely to generate a net social cost.

[11] Overall, taking account of all thirteen reform effects that we were able to estimate quantitatively, the total effect of reform is a net external benefit of around £280-460m if we anticipate a low demand response; a net benefit of £100-415m for the most plausible moderate demand response; and a projected net external cost of £430 in the case of a large demand response. This last estimate is very uncertain, with an indicative range of uncertainty from -£1.3bn to +£400m.

[12] There are many other possible effects of reform which we believe are not possible to quantify with any degree of confidence. Four of these may be particularly important: indirect effects of relative price changes on the consumption of other harmful substances including tobacco, alcohol and other illicit drugs; failures of decision making by certain vulnerable groups whose evaluations of their personal costs and benefits may be unreliable as a basis for welfare evaluation; the possible improvement in the credibility of health information achievable by separating health messages from legal penalties; and the possibility of "drug tourism" as a response to a unilateral UK policy initiative. Although we cannot quantify these effects, it is likely that they will follow a similar pattern to the quantified effects: no substantial net social costs if demand response is low or moderate and a risk of large social costs only if the demand response is large. The degree of uncertainty, particularly in the last case, is again very high.

[13] Tax revenues are a transfer of resources within society rather than a net benefit to society, but they are an important aspect of policy outcomes. We estimate that tax revenue from

licensed cannabis supply in England and Wales would fall somewhere in the range £0.4-0.9bn, which is far less than some of the assumptions that have appeared in the policy debate. We expect tax revenue to be lower in the case of strong demand response to reform, because of the large residual illicit market for high-potency cannabis that could exist in that case. Overall, the contribution of cannabis licensing in England and Wales to reduction of the government deficit is expected to lie in the range £0.5-1.25bn.

[14] Uncertainty about the magnitude of certain impacts and the response of demand to market reform make it impossible to give an unambiguous *ex ante* evaluation of the net social benefit of reform. However, it seems clear that the risk of large net social costs is only significant if there is a large demand response to reform. This suggests that a good way to proceed in practice might be to introduce the reform together with a monitoring system to give early warning of any large demand response, particularly among the very young or other vulnerable groups. One of the clear lessons to be learned from policy experience over the last decade or so is that it is possible to reverse policy quickly if monitoring were to suggest a large expansion of demand. Policy monitoring should distinguish between consumption of low- and high-potency forms of cannabis, since the largest social costs are linked to the latter rather than the former.

[15] The Home Office relies heavily on the British Crime Survey (now known as the Crime Survey for England and Wales) as the primary source of data on drug use. The BCS has significant shortcomings: it is a cross-sectional survey that does not allow analysis of the dynamics of drug use at the individual level; it gives data on drug use and crime victimisation but not respondents' own criminal activity; and it under-represents prolific offenders and drug users. In this study, we have exploited research based on a combination of the Arrestee Survey (AS) and Offending Crime and Justice Survey (OCJS), to avoid the under-recording of cannabis consumption by the BCS and to estimate the volume of cannabis-related crime. The abandonment of both the AS and OCJS in 2006 makes it now virtually impossible to construct these estimates using current, nationally representative data. If drugs policy is to be evidence-based, this gap in our data resources is a serious problem and should be reconsidered. A second obvious gap in our data resources is the lack of regular, representative data on drug prices and potency, which makes it virtually impossible to attempt an analysis of demand in the current cannabis market.

[16] The uncertainty inherent in our estimates is greatest in the scenario which envisages a large demand response to market reform. We see this outcome as relatively implausible, given the limited evidence of response to less radical policy liberalisation in many countries and the lack of any detectable increase in demand in response to the reclassifications of cannabis in 2004 and 2009, but the evidence on demand behaviour is weak. Published attempts to estimate

demand responses come from US and Australian data and do not give a good basis for projecting the effect of reform in the UK. Standard statistical models of cannabis use also fail to offer any clear explanation for the steady decline in cannabis demand over the last decade and they do not capture the important distinction between low- and high-potency forms of the drug or explain the structural shift in the cannabis market. There is a clear need for a better understanding of the demand for cannabis, which will only be achievable with better data on consumption, price and potency.

9 References

Advisory Council on the Misuse of Drugs (2008). Cannabis: Classification and Public Health. London: Home Office.

Allender, S., Balakrishnan, R., Scarborough, P., Webster, P. and Rayner, M. (2009). The burden of smoking-related ill health in the UK, *Tobacco Control* **18**, 262-267.

Anderson, D. M. and Rees, D. I. (2011). Medical marijuana laws, traffic fatalities and alcohol consumption. Bonn: IZA Discussion Paper no. 6112.

APPGSH (2010). Inquiry into the effectiveness and cost-effectiveness of tobacco control. London: All-Party Parliamentary Group on Smoking and Health.

ASH (2011). ASH Briefing: UK Tobacco Control Policy and Expenditure. London: Action on Smoking and Health.

Atha, M. J. and Davis, S. T. (2011). Taxing the UK Cannabis Market (report commissioned by CLEAR). Independent Drug Monitoring Unit.

Bhattacharyya, S., Martin-Santos, M., Seal, M. L. and Mechelli, A. (2009). Modulation of mediotemporal and ventrostriatal function in humans by Δ^9-tetrahydrocannabinol. A neural basis for the effects of cannabis sativa on learning and psychosis, *Archives of General Psychiatry* **66**, 442-451.

Boydell, J., Van Os, J., Lambri, M., Castle, D., Allardyce, J. and Murray, R. M. (2003). Incidence of schizophrenia in south-east London between 1965 and 1997, *British Journal of Psychiatry* **182**, 45-49.

Brand, S. and Price, R. (2000). The Economic and Social Costs of Crime. London: Home Office Research Study 217.

Branson, C., Duffy, B., Perry, C. and Wellings, D. (2012). Acceptable behaviour? Public opinion on behaviour change policy. London: Ipsos MORI.

Bray J. W., Zarkin, G. A., Ringwalt, C. and Qi. J. (2000). The relationship between Marijuana initiation and dropping out of high school, *Health Economics* **9**, 9–18.

Bryan, M., DelBono, E. and Pudney, S. E. (2011). Drug-related crime. University of Essex: Working Paper.

Callum, C., Boyle, S. and Sandford, A. (2011). Estimating the cost of smoking to the NHS in England and the impact of declining prevalence. *Health Economics, Policy and Law* **6**, 489-

508.

Cameron, L. and Williams, J. (2001). Cannabis, alcohol and cigarettes – substitutes or complements?, *Economic Record* **77**, 19-34.

Caulkins, J. P. (2010). Estimated Costs of Production for Legalized Cannabis, RAND working paper WR-764-RC.

Caulkins, J.P., Hawken, A., Kilmer, B., Kleiman, M. A. R. (2012). *Marijuana Legalization. What Everyone Needs to Know*. Oxford: Oxford University Press.

Caulkins, J.P., Kilmer, B., MacCoun, R. J., Pacula, R. L., Reuter, P. H. (2013). Design considerations for legalizing cannabis: lessons inspired by analysis of California's Proposition 19, Addiction, **107**, 865–871.

Chaloupka, F. J. and Laixuthai, A. (1997). Do Youth Substitute Alcohol and Marijuana? Some Econometric Evidence, *Eastern Economic Journal*, **23**, 253–275.

Chaloupka, F. J., Pacula, R. L., Farrelly, M. C., Johnston, L. D., and O'Malley, P. M. (1999). Do higher cigarette prices encourage youth to use marijuana?, NBER Working Paper 6939.

Chatterji, P. (2006). Illicit drug use and educational attainment. *Health Economics* **15**, 489–511.

Chivite-Matthews, N., Richardson, A., O'Shea, J., Becker, J., Owen, N., Roe, S. and Condon, J. (2005). *Drug Misuse Declared: Findings from the 2003/04 British Crime Survey England and Wales*. London: Home Office Statistical Bulletin 04/05.

Clements, K. and Daryal, M. (2005). The Economics of Marijuana Consumption. In: Selvanathan, E. and Selvanathan, S. (eds). *The Demand for Alcohol, Tobacco, Marijuana and Other Evils*. Ashgate, London.

Clements, K. W. and Zhao, X. (2005). Economic aspects of marijuana, University of Western Australia: Department of Economics Discussion Paper 05-28.

Cohen, M. A (1998). The Monetary Value of Saving a High Risk Youth, *Journal of Quantitative Criminology* **14**, 5-33.

Cohen, M. A. and Piquero, A. R. (2009). New Evidence on the Monetary Value of Saving a High Risk Youth, *Journal of Quantitative Criminology* **25**, 25-49.

Conti, G. (2010). Cognition, cannabis and wages. Mimeo, Department of Economics, University of Chicago.

Cooter, R. (1998). Expressive law and economics, *Journal of Legal Studies* **27**, 585–607.

Criminal Records Bureau (2010). *Annual Report and Accounts 2009/10*. London: The Stationery Office, House of Commons document HC231.

Curran, H. V., Brignell, C., Fletcher, S., Middleton, P. and Henry, J. (2002). Cognitive and subjective dose-response effects of acute oral Δ^9-tetrahydrocannabinol (THC) in infrequent cannabis users, *Psychopharmacoloogy* **164**, 61-70.

Degenhardt, L., Hall, W. and Lynskey, M. (2002). Testing hypotheses about the relationship between cannabis use and psychosis, *Drug and Alcohol Dependence* **71**, 37-48.

Department of Energy and Climate Change (2011). Quarterly Energy Prices, June 2011. http://www.decc.gov.uk/en/content/cms/statistics/publications/prices/prices.aspx.

Department for Environment, Food and Rural Affairs (2011), Farm Rents 2009 – England. http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-farmmanage-fbs-

farmrents2009.pdf

Department for Transport (2010). Reported Road Casualties Great Britain: 2009 Annual Report. London: HMSO.

Department for Transport (2011). Transport Analysis Guidance Documents: Expert. http://www.ddft.gov.uk/webtag/documents/index.php, accessed 6 September 2011.

Department of Health (2002). Statutory Instrument 2002/3041: the tobacco products (manufacture, presentation and sale) (safety) regulations. London: HMSO.

Desimone, J. and Farrelly, M.C. (2003). Price and Enforcement Effects on Cocaine and Marijuana Demand, *Economic Inquiry*, **41,** 98-115

DiNardo, J. and Lemieux, T. (2001). Alcohol, Marijuana, and American Youth: The Unintended Effects of Government Regulation, *Journal of Health Economics* **20**, 991–1010.

Dolan, K., Khoei, E. M., Brentari, C. and Stevens, A. (2007). Prison and drugs: A global review of incarceration, drug use and drug services. Oxford: The Beckley Foundation.

Duffy, M., Schaefer, N., Coomber, R., O'Connell, L. and Turnbull, P. J. (2008). *Cannabis supply and young people 'It's a social thing'*. York: Joseph Rowntree Foundation.

Ellgren, M., Spano, S. M. and Hurd, Y. L. (2006). Adolescent cannabis exposure alters opiate intake and opioid limbic neuronal populations in adult rats, N*europsychopharmacology* **32**, 607–615.

Engberg J, Morral AR. 2006. Reducing substance use improves adolescents' school attendance. Addiction 101: 1741–1751.

European Commission (2000). Communication from the Commission on the precautionary principle. Brussels: COM(2000) 1 final, 2nd February.

Farrelly, M. C., Bray, J. W., Zarkin, G. A., and Wendling, B. W. (2001). The joint demand for cigarettes and marijuana: evidence from the National Household Surveys on Drug Abuse", *Journal of Health Economics* **20**, 51-68.

Fergusson DM, Horwood LJ. 1997. Early onset cannabis use and psychosocial adjustment in young adults. Addiction 92: 279–296.

Fischer, B., Jeffries, V., Hall, W., Room, R., Goldner, E. and Rehm, J. (2011). Lower risk cannabis use guidelines for Canada (LRCUG): A narrative review of evidence and recommendations, *Canadian Journal of Public Health* **102**, 324-327.

Gill A and R Michaels. (1992). Does drug use lower wages? *Industrial and Labor Relations Review* **45**, 419–434.

Glaeser, E. L. and Schleifer, A. (2001). A reason for quantity regulation, *American Economic Review Papers and Proceedings* **91**, 431-435.

Godfrey, C., Eaton, G., McDougall, C. and Culyer, A. (2002). The economic and social costs of class A drug use in England and Wales. London: Home Office Research Study 249.

Goldstein, P. (1985). The drugs/violence nexus: a tripartite conceptual framework, *Journal of Drug Issues* **15**, 493-506.

Gordon, L., Tinsley, L. Godfrey, C. and Parrott, S. (2006). The economic and social cossts of class A drug use in England and Wales 2003/4, in *Measuring Different Aspects of Problem Drug Use: Methodological Developments*, Home Office Online Report 16/06, pp. 41-45.

Gorman, W. M. (1980). A possible procedure for analysing quality differentials in the egg market, *Review of Economic Studies* **47**, 843-856.

Gossop, M., Marsden, J., Stewart, D. (2001). NTORS after five years: changes in substance use, health and criminal behaviour during the five years intake. London: National Treatment Agency for Substance Misuse.

Gossop, M. (2006). Treating drug misuse problems: evidence of effectiveness. London: National Treatment Agency for Substance Misuse.

Grossman, M. (2004). Individual behaviours and substance use: the role of price, NBER Working Paper 10948.

Hardwick, S. and King, L. (2008). *Home Office Cannabis Potency Study*. London: Home Office.

Harries, R. (1999). The cost of criminal justice. London: Home Office Research Findings no. 103.

HMRC (2010). Measuring Tax Gaps 2010. London: HM Revue & Customs.

Hernandez, M. and Pudney, S. E. (2011). What you don't see can't hurt you? Panel data analysis and the dynamics of unobservable factors. University of Essex: ISER Working Paper no. 2011-13.

Hickman M., Vickerman P., Macleod J. (2007). Cannabis and schizophrenia: model projections of the impact of the rise in cannabis use on historical and future trends in schizophrenia in England and Wales, *Addiction* **102**, 597–606

House of Commons (2009). Health Committee – First Report Session 2009/10 Alcohol. London: Parliament.

Hough, M., Warburton, H., Few, B., May, T., Man, L.-H., Witton, J. and Turnbull, P. J. (2003). A growing market. The domestic cultivation of cannabis. York: The Joseph Rowntree Foundation.

Hughes, C. E. and Stevens, A. (2010). What can we learn from the Portuguese decriminalization of illicit drugs? *British Journal of Criminology* **50**, 999-1022.

Hyggen, C. (2012). Does smoking cannabis affect work commitment? *Addiction* **107**, 1309-1315.

Irons, D. E., McGue, M., Iacono, W. G. and Oetting, W. S. (2007). Mendelian randomization: a novel test of the gateway hypothesis and models of gene-environment interplay, *Development and Psychopathology* **19**, 1181-1195.

Kaestner, R. (1991). The effects of illicit drug use on the wages of young adults, *Journal of Labor Economics* **9**, 381–412.

Kaestner, R .1994. New estimates of the effects of marijuana and cocaine use on wages. *Industrial and Labor Relations Review* **47**, 454–470.

Kahneman, D., and Tversky, A. (1979) Prospect theory: an analysis of decision under risk, *Econometrica*, **47**, 263-291.

Kandel, D. B. (2002). *Stages and Pathways of Drug Involvement*, Cambridge: Cambridge University Press.

Kandel, D., Chen, K. and Gill, A. (1995). The impact of drug use on earnings: a life-span perspective, *Social Forces* **74**, 243-270.

Kilmer, B., Caulkins, J.P., Pacula, R. L., MacCoun, R. J., Reuter, P. H. (2010). Altered State? Assessing how marijuana legalization in California could influence marijuana consumption and public budgets, RAND Occasional Paper. Santa Monica, CA: RAND Corporation.

Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics* **112**, 443–477.

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy* **74**, 132-157.

Laumon, B., Gadegbeku, B., Martin, J.-L. and Biecheler, M.-B. (2005). Cannabis intoxication and fatal road crashes in France: population based case-control study, *British Medical Journal* **331**, 1371-1374.

McCaffrey, D. F., Pacula, R. L., Han, B. and Ellickson, P. (2010). Marijuana use and high school dropout: the influence of unobservables. *Health Economics* **19**, 1281-1299.

MacCoun, R. J. and P. Reuter (2001). *Drug War Heresies. Learning from Other Vices, Times and Places*, Cambridge University Press, Cambridge.

MacCoun, R. J. (2010). Estimating the non-price effects of legalization on cannabis consumption, RAND Working Paper WR-767-RC.

McCrone, P., Dhanasiri, S., Patel, A., Knapp, M. and Lawton-Smith, S. (2008). Paying the price. The cost of mental health care in England to 2026. London, King's Fund.

MacDonald, Z. and Pudney, S. E. (2000). Illicit drug use, unemployment, and occupational attainment, *Journal of Health Economics* **19**, 1089–1115.

MacDonald, Z. and Pudney, S. E. (2001). Illicit drug use and labour market achievement, *Applied Economics* **33**, 1655–1668.

MacDonald, Z., Tinsley, L., Collingwood, J., Jamieson, P., Pudney, S. E. (2005) Measuring the Harm from Illegal Drugs using the Drug Harm Index. London: Home Office Online Report 24/05.

MacDonald, Z., Collingwood, J., and Gordon, L. (2006) Measuring the Harm from Illegal Drugs using the Drug Harm Index – an Update. London: Home Office Online Report 08/06.

McManus, S., Meltzer, H., Brugha, T., Bebbington, P. and Jenkins, R. (2009). *Adult Psychiatric Morbidity in England, 2007*. London: NHS Information Centre for Health and Social Care.

Madden, G. J., Petry, N. M., Bickel, W. K., Badger, G. J. (1997). Impulsive and self-control choices in opiate-dependent patients and non-drug-using control participants: Drug and monetary rewards. *Experimental and Clinical Psychopharmacology* **5**, 256–262.

Markowitz, S. and Tauras, J. (2006). Even for teenagers, money does not grow on trees: teenage substance use and budget constraints, NBER Working Paper 12300.

May, T., Warburton, H., Turnbull, P. J. and Hough, M. (2002). *Times they are a-changing. Policing of cannabis*. York: Joseph Rowntree Foundation.

May, T., Duffy, M., Warburton, H. and Hough, M. (2002). *Policing cannabis as a class C drug An arresting change?*. York: Joseph Rowntree Foundation.

May, T., Duffy, M., Few, B. and Hough, M. (2005). *Understanding Drug Selling in Communities. Insider or Outsider Trading?* York: Joseph Rowntree Foundation.

Metcalf, H., Anderson, T. and Rolfe, H. (2001). *Barriers to Employment for Offenders and Ex-*

Offenders. London: Department for Work and Pensions.

Mills, H., Silvestri, A. and Grimshaw, R. (2010). *Police Expenditure 1999-2009*. London: Centre for Crime and Justice.

Ministry of Justice (2010a). *Sentencing Statistics: England and Wales 2009*. London: Ministry of Justice Statistics Bulletin.

Ministry of Justice (2010b). *Ministry of Justice Resource Accounts 2009-10*. London: The Stationery Office, House of Commons document HC194.

Miron, J. A. (2003). The effect of drug prohibition on drug prices: evidence from the markets for cocaine and heroin, *Review of Economics and Statistics* **85**, 522-530.

Moore, T. H. M., Zammit, S., Lingford-Hughes, A., Barnes, T. R. E., Jones, P. B., Burke, M. and Lewis, G. (2007). Cannabis use and risk of psychotic or affective mental health outcomes: a systematic review, *The Lancet* **370**, 319-328.

Morgan, C. J. and Curran, H. V. (2008). Effects of cannabidiol on schizophrenia-like symptoms in people who use cannabis, *British Journal of Psychiatry* **192**, 306-307.

Morgan, C. J., Freeman, T. P., Schafer, G. L. and Curran, H. V. (2010). Cannabidiol attenuates the appetitive effects of Delta 9-tetrahydrocannabinol in humans smoking their chosen cannabis, *Neuropsychopharmacology.* **35**, 1879-1885.

Morgan, C. J., Schafer, G. L., Freeman, T. P. and Curran, H. V. (2010). Impact of cannabidiol on the acute memory and psychotomimetic effects of smoked cannabis: naturalistic study, *British Journal of Psychiatry* **197**, 285-290.

Murray, R. (2007). Teenage schizophrenia is the issue, not legality. *The Independent* 18 March 2007.

National Audit Office (2006). Department for Constitutional Affairs. Fines Collection. London: The Stationery Office.

National Audit Office (2008). National Probation Service. The supervision of community orders in England and Wales. London: The Stationery Office.

National Audit Office (2010). Tackling Problem Drug Use. London: The Stationery Office, House of Commons document HC297.

National Centre for Social Research (2011). *Smoking, Drinking and Drug Use by Young People in England in 2010*. London: National Centre for Social Research.

NDTMS (2011). *Statistics from the National Drug Treatment Monitoring System 1st April 2009-31st March 2010*. University of Manchester: National Drug Evidence Centre.

NICE (2003). Review of Clinical Guideline (CG8) – Multiple sclerosis: national clinical guideline for diagnosis and management in primary and secondary care. National Institute for Health and Clinical Excellence, Centre for Clinical Practice.

NTA (2006). *Improving Services for Substance Misuse*. London: Commission for Healthcare Audit and Inspection.

North, P. (2010). Report of the review of drink and drug driving law. London: Department for Transport.

Nutt, D. (2008). Equasy – an overlooked addiction with implications for the current debate on drug harms. *Journal of Psychopharmacology* **23**, 3–5.

Pacula, R. L. (1998). Does increasing the beer tax reduce marijuana consumption?, *Journal of Health Economics*, **17**(5), 557-585.

Pacula, R. L. (2010). Examining the impact of marijuana legalization on marijuana consumption: insights from the economics literature. RAND Corporation Santa Monica: RAND Working Paper WR-770-RC

Pacula, R. L., Grossman, M., Chaloupka, F. J., O'Malley, P. M., Johnston, L. D. and Farrelly M. C. (2001). Marijuana and youth, in Gruber, J. (Eds), *Risky Behavior Among Youth: An Economic Analysis*, Chicago: University of Chicago Press.

Pacula, R. L., Ringel, J. and Ross, K. E. (2003). Does marijuana use impair human capital formation? NBER Working Paper 9963.

Pager, D. (2003). The mark of a criminal record, *American Journal of Sociology* **108**, 937-975.

Panlilio, L. V., Solinas, M., Matthews, S. A. and Goldberg, S. R. (2006). Previous exposure to THC alters the reinforcing efficacy and anxiety-related effects of cocaine in rats, *Neuropsychopharmacology* **32**, 646–657.

Pearl, J. (2000). *Causality: Models, Reasoning and Inference*. Cambridge: Cambridge University Press.

Phillips, C. and Bloodworth, A. (2009). Cost of Smoking to the NHS in Wales, ASH Wales/ BHF Cymru.

Potter, D. J., Clark, P. and Brown, M. B. (2008). Potency of Δ^9-THC and other cannabinoids in cannabis in England in 2005: implications for psychoactivity and pharmacology, *Journal of Forensic Science* **53**, 90-94.

Pudney, S. E. (1981). Instrumental Variable Estimation of a Characteristics Model of Demand, *Review of Economic Studies* 48, 417-433.

Pudney, S. E. (2004). Keeping off the grass? An econometric model of cannabis consumption in Britain, *Journal of Applied Econometrics* **19**, 435-453.

Pudney, S. E. (2003). The road to ruin? Sequences of initiation to drugs and crime in Britain, *Economic Journal*, **113**, C182-C198.

Pudney, S.E., Badillo, C., Bryan, M., Burton, J., Conti, G. and Iacovou, M. (2006). Estimating the Size of the UK Illicit Drugs Market, in *Measuring Different Aspects of Problem Drug Use: Methodological Developments*, Home Office Online Report 16/06, pp. 46-120.

Pudney, S. E. (2010). Drugs policy: what should we do about cannabis? *Economic Policy* **25**, 165-211.

Register, C. A. and Williams, D. R. (1992). Labor market effects of marijuana and cocaine use among young men, *Industrial and Labor Relations Review*, **45**, 435-451.

Register, C. A., Williams, D. R. and Grimes, P. W. (2001). Adolescent drug use and educational attainment, *Education Economics* **9**, 1–18.

Roebuck, M. C. , French, M. T. and Dennis, M. L. (2004). Adolescent marijuana use and school attendance, *Economics of Education Review* **23**, 133–141.

Rolles, S. (2009). After the War on Drugs: Blueprint for Regulation. Bristol: Transform Drug Policy Foundation.

Saffer, H. and Chaloupka, F. (1999). The Demand for Illicit Drugs, *Economic Inquiry*, **37,** 401-411

Saffer, H. and F. J. Chaloupka (2000). The effect of tobacco advertising bans on tobacco consumption, *Journal of Health Economics* **19**, 1117–1137.

Saffer, H. and D. Dave (2002). Alcohol consumption and alcohol advertising bans, *Applied Economics* **34**, 1325–1334.

Shanahan, M. and Ritter, A. (2011). Cost benefit analysis of two policy options for cannabis: status quo and legalisation. National Drug and Alcohol Research Centre: mimeo.

Shanahan, M. and Ritter, A. (2013). Confronting the challenges of conducting a CBA of cannabis policies, *Drugs:Education, Prevention and Policy*, forthcoming.

Shrier, I. and Platt, R. W. (2008). Reducing bias through directed acyclic graphs, *BMC Medical research Methodology* **8**: 70.

Solinas, M., Panlilio, L. V. and Goldberg, S. R. (2004). Exposure to Δ-9-tetrahydrocannabinol (THC) increases subsequent heroin taking but not heroin's reinforcing efficacy: a self-administration study in rats, *Neuropsychopharmacology* **29**, 646–657.

Suff, R. (2005). Checking out the activities of the Criminal Records Bureau, *IRS Employment Review* **483**, 42-48.

Toonen M., Ribo, S. and Thissen, J.(2006). Yield of illicit indoor cannabis cultivation in the Netherlands, *Journal of Forensic Sciences* **51**, 1050–1054.

Tunbridge, R. J., Keigan, M. and James, F. (2001). The incidence of drugs and alcohol in road accident fatalities. Crowthorne: TRL Report 495.

UK Focal Point (2001), *Annual Report on the United Kingdom Drug Situation 2001* http://www.emcdda.europa.eu/html.cfm/index34779EN.html

UK Focal Point (2005), *National Report to the EMCDDA by the Reitox National Focal Point: New developments, trends and in-depth information on selected issues* http://www.nwph.net/ukfocalpoint/writedir/95f02005%20FP%20Annual%20Report.pdf

UK Focal Point (2010), *United Kingdom Drug Situation (2010 edition). Annual Report to the EMCDDA.* http://www.nwph.net/ukfocalpoint/writedir/fcf022035%20FOCAL%20POINT%20REPORT%202010%20A4.pdf

Uva, W.-F. and Richards, S. (2003). New York greenhouse business summary and financial analysis, derived from 2001 business records. Cornell University: Department of Applied Economics and Management Extension Bulletin EB 2003-12.

Van Ours, J. C. (2007a). Cannabis use when it's legal, *Addictive Behaviors* **32**, 1441–50.

Van Ours, J. C. (2007b). The effects of cannabis use on wages of prime-age males, *Oxford Bulletin of Economics and Statistics* **69**, 619-634.

Van Ours, J. C. and Williams, J. (2007). Cannabis prices and dynamics of cannabis use, *Journal of Health Economics*, **26**, 578-596.

Van Ours, J. C., and Williams, J. (2009). Why parents worry: initiation into cannabis use by youth and their educational attainment, *Health Economics* **29**, 132-142.

Wilkins, C., and Sweetsur, P. (2006). Exploring the structure of the illegal market for cannabis in New Zealand. *De Economist* **154**, 547-562.

Williams, J. (2004). The effects of price and policy on marijuana use: what can be learned from

the Australian experience? *Health Economics* **13**, 123-137.

Williams, J., Pacula, R. L., Chaloupka, F. J. and Wechsler, H. (2004). Alcohol and marijuana use among college students: economic complements or substitutes? *Health Economics*, **13**, 825–843.

Yamada, T., Kendix, M. and Yamada, T. (1996). The impact of alcohol consumption and marijuana use on high school graduation. *Health Economics* **5**, 77–92.

Yörük, B. K. and Yörük, C. E. (2011). The impact of minimum legal drinking age on alcohol consumption, smoking, and marijuana use: evidence from a regression discontinuity design using exact date of birth, *Journal of Health Economics* **30**, 740-752.

Zhao, X. and Harris, M. N. (2004). Demand for marijuana, alcohol and tobacco: participation, levels of consumption and cross-equation correlations, *Economic Record*, **80**, 394–410.

10 Appendices

A4.2 External and internal costs and benefits

We set out a simple static analysis of fully-informed decision-making purely to illustrate the reasoning behind the external cost/benefit evaluation principle.

Suppose that a consumer of type i has preferences represented by a utility function $U^i\big((1-\tau)Y - \pi_t C_t^i, C_t^i, P, D\big)$ where: P is the penalty imposed on cannabis users (if detected) under prohibition; $Y = \bar{Y} - L(P)$ is taxable earnings, $\bar{Y}$ is taxable earnings in the absence of any penalty; $L(P)$ is the loss of earnings associated with penalty level P (e.g. because of incarceration); τ is the direct tax rate; π_t and C_t^i are the price and quantity of cannabis under prohibitive (t=0) and regulatory (t=1) systems; and D is a measure of severity of cannabis-induced disease, if any. Both P and D are uncertain when the consumption decision is made, except when there is no cannabis use (C_t^i = 0), in which case both P and D are zero. Assume there is no black market under the regulated system, so that P is always zero in that case. Individuals are assumed to know the risks of criminal justice penalties and health harms, and they are capable of making decisions based on expected utility.

There are three classes of individual[58]: type 1 are abstainers who would not use cannabis under prohibition or regulation. There is no welfare gain or loss arising from these people. Type 2 individuals would be non-users of cannabis in the current illicit market, but would choose to become users in a regulated market. Thus:

$$U^2(\bar{Y},0,0,0) > \max_{C_0^2>0} E[U^2((1-\tau)[\bar{Y} - L(P)] - \pi_0 C_0^2, C_0^2, P, D)] \qquad \text{(A4.2.1)}$$

$$\max_{C_1^2>0} E[U^2((1-\tau)\bar{Y} - \pi_1 C_1^2, C_1^2, 0, D)] > U^2((1-\tau)\bar{Y},0,0,0) \qquad \text{(A4.2.2)}$$

where the expectation is with respect to the uncertain internal criminal justice and health costs, P and D. Type 3 people are users of cannabis under both prohibition and regulation:

$$\max_{C_0^3>0} E[U^3((1-\tau)[\bar{Y} - L(P)] - \pi_0 C_0^3, C_0^3, P, D)] > U^3((1-\tau)\bar{Y},0,0,0) \qquad \text{(A4.2.3)}$$

$$\max_{C_1^3>0} E[U^3((1-\tau)\bar{Y} - \pi_1 C_1^3, C_1^3, 0, D)] > U^3((1-\tau)\bar{Y},0,0,0) \qquad \text{(A4.2.4)}$$

There are three further costs external to the consumer: the costs of enforcement and medical treatment; and society's share of the output that would have been produced by the individual had the penalty not been imposed. The latter is the loss of revenue from earnings taxation.

[58] We make a monotone response assumption: there is no-one who would be a cannabis user under prohibition, but an abstainer under regulation.

Assume that the unit costs of enforcement and disease treatment are u_P and u_D; that the social value (measured in money terms) of a unit of individual utility is v; and that the population numbers of type 1 and 2 people are n_2 and n_3. Then the expected change in aggregate social welfare generated by the policy change is:

$$\Delta\mathrm{E(W)} = n_2 v\left\{\max_{C_1^2>0} E[U^2((1-\tau)\bar{Y} - \pi_1 C_1^2, C_1^2, 0, D)] - U^2(\bar{Y}, 0,0,0)\right\}$$

$$+n_3 v\left\{\max_{C_1^3>0} E[U^3((1-\tau)\bar{Y} - \pi_1 C_1^3, C_1^3, 0, D)] - \max_{C_0^3>0} E[U^3((1-\tau)[\bar{Y} - L(P)] - \pi_0 C_0^3, C_0^3, P, D)]\right\}$$

$$-n_2 u_D E(D|C_1^2) \quad + \quad n_3\{\tau E[L(P)] + u_P E(P|C_0^3) - u_D[E(D|C_1^3) - E(D|C_0^3)]\} \qquad \text{(A4.2.5)}$$

The first term of this expression is the change in self-perceived expected welfare of people who are drawn into cannabis use by the policy reform. Revealed preference (equation A4.2.2) tells us that this term must be non-negative, since these people retain the option of not using cannabis after reform, but choose not to do so. Similarly, the second term is the perceived change in welfare of cannabis users. It is non-negative since the consumer retains the option of consuming at the previous level C_0^3, but the risk of a criminal penalty is removed, thus increasing welfare. These first two components of the change in aggregate welfare represent internal benefits accruing to drug users; the remaining two terms are external impacts of reform on society as a whole.

The first external impact represents the treatment costs for drug-induced ill-health experienced by new users and is clearly negative. The remaining component is ambiguous in sign, consisting of a gain to society in the tax revenue from productive employment ($n_3\tau E[L(P)]$), a saving to society in the cost of enforcing prohibition ($n_3 u_P E(P|C_0^3)$) and a change in the cost of treatment for drug-induced illness ($-n_3 u_D[E(D|C_1^3) - E(D|C_0^3)]$), which is negative if the reform has the effect of increasing intensity of use for existing users.

Our approach to evaluation is to consider primarily the external costs and benefits of reform. Since the revealed preference principle tells us that the internal impacts are necessarily non-negative, this means that our analysis will be conservative in that it has a built-in bias in favour of the status quo. However, it should be borne in mind that there are several circumstances, discussed in section 4.2.1 above, which might tend to offset this conservatism.

A4.4 Estimating production costs

The first step is to estimate the yield of cannabis per unit area of greenhouse. Cannabis plants in greenhouses are likely to grow taller than in residential settings, and it is necessary to allow for

the higher yield of taller plants. The IDMU website[59] gives yield figures from over 2000 court cases in which IDMU staff have acted as expert witnesses. We use their yield figure of 40 g per plant, corresponding to the approximate average yield of mature plants more than 1.2 m tall. It is somewhat higher than the 1.2 oz figure (=34 g) used by Caulkins (2010), based on home production yields. These yields assume that only the flowering tops of the plant (which contain by far the highest concentration of THC) are used, as is normal in 'cottage-industry' production. It may also be possible to extract THC content (as resin) from the lower leaves of the plant. However, such extraction techniques are currently under-developed: Caulkins (2010) gives an example of a home processing method which yields only 3 kg of resin from 100 kg of leaves. The IDMU data indicate that only 30% of the weight of tall plants (more than 1.2 m in height) is leaf and stem matter (the other 70% being flowering tops). Extracting resin from the leaves with an efficiency of 3%, and making the generous assumption that resin has the same THC content as the flowering tops, would increase the effective cannabis yield by only about 1%. It is likely that extraction techniques would become much more efficient under a legal regime, but given this very low baseline figure and the uncertainty around technical progress in this area, we base our estimates only on product from flowering tops. We assume a density of 15 plants per square metre (Toonen 2006), but subtract 20% to allow for greenhouse walkways, giving an effective density of 12 plants per square metre. This corresponds to a production rate of 480 g per square metre per harvest, or 2400 kg per harvest for the entire operation (5000m^2 under glass).

An important issue is the number of harvests per year. Cannabis requires long days (ideally 18-24 hours of light per day) during its vegetative growth phase and much shorter days (10-12 hours, which signal approaching winter) in order to flower. Achieving these daylight periods at UK latitudes would require artificial light, especially during the winter months. Following Caulkins (2010), we assume that plants would be exposed to light for 24 hours per day for the first month and then for 12 hours per day for the remaining two months. We consider two growing scenarios: first, two harvests per year, covering late spring to early autumn, and second, a year-round operation involving four harvests. The first scenario minimises the use of artificial light but leaves the greenhouses unused during winter, while the second scenario uses more artificial light (and heat) but spreads the fixed costs of the operation. Our purpose in considering these two scenarios is not to specify an optimal system of production, but to give an idea of the likely sensitivity of costs to plausible variations in the way production might be organised.

The main inputs to be costed are consumables (such as growing medium and fertiliser), durables (hydroponic equipment, fans etc), lighting, rent and structural costs, and labour. The

[59] http://www.idmu.co.uk/cannabis-plants-cultivation-yields.htm, retrieved 2 September 2001

total cost of consumables and amortised durables, taken from Caulkins (2010), is £142 per kg (with a low-high range of £71–£214). We also take greenhouse construction costs (amortised over 4 years) from Caulkins (2010), at £42 per square metre (with a range of £33–£49), which works out to £43 per kg with two harvests (42*5000m^2/[2400kg*2]), and £22 per kg with 4 harvests. The other costs may differ substantially between the US and UK and so we derive these estimates from separate sources.

Lighting requirements depend on the length of the natural day, the required intensity of artificial lighting, and the cost of electricity. Using the day lengths given above, we estimate that cannabis plants would need 270 hours of artificial light for each of the two summer crops, 660 hours for the November-January crop, and 480 hours for the February-April crop. Based on the light intensities cited by Caulkins, plants would need 430W of illumination per square metre, which implies a total energy per year of 1.2 MWh for two harvests and 3.6 MWh for four harvests. We cost these lighting requirements at £0.11 per kWh, a typical non-domestic tariff for small (less than 20MWh) consumers (DECC 2011). Using our assumed yields, lighting would cost £27 per kg in the two-harvest secenario and £42 per kg with four harvests.

There would also be heating requirements, although it is likely that they would be negligible during the summer growing season. To obtain a very approximate estimate of possible heating costs, we take figures from Uva and Richards' (2003) study of commercial greenhouses in New York state. They give a cost of about $1 of heating fuel per square foot. In 2011 prices, this equates to nearly £8 per square metre, and we allow for a high degree of uncertainty using a range of £3.60 to £10.90. With four harvests per year (9600 kg) covering 5000 m^2, the heating cost per kg works out to just over £4 (£1.90-£5.70), which is only a tenth of the lighting costs.

Data on farm rents in England (DEFRA 2011) indicate there is variation over type of tenancy and over region, which we reflect in a range of £100-£200 per hectare per year, spanning a central estimate of £150. Rental costs are trivial, however, amounting to only £0.03 per kg (over two harvests).

Labour costs are much more substantial. We base our estimates on the labour efficiencies reported in Uva and Richards' (2003) study of commercial greenhouses in New York state. Labour efficiency is expressed as the greenhouse area covered per full-time equivalent (FTE) worker (including management labour), and we use a figure of 790 square metres per FTE worker, allowing for a range of 650–930 m^2/FTE. Uva and Richards assume that a full-time job requires 55 hours per week for 50 weeks per year, which is high by UK standards, so we adjust these figures downwards to 40 hours per week and 48 weeks per year. This yields an adjusted efficiency of 551 m^2/FTE (454–648). From similar efficiency figures on management labour, we calculate the ratio of total FTE labour to FTE managers as 5.85 (allowing for a range of 5–7).

Based on overall labour efficiency and the total labour to management ratio, we can calculate that 5000 m² of greenhouse area would require 1.5 FTE managers (=5000/551/5.85) and 7.5 FTE operatives (=5000/551 – 1.5). Taking account of the range of labour efficiencies and amount of management needed, the overall range of labour inputs is 1.1–2.2 FTE managers and 6.6–8.8 FTE operatives. These figures relate only to the growing operation. Labour would also be needed to harvest and process the flowering tops into saleable cannabis products. Current techniques are time consuming (Caulkins 2010) but we could expect rapid technical progress in a legal industry. Caulkins gives an estimated range of processing times post-legalisation of 4.8 to 7.3 hours per kg, which we assume would be operative labour.

We cost both the growing and processing labour inputs using information about the distribution of gross annual full-time pay in the Agriculture, Forestry and Fishing industries from the Annual Survey of Hours and Earnings (ASHE) 2009 (indexed to 2011 using an average earnings index). We assume that a manager is paid at the 75th percentile of the distribution (£28,400 pa), while an operative is paid at the 10th percentile (£13,600 pa). Based on these figures and the estimated cannabis yields, we estimate total labour costs at £54 per kg, with a range of £47–£71. The results are given in Table 4.4.1 above.

A4.5 The market price-potency frontier

Suppose the market offers two products: standard herb/resin, which has unit THC content t_1, at price p_1; and sinsemilla, with THC content t_2 and price p_2. We consider two alternative versions of the Gorman-Lancaster characteristics model, describing the behaviour of a representative individual facing a budget constraint:

$$p_1 x_1 + p_2 x_2 + C \leq M \tag{A4.5.1}$$

where C is expenditure on all goods except cannabis and M is the total budget. Define $X = x_1 + x_2$ to be the total weight of cannabis consumed and $T = t_1 x_1 + t_2 x_2$ to be total THC intake.

Model 1 Here we assume that the consumer is only interested in THC intake, so that preferences are representable by a utility function $U(T, C)$. In this case, with two products and only a single desirable characteristic, the optimal consumption strategy is to consume only the variety of cannabis which offers the lowest price per unit of THC. If this is sinsemilla (as we observe in the current market), then $p_1/t_1 > p_2/t_2 \Rightarrow x_1 = 0$ and $P_T = p_2/t_2$ is the implicit market price of THC. This model implies that standard herb/resin will disappear from the market. If this is the case, then a new licensed product with THC content t_0 offered at price p_0 will be competitive only if $p_0 \leq t_0 p_2/t_2$. Note also that total quantity consumed is proportional

to THC intake, so the elasticity of demand is the same in quantity and THC terms.

Assume that the licensed product enters at a price p_0 sufficiently far below the level $t_0 p_2 / t_2$ to dominate the market so that the illicit market essentially disappears. In that case, if the demand for THC has price elasticity ϵ, the proportionate rise in consumption post-reform is:

$$\dot{X} \cong \epsilon \left(\frac{p_0 - p_2}{p_2} \right) \tag{A4.5.2}$$

Assume that the tax rate is set sufficiently low that the new licensed supply dominates the market as the implicit THC price falls below its current market level of £46.67, with the magnitude of the demand increase determined by the elasticity of price Assuming perfectly elastic supply and alternative constant values of the demand elasticity ranging from -0.25 to -1, we have the predictions summarised in Figure A4.5.1. The greater is the margin by which licensed supply undercuts the current illicit market, the greater is the expansion of demand that will be observed after reform. A plausible assumption of a demand elasticity of -0.7 and a 10% cut in price implies a 7% rise in demand, if price is the only channel by which reform affects consumption.

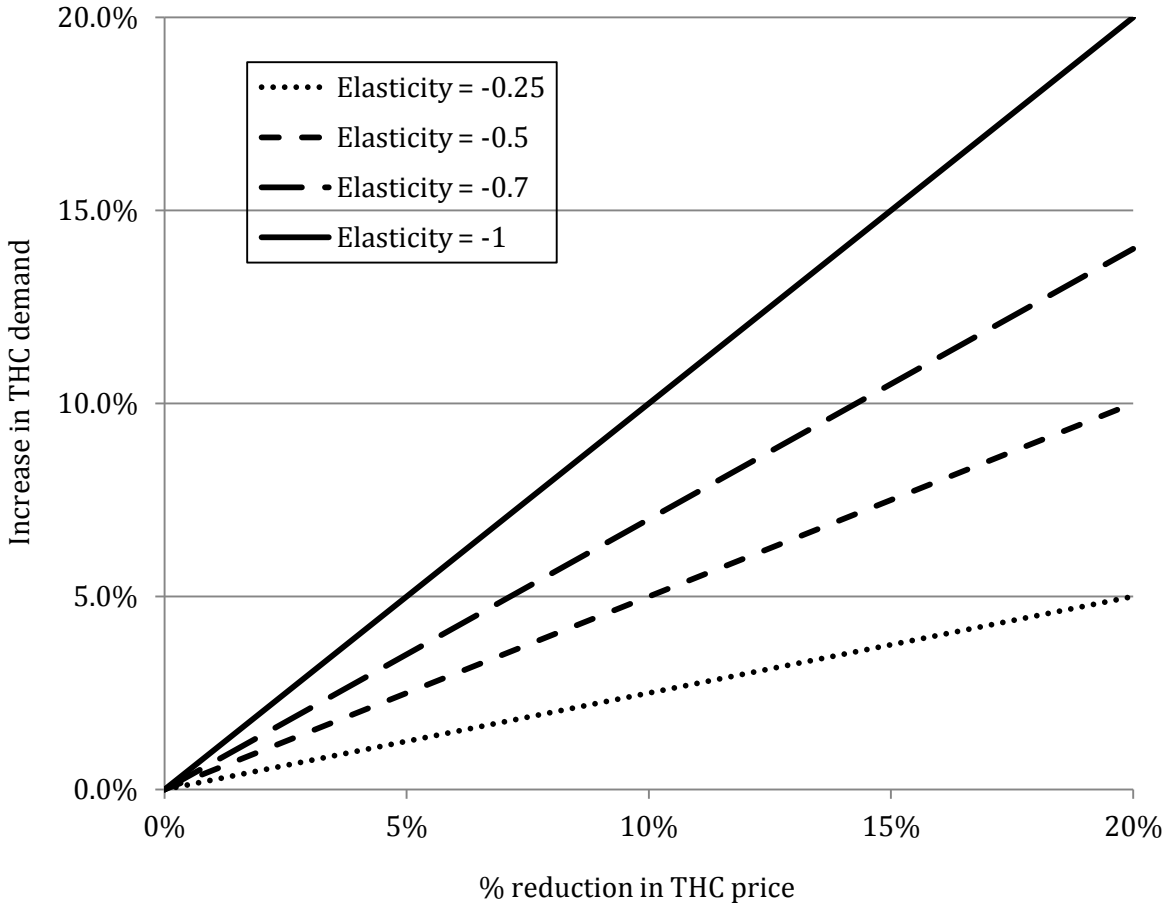


Figure A4.5.1 Policy-induced increase in THC demand: 1-component model

The tax raised under a proportional tax system is:

$$R \cong \left(\frac{\tau(1+\dot{X})p_0}{p_2}\right)E \qquad \text{(A4.5.3)}$$

where τ is the proportion of market price taken in tax and E is aggregate cannabis expenditure in the initial illicit market. If the licensed price p_0 is set to reduce the market price of THC by 10%, and if the producer/retailer costs and margins amount to £1.45 per gram of cannabis, the tax rate τ is 42.5%, 56.8% and 65.5% for THC limits of 6%, 8% and 10% respectively. Then approximation (A4.5.3) suggests total tax receipts equal to 16%, 29% or 42% of pre-reform illicit market turnover, for THC limits of 6%, 8% and 10% respectively.

Model 2 Now assume that the consumer is interested both in the amount of THC consumed and in the volume of cannabis. With two characteristics and two products in the market, the optimum will typically involve consumption of both varieties of cannabis in some proportion and our interpretation of the current market is that there continues to be a role for standard

herb/resin. With $(x_1, x_2) > 0$, the identities defining T and X can be used to rewrite the budget constraint:

$$\left(\frac{p_2 - p_1}{t_2 - t_1}\right) T + \left(\frac{t_2 p_1 - t_1 p_2}{t_2 - t_1}\right) X + C \leq M \tag{A4.5.4}$$

Therefore, in the original illicit market, the implicit prices of THC and cannabis volume are:

$$P_T = (p_2 - p_1)/(t_2 - t_1) \tag{A4.5.5}$$

$$P_X = (t_2 p_1 - t_1 p_2)/(t_2 - t_1) \tag{A4.5.6}$$

Preferences can be represented by a utility function:

$$U(T, X, C) \tag{A4.5.7}$$

Maximisation subject to the budget constraint gives the marginal condition:

$$\frac{p_2}{p_1} = \frac{a t_2 + 1}{a t_1 + 1} \tag{A4.5.8}$$

where a is the marginal rate of substitution $(\partial U/\partial T)/(\partial U/\partial X)$. This can be solved for a:

$$a = \frac{p_1 - p_2}{p_2 t_1 - p_1 t_2} \tag{A4.5.9}$$

If a new product with THC content t_0 is introduced, it will be competitive with sinsemilla and resin in the market if its price p_0 satisfies:

$$\frac{p_0}{p_j} \leq \frac{a t_0 + 1}{a t_j + 1} \tag{A4.5.10}$$

where j = 1 or 2 is arbitrary. Conditions (A4.5.9) and (A4.5.10) imply:

$$p_0 \leq \frac{(p_1 - p_2) t_0 + p_2 t_1 - p_1 t_2}{t_1 - t_2} \tag{A4.5.11}$$

This maximum price frontier is shown in Figure A4.5.2 together with that implied by the 1-component (THC-only) model.[60] Thus, if government wishes the licensed product to undercut the illicit market, and considers alternative THC limits of 6%, 8% and 10% as illustrated, it would need to set the excise tax rate at a level which will generate a market price significantly below £2.80, £3.73 or £4.67 respectively, according to the 1-component model, or £4, £4.67 or £5.33 per gram according to the 2-component model. Note that these valuation frontiers are independent of the form of the utility function $U(T, C)$ or $U(T, X, C)$ and depend only on the prices and technical characteristics of the three cannabis varieties.

[60] This frontier takes no account of the role of CBD regulation. If CBD is perceived by consumers to be protective of mental health, then a licensed product meeting a minimum CBD threshold might be competitive beyond this frontier.

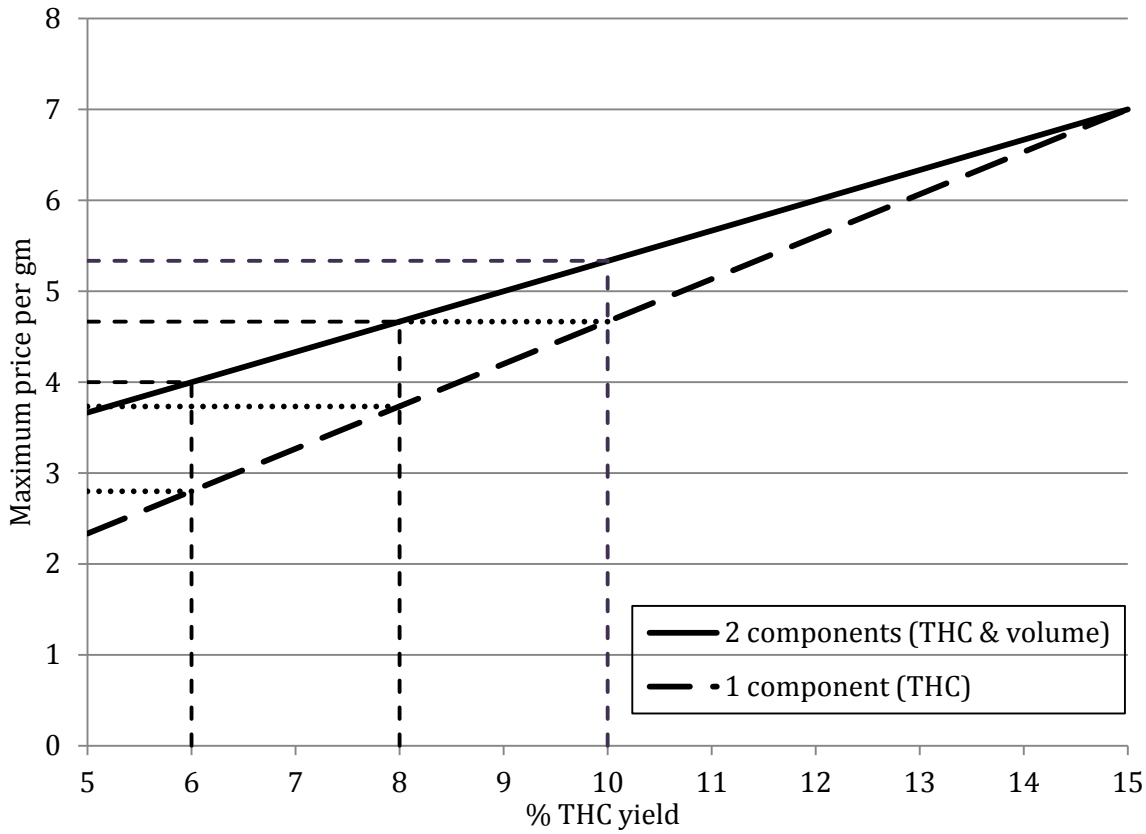


Figure A4.5.2 Gorman-Lancaster market valuation frontiers

Under what circumstances will the new optimal demand not involve consumption of imported resin? The identity $T = t_0 x_0 + t_2 x_2$ implies that the market share of sinsemilla satisfies:

$$\left(\frac{x_2}{X}\right)(t_2 - t_0) \;\; = \left(\frac{T}{X}\right) - t_0 \qquad \text{(A4.5.12)}$$

Thus, sinsemilla will be purchased by the representative consumer only if t_0 is set below his or her utility-maximising level of mean potency T/X. In practice there will be a mix of consumers with different preferences, operating at different optima, but if t_0 is set sufficiently low, we would expect demand for traditional resin to fall so low that it will be uneconomic to supply.

The policy-induced proportionate price changes caused by a switch to a new equilibrium involving consumption only of licensed product and illicit sinsemilla are:

$$\dot{P}_X \;=\; \frac{(t_2 p_0 - t_0 p_2)/(t_2 - t_0)}{(t_2 p_1 - t_1 p_2)/(t_2 - t_1)} - 1 \;\; ; \quad \dot{P}_T \;= \frac{(p_2 - p_0)/(t_2 - t_0)}{(p_2 - p_1)/(t_2 - t_1)} - 1 \qquad \text{(A4.5.13)}$$

Figures A4.5.3 and A4.5.4 show these implicit price effects for various combinations of THC limit and entry price. Note that these changes in implicit prices are very sensitive to the entry price p_0, so the choice of tax rate is critical to the success of the reform.

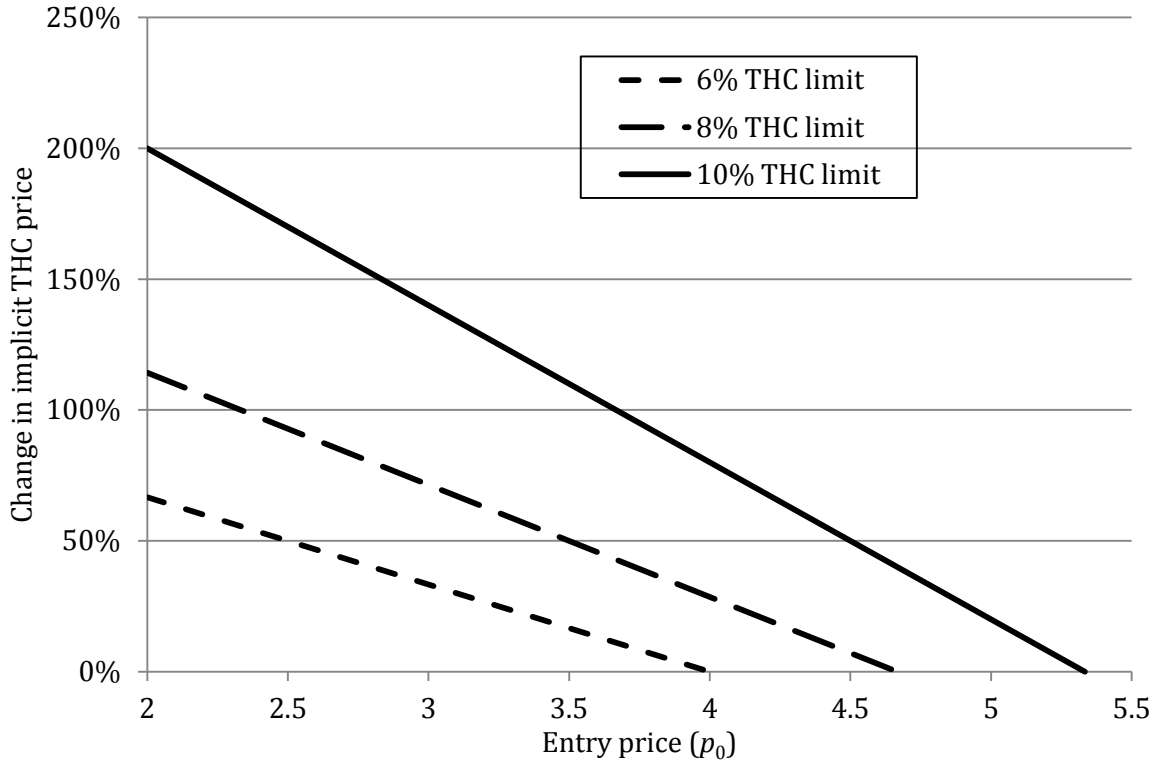


Figure 4.5.3 Policy-induced change in implicit price of THC: 2-component model

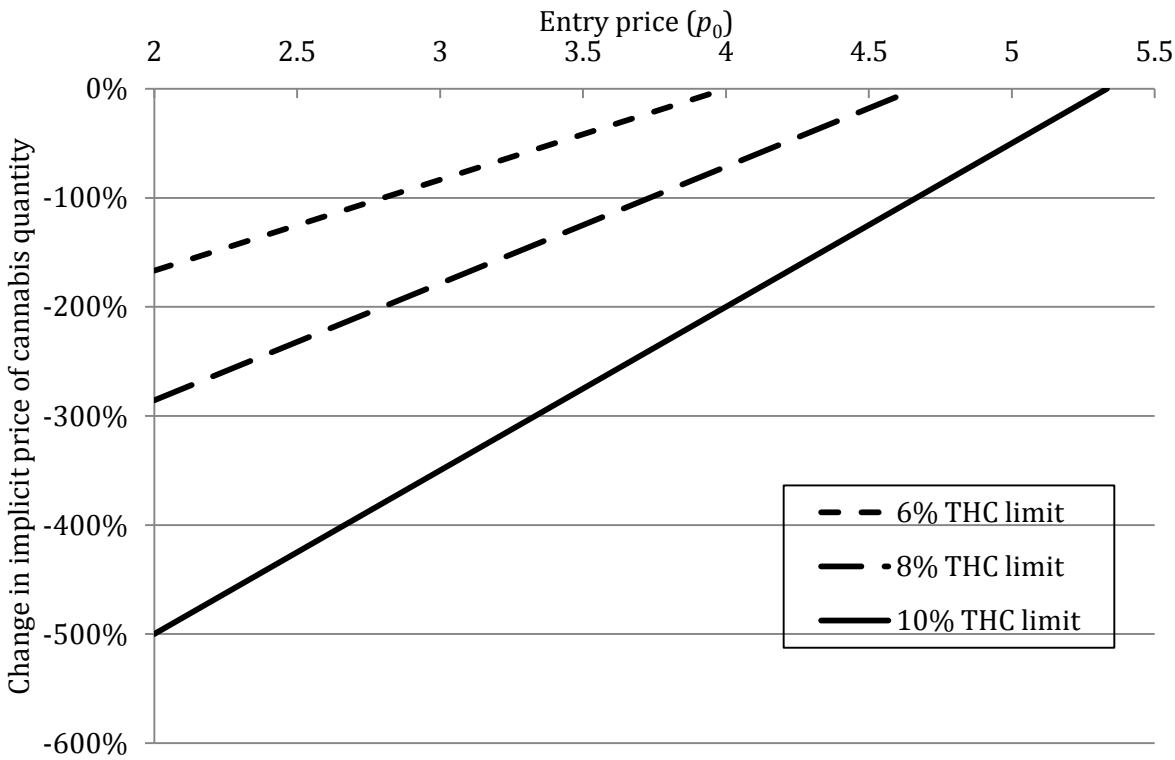


Figure 4.5.4 Policy-induced change in implicit price of cannabis volume: 2-component model

Define x_1 and x_2 to be the pre-reform consumption of standard herb/resin and sinsemilla, x_0^* and x_2^* the post-reform quantities of licensed product and sinsemilla, and T and X the pre-reform quantities of THC and cannabis volume. Let $\theta = x_2/X$ be the pre-reform quantity share of sinsemillla and $\bar{t} = t_1(1-\theta) + t_2\theta$ be the average pre-reform potency. Then we have the following identities:

$$T = \bar{t}X \qquad (A4.5.14)$$

$$X^* = X\left(1 + \dot{X}\right) \qquad (A4.5.15)$$

$$T^* = \left(\frac{\bar{t}\left(1 + \dot{T}\right)}{1 + \dot{X}}\right)X^* \qquad (A4.5.16)$$

The post-reform shares of unlicensed cannabis in quantity and THC terms respectively are:

$$\frac{x_2^*}{X^*} = \frac{\bar{t}(1 + \dot{T}) - t_0(1 + \dot{X})}{\left(1 + \dot{X}\right)(t_2 - t_0)} \qquad (A4.5.17)$$

$$\frac{t_2 x_2^*}{\bar{t}\, X^*} = \frac{t_2\left[\bar{t}(1 + \dot{T}) - t_0(1 + \dot{X})\right]}{\bar{t}\left(1 + \dot{T}\right)(t_2 - t_0)} \qquad (A4.5.18)$$

Licensed supply is:

$$x_0^* = \frac{t_2(1 + \dot{X}) - \bar{t}(1 + \dot{T})}{t_2 - t_0}X \qquad (A4.5.19)$$

and thus tax revenue is:

$$R = \frac{\tau p_0\left[t_2(1 + \dot{X}) - \bar{t}(1 + \dot{T})\right]}{(p_1(1-\theta) + p_2\theta)(t_2 - t_0)}E \qquad (A4.5.20)$$

What effect would the implicit price changes (A4.5.13) have on consumption? We are concerned with the consumption of THC for possible mental health and dependency costs, but with consumption of cannabis itself for physical health costs linked to smoking. We know very little about the underlying structure of implicit demands for the characteristics provided by cannabis use, so it is not possible to make a formal prediction of demand under a system of licensed supply. However, we would normally expect the consumer's response to the increased implicit price of THC and reduced implicit price of cannabis volume to be to consume less THC but more cannabis volume by substituting the licensed product for illicit sinsemilla.

Maximisation of utility (A4.5.7) subject to the budget constraint (A4.5.1) yields demand functions for the quantity of cannabis and THC:

$$X = d_X(P_X, P_T, M)\,; \qquad T = d_T(P_X, P_T, M) \qquad (A4.5.21)$$

Assume that there is an approximately constant price markup m for high-quality sinsemilla over standard herb/resin so that $p_2 = (1+m)p_1$ and both P_X and P_T vary in proportion to p_1 over time. Then empirical estimates of the price elasticity of cannabis demand can be interpreted as the sum of the elasticities of quantity with respect to P_X and P_T :

$$\frac{\partial lnX}{\partial lnp_1} = \frac{\partial lnX}{\partial ln\, P_X} + \frac{\partial lnX}{\partial ln\, P_T} \tag{A4.5.22}$$

Now suppose that a new licensed variety is introduced, undercutting standard herb/resin and thus generating a new market dominated by licensed cannabis and illicit sinsemilla. The proportionate effect on aggregate consumption of THC and cannabis quantity will be:

$$\dot{T} \cong \epsilon_{TX}\, \dot{P}_X \; + \; \epsilon_{TT}\, \dot{P}_T \tag{A4.5.23}$$

$$\dot{X} \cong \epsilon_{XX}\, \dot{P}_X \; + \; \epsilon_{XT}\, \dot{P}_T \tag{A4.5.24}$$

where ϵ_{XX} and ϵ_{TT} are the elasticities of the demand for cannabis quantity and THC with respect to their own implicit prices P_X and P_T respectively, ϵ_{TX} and ϵ_{XT} are the corresponding cross-elasticities.

In a 2-component Gorman-Lancaster model, the demand elasticity can be viewed as the sum of the elasticities with respect to the shadow prices of THC and cannabis volume (A4.5.22). Elasticities can also be decomposed into the effects of price on participation in the market and intensity of use by those who do participate. Let C be some measure of consumption of cannabis and P be its actual or shadow price, with other influences on demand held constant. The expected value of consumption for a randomly-selected individual is:

$$E(C|P) = Pr(C > 0|P)E(C|C > 0, P) \tag{A4.5.25}$$

The elasticity of quantity consumed with respect to price is:

$$\frac{dlnE(C|P)}{dlnP} = \frac{dlnPr(C > 0|P)}{dlnP} + \frac{dlnE(C|C > 0, P)}{dlnP} \tag{A4.5.26}$$

or:

$$\text{Total elasticity} \; = \; \text{Participation elasticity} + \text{Intensity elasticity} \tag{A4.5.27}$$

The estimated elasticities which appear in the published research literature vary in terms of their focus on participation or intensity of consumption and, among the latter, in terms of the measure of consumption. Almost all of the available estimates come from the USA or Australia, which are the two countries with the best-developed retail price data. None of the estimates control for differences in THC content. Table A4.5.1 summarises the major studies of own-price elasticity. See Pacula (2010 for a review of the (predominantly US) literature on price elasticities of demand and other non-price influences relevant to policy liberalisation.

Although the estimates cover a wide range, they suggest a total own-price elasticity of around -0.7 for cannabis. We showed (equation A4.5.22) that this elasticity can be interpreted as the sum of the underlying price elasticities for THC and cannabis quantity. In line with this, we assume an elasticity of -0.35 for each, but allow for alternative assumptions about the substitutability or complementarity of THC and cannabis volume in consumers' preferences. In all cases except strong complementarity, the increased implicit price of THC produces a fall in the consumption of THC, but there is, in every case, a rise in the volume of cannabis consumed. If this view is correct, then the concern over cannabis-induced psychotic illness may lessen relative to the concern over smoking-related physical illness, following this type of reform.

Table A4.5.1 Published estimates of cannabis demand elasticities

Study	Country	Type of elasticity	Estimate
Pacula et al (2001)	USA (high school seniors)	Participation	-0.06 to -0.47
Pacula et al (2001)	USA (high school seniors)	30-day participation	-0.002 to -0.69
Grossman (2004)	USA (high school seniors)	Participation	-0.46
Cameron and Williams (2001)	Australia	Participation	-0.89
Williams (2004)	Australia	Participation	-0.18
Zhao and Harris (2004)	Australia	Participation	-0.21
Williams et al (2004)	USA (college students)	Participation	-0.20
Williams et al (2004)	USA(college students)	30-day participation	-0.24
Desimone and Farrelly (2003)	USA	Participation: Age 12-17 yrs Age 18-39 yrs	 0.02 (NS) to -0.29 0.00 to -0.29
Williams (2004)	Australia	Frequency (among users)	<0
Zhao and Harris (2004)	Australia	Frequency (among users)	<0 (NS)
van Ours and Williams (2007)	Australia (14-22 yr olds)	Risk of initiation	-0.47 to -0.55
Clements and Daryal (2005)	Australia	Consumption volume	-0.84
Clements and Zhao (2005)	Australia	Consumption volume	-0.69

"wrt" = with respect to; "NS" = not statistically significant; participation is measured over 12 months unless otherwise stated. All Australian studies cover individuals aged 14 and over unless otherwise stated

Table A4.5.2 gives some numerical examples to illustrate these effects, under two assumptions: that the licensed cannabis product enters the market 10% below the competitive price frontier and succeeds in eliminating the now uncompetitive illicit supply of standard herb/resin; and that the price of illicit sinsemilla remains at its current level.

Table A4.5.2 Projected price and demand responses under alternative assumptions

Demand elasticities	THC limit	Licensed price [a]	% change in implicit price of THC	% change in implicit price of cannabis volume	% change in THC consumed	% change in cannabis quantity consumed
Neutrality:	10%	£4.80	+32%	-80%	-11.2%	+28.0%
$\epsilon_{TT} = \epsilon_{XX} = -0.35$;	8%	£4.20	+20%	-50%	-7.0%	+17.5%
$\epsilon_{TX} = \epsilon_{XT} = 0$	6%	£3.60	+13%	-33%	-4.7%	+11.7%
Substitutes:	10%	£4.80	+32%	-80%	-27.2%	+34.4%
$\epsilon_{TT} = \epsilon_{XX} = -0.35$;	8%	£4.20	+20%	-50%	-17.0%	+21.5%
$\epsilon_{TX} = \epsilon_{XT} = 0.2$	6%	£3.60	+13%	-33%	-11.3%	+14.3%
Complements:	10%	£4.80	+32%	-80%	+4.8%	+21.6%
$\epsilon_{TT} = \epsilon_{XX} = -0.35$;	8%	£4.20	+20%	-50%	+3.0%	+13.5%
$\epsilon_{TX} = \epsilon_{XT} = -0.2$	6%	£3.60	+13%	-33%	+2.0%	+9.0%

[a] Set as 90% of the THC-specific competitive market price defined by sinsemilla (15% THC and £7 per gm) and standard herb/resin (6% THC and £4 per gm).

Table A4.5.3 Published estimates of cross-price elasticities of cannabis and tobacco demand

Study	Country	Type of elasticity	Estimate
Chaloupka et al (1999)	USA (adolescents)	30-day cannabis participation wrt tobacco price	-0.34 to -0.73 (both NS)
Farrelly et al (2001)	USA (12-20 yr olds)	30-day cannabis participation wrt tobacco price (tax)	-0.05 to -0.10 (both NS)
Markowitz and Tauras (2006)	USA (teenagers)	30-day cannabis participation wrt tobacco price	0.56 to 0.99
Cameron and Williams (2001)	Australia	Cannabis participation wrt tobacco price	0.003 (NS)
Zhao and Harris (2004)	Australia	Cannabis participation wrt tobacco price	-1.1
Chaloupka et al (1999)	USA (adolescents)	Cannabis frequency (among users) wrt tobacco price	-0.36 to -0.84
Farrelly et al (2001)	USA (12-20 yr olds)	Cannabis frequency (among users) wrt tobacco price (tax)	-0.44
Markowitz and Tauras (2006)	USA (teenagers)	Cannabis frequency wrt tobacco price	0.58
Zhao and Harris (2004)	Australia	Cannabis frequency (among users) wrt tobacco price	<0 (NS)
Cameron and Williams (2001)	Australia	Tobacco participation wrt cannabis price	-0.13
Zhao and Harris (2004)	Australia	Tobacco participation wrt cannabis price	0.06 (NS)
Zhao and Harris (2004)	Australia	Tobacco frequency (among users) wrt cannabis price	>0 (NS)

"wrt" = with respect to; "NS" = not statistically significant; participation is measured over 12 months unless otherwise stated. All Australian studies cover individuals aged 14 and over.

Table A4.5.4 Published estimates of cross-price elasticities of cannabis and alcohol demand

Study	Country	Type of elasticity	Estimate
Markowitz and Tauras (2006)	USA (teenagers)	30-day cannabis participation wrt beer price	-0.71
Saffer and Chaloupka (1999)	USA (aged 12+)	Cannabis participation wrt alcohol price	<0 (NS)
Pacula (1998)	USA (19-26 yr olds)	Cannabis participation wrt beer tax	<0
Markowitz and Tauras (2006)	USA (teenagers)	Cannabis frequency wrt beer price	<>0 (NS)
Pacula (1998)	USA (19-26 yr olds)	Cannabis frequency wrt beer tax	<0 (NS)
Clements and Daryal (2005)	Australia	Cannabis volume wrt:	
		beer price	-0.33
		wine price	-0.07
		spirits price	0.04
Clements and Zhao (2005)	Australia	Cannabis volume wrt:	
		beer price	-0.38
		wine price	-0.10
		spirits price	-0.03
Williams et al (2004)	USA (college students)	Alcohol participation wrt cannabis price	<0
Williams et al (2004)	USA (college students)	30-day alcohol participation wrt cannabis price	<0
Chaloupka and Laixuthai (1997)	USA (high school seniors)	(30-day) alcohol participation wrt cannabis price	>0
Clements and Daryal (2005)	Australia	Beer volume	-0.04
		Wine volume	-0.08
		Spirits volume	-0.15
		wrt cannabis price	
Clements and Zhao (2005)	Australia	Beer volume	-0.07
		Wine volume	-0.15
		Spirits volume	-0.30
		wrt cannabis price	

"wrt" = with respect to; "NS" = not statistically significant; participation is measured over 12 months unless otherwise stated. All Australian studies cover individuals aged 14 and over.

Table A4.5.5 Published estimates of cross-price elasticities of cannabis and illicit drugs demand

Study	Country	Type of elasticity	Estimate
Desimone and Farrelly (2003)	USA	Cannabis participation wrt cocaine price: Age 12-17 yrs Age 18-39 yrs	 0.05 to -0.20 (both NS) -0.19 to -0.24
Saffer and Chaloupka (1999)	USA (aged 12+)	Cannabis participation wrt cocaine price	<0
Saffer and Chaloupka (1999)	USA (aged 12+)	Cannabis participation wrt heroin price	<0
Desimone and Farrelly (2003)	USA	Cocaine participation wrt cannabis price: Age 12-17 yrs Age 18-39 yrs	 -0.10 (NS) to -0.53 -0.04 (NS) to -0.21

"wrt" = with respect to; "NS" = not statistically significant; participation is measured over 12 months unless otherwise stated. All Australian studies cover individuals aged 14 and over.

A5.1 Calculation of hourly police costs

Estimates of unit costs of policing need to address the possibility that more serious offences (such as cannabis supply) involve more senior staff and thus higher hourly costs than low-level offences such as cannabis possession. For this reason, we have produced a set of grade-specific hourly cost factors based on the following assumptions:

- average rates of pay within grades are proportional to the mid-point of the pay scale for that grade in England and Wales in effect from September 2010
- the total of other costs (apart from pay of police officers) are distributed as support costs in proportion to the wage bill within each officer grade.

Let n_r be the number of police officers of rank r and s_r be the mid point of the salary scale for rank r. Data for the former are taken from Mills et al (2010) Table 16 and relate to March 31st 2009. For the latter, we use official salary scales in effect from September 1st 2010, as set out in the police information website (www.police-information.co.uk/policepay.htm). Total police expenditure, T is taken from Mills et al (2010) Table 9 and relates to the 2008/9 financial year.

If we make the assumption that all other costs are incurred as support costs in proportion to officer salary costs, the following relationship determines full cost per unit of police time (w_r):

$$w_r = \frac{T s_r}{\sum_r s_r n_r}$$

In implementing this formula, we combine the ranks of superintendent and above, assuming arbitrarily that numbers of superintendents and chief-superintendents are in the ratio 70:30% and that average salary above the rank of chief-superintendent is £100,000.

Under these assumptions, the hourly costs are as set out in Table A5.1.1. The weighted average across all ranks is £68.46 per hour.

Table A5.1.1 Gross hourly costs by police grade

Constable	Sergeant	Inspector	Chief Inspector	Higher ranks
£62.41	£78.51	£98.09	£107.35	148.7

A6.1 The difficulty of causal analysis

There are six main approaches that have been used in the research literature to address the confounding problem in the absence of long-term randomised controlled trials.

Approach 1: Experimental neuroscience

For the particular issue of mental health, functional Magnetic Resonance Imaging (fMRI) can be used to monitor the change in blood flow within the brain and spinal cord as the subject undertakes cognitive tasks, following exposure to a treatment such as the administration of THC. The results of this kind of analysis can demonstrate convincingly the short-term causal effects of cannabis on brain activity, but the links between that activity and long-term behavioural and clinical outcomes are not fully understood. However, a tendency for cannabis exposure to generate brain activity patterns similar to those observed in people diagnosed with mental illness has been used as supporting evidence for a causal interpretation of the association between cannabis use and mental illness found in observational data.

Approach 2: Animal models

Patterns of drug dependence, including behavioural features like withdrawal symptoms and relapse, can be induced in laboratory animals under experimental control. With suitable randomised design of the experiments, causality can be demonstrated convincingly in this setting. The main drawbacks of animal experiments are that the quality of the animal-human comparison is uncertain and that it is often difficult to design experimental treatments which are close analogues of the policy variations of interest to us.

Approach 3: Trend analysis

Cannabis consumption followed a strongly rising trend from the 1960s until the early years of

the millennium. If there were a significant causal link from cannabis use to some particular outcome, we would expect to see a corresponding trend in the incidence of that outcome. This approach is not necessarily straightforward, since the outcome of interest (such as psychotic illness) is often very rare and population impacts consequently hard to detect in aggregate data. Outcomes may also only respond to the cannabis rise with a long lag, or may respond to cumulative cannabis use rather than point prevalence. There may also be trends in other contributory factors which have the effect of obscuring the relationship with cannabis.

Approach 4: Mendelian randomisation

If it can be shown that a specific genetic variant is both causally linked to the appetite for cannabis and randomly distributed through a relevant population, then division of a sample of individuals into genotype groups is analogous to experimental randomisation of exposure to cannabis itself. A comparison of outcomes between genotype groups then establishes causality in much the same way as randomised controlled trials. This approach has been applied in the case of alcohol (see Irons et al 2007), but its power to generate clear conclusions is often limited and its potential in the case of cannabis is not yet clear.

Approach 5: Proxy covariates

The most obvious solution to the confounding problem is to use surveys data to measure as many relevant characteristics of the individual as possible and include them jointly with measures of cannabis use as explanatory factors. Published studies have used a wide range of covariates, such as measures of personality traits, related behaviours including alcohol and tobacco consumption, early mental health and family background. These covariates fulfil a dual role: as influences on cannabis use in their own right and as proxies for other unobservable determinants of the outcome of interest. The presumption behind this practice is that inclusion of each additional proxy must necessarily reduce bias by reducing the degree of confounding, but this general presumption is not necessarily correct, as has been shown by Pearl (2000) (see also Shrier and Platt 2008).

Using simulation of an artificial example, we can show that it is quite possible for the bias in estimates of the causal impact to worsen when additional controls for confounding are included in the analysis.[61] Let U be an unobservable factor which tends to predispose people to cannabis use and schizophrenia; C is a measure of cannabis use; P is an indicator of psychotic illness, W and Y are covariates which are influenced by U; and X is another observed causal factor which may be correlated with U. Consider the following simple statistical model:

[61] The use of proxies can be improved in some circumstances by using more sophisticated methods, including latent variable modelling and propensity score matching.

$$U = a_0 + a_1 X + e_u$$

$$P = \mathbf{1}\big(b_0 + b_1 U + b_2 X + e_p > 0\big)$$

$$C = max(c_0 + c_1 U + c_2 X + e_c, 0)$$

$$W = d_0 + d_1 U + d_2 X + [e_w + r\, e_c]$$

$$Y = \mathbf{1}\big(f_0 + f_1 U + f_2 X + e_y > 0\big)$$

where X, e_u, e_p, e_c, e_w, e_y are independent N(0,1) random variables and $\mathbf{1}(A)$ is the indicator function, equal to 1 if condition A is true and 0 otherwise . In this case, there is, by construction, no true causal effect of cannabis use C on psychotic illness P. Note that the parameter r determines the degree to which cannabis use C and the covariate W are correlated independently of the underlying factor U (r is most likely to be non-zero, reflecting intrinsic substitutability or complementarity, if W is another endogenous outcome, such as a measure of alcohol or other drug use). It is common practice to include such variables as additional "controls".

We use the method of Monte Carlo simulation, generating 1000 replications of a sample of 5,000 individuals from the distribution implied by this model. We then average the results over the replications to give estimates of the bias in the results produced by each of the following three probit analyses: (*i*) P on C and X; (*ii*) P on C, W and X; (*iii*) P on C, W, Y and X. In each case, we take the probit coefficient of C as the estimate of the causal impact of C on P.

The estimated biases for two specific choices of parameter values are shown in Table A6.1. These results are arbitrary, but they illustrate some important methodological points which have been overlooked in much of the research literature.

- The spurious causation bias can be large – in this case, the coefficient of C is highly significantly (P<0.01) different from the true value of zero in every replication
- The inclusion of additional "controls" W and/or Y for unobserved confounders never succeeds in reducing the bias very much
- Results with additional controls may be more biased than the original naive estimate (see specification 2).

Table A6.1 Monte Carlo simulations of bias

Probit model	Parameter specification 1[a]	Parameter specification 2[b]
P on C, X	0.3691	0.3691
P on C, W, X	0.3597	0.5245
P on C, W, Y, X	0.3575	0.5220

[a] Parameters: $a_0 = 0$; $a_1 = 1$; $b_0 = -2.0$; $b_1 = 0.7$; $b_2 = 0.8$; $c_0 = -0.7$; $c_1 = 0.7$; $c_2 = 0.5$; $d_0 = -1.8$; $d_1 = 0.2$; $d_2 = 0.4$; $f_0 = -0.5$; $f_1 = 0.2$; $f_2 = -0.4$; $r = 0$ [b] Parameters identical except for $r = -1$

Approach 6: Fixed/random effects

A second approach is to deal with unobservable confounding factors by using "fixed effects" or "random effects" methods which assume the confounding factors to remain constant as the individual is observed through time. This makes it possible to use observations on the individual's own past to isolate the common unobserved factors and strip them out, leaving an estimate of the remaining causal impact of cannabis use on the outcome of interest. This widely used method has been criticised by Hernandez and Pudney (2011), who show that the assumption of constancy over time is critical and that even modest degrees of time-variation in confounding factors can lead to spurious causal estimates.

A6.2 Criminal records and the labour market

Evidence suggests the existence of two distinct sectors. Sector 1 covers occupations (such as education, finance and health) in which criminality is perceived to be a potential problem, so that employers are highly likely to carry out criminal record checks when filling vacant posts. Sector 2 covers less sensitive occupations (such as manual work) where criminality is not a major issue and the likelihood of checks is much lower. Consider the following two-sector search model of unemployment, based on Thomas (1998).

The probability of locating a vacant post in sector s = 1, 2 within any short time interval [t, t+dt] is $v_s(e_s)dt$, where e_s is the effort devoted to searching in sector j. The probability of a job application being successful is θ_s and the distribution of offered wage rates is $Pr(w_s > w) = \bar{F}_s(w)$. The individual will accept any job with a wage rate exceeding the reservation wage w^*. If the marginal cost of search effort is c and the interest rate is r, then search in each sector will be undertaken up to the point where the marginal return to search is equal to its marginal cost. The hazard rate for movements from unemployment into sector s is the instantaneous probability of locating a vacancy, successfully applying and receiving an acceptable wage offer:

$$h_s = \theta_s v_s(e_s)\bar{F}_s(w^*) \qquad \text{(A6.2.1)}$$

and the overall hazard rate for any exit from unemployment is:

$$h = h_1 + h_2 \qquad \text{(A6.2.2)}$$

If out-of-work income, the vacancy discovery rate, the application success rate and the sectoral wage offer distributions are all constant through time, the resulting duration distribution is exponential and has mean:

$$\mu_u = 1/(h_1 + h_2) \tag{A6.2.3}$$

If we also assume that all employment spells have the same expected duration μ_e, then the proportion of a long career spent in unemployment will be:

$$\text{Career unemployment rate} = \frac{\mu_u}{\mu_u + \mu_e} \tag{A6.2.4}$$

The probability that the individual finds work in sector s is:

$$Pr(\text{exit to sector } s) = \frac{h_s}{h_1 + h_2} \tag{A6.2.5}$$

and the average wage while in employment is:

$$\text{Average wage} = \frac{h_1}{h_1 + h_2} E(w_1 | w_1 > w^*) + \frac{h_2}{h_1 + h_2} E(w_2 | w_2 > w^*) \tag{A6.2.6}$$

Under normal assumptions, search theory implies that, if the probability of an offer in sector 1 falls because of a criminal record ($\theta_1 \downarrow$), search effort will be diverted to sector 2 ($e_1 \downarrow, e_2 \uparrow$), the reservation wage will fall in response to the lower overall availability of jobs ($w^* \downarrow$), but the overall exit rate from unemployment will fall ($h_1 + h_2 \downarrow$). Therefore, the proportion of time spent unemployed will rise. Given the lower average wage in sector 2, the fall in the reservation wage and the diversion of search effort to sector 2, the average wage while in employment will also fall.

Where is the social cost in all this? Assume the criminal record does not alter the individual's potential productivity in any causal sense and that the reduced success rate is purely the result of stigma. Then the loss to the individual and society is the output lost during the additional periods of unemployment plus the difference between the output that would have been produced in a normal configuration of employment and that produced during a career of poorer job matches. If productivity is perfectly rewarded by earnings, the social cost can be evaluated as the change caused by the conviction to the career average level of annual earnings:

$$\text{Average earnings} = \frac{\mu_e}{\mu_u + \mu_e} \left\{ \frac{h_1}{h_1 + h_2} E(w_1 | w_1 > w^*) + \frac{h_2}{h_1 + h_2} E(w_2 | w_2 > w^*) \right\} \tag{A6.2.7}$$

For any individual, we can calibrate this structure by adopting specific numerical values for two characteristics: the proportion of elapsed career time spent unemployed (C_1); and the proportion of time in employment which is spent in sector 1 (C_2). These quantities are defined by equations (A6.2.4) and (A6.2.5) respectively.

Now make a further assumption that the effect of a criminal record for a cannabis offence is to halve the hazard rate h_1 for transitions from unemployment to sector 1 employment, while h_2

remains unchanged.[62] We then replace h_1 by $0.5h_1$ and re-compute (A6.2.7). As examples of this, consider two hypothetical individuals. Individual A has low qualifications and, without a criminal record would be expected to spend 8% of his career unemployed, to have mean unemployment spell durations of 6 months and, when employed, has jobs in the favoured sector 1 only 20% of the time. Individual B would normally spend only 2% of his career unemployed, with a mean unemployment spell length of 3 months, and 80% of his employment is in sector 1. Both A and B have the same average pay when employed in sector 2; A's pay in sector 1 is 20% higher than in sector 2 but, for individual B sector 2 pay is double the level in sector 1.

For individual A, the social cost of a criminal record amounts to 2.6% of his expected career earnings, as a consequence of a 10% rise in the time he spends unemployed, and a near-halving of the proportion of employment spent in sector 1. In the absence of a criminal record, individual B has average career earnings 84% higher than individual A and, for him, the potential social cost is much greater, amounting to 8.6% of career earnings, which is a consequence of a 65% rise in time spent unemployed and a 20% fall in his proportion of employment in sector 1.

We use this approach to estimate the aggregate social cost of drug-related criminal records in the following way.

Step 1 Define x as a set of personal characteristics which are observable in the Arrestee Survey and the British Household Panel Survey (BHPS). They include gender and the age at which full-time education was completed. Define sector 1 to cover all occupations in education, health, finance, the law and public service. Using BHPS observations for people aged 20-35 during the period since 2000, estimate cross-section statistical models of Pr(unemployed|x) and Pr(sector 1|employed, x). The predicted probabilities from these models provide values of C_1 and C_2 for any individual with given characteristics x.

Step 2 For each Arrestee Survey respondent who is: (*i*) a first-time arrestee; (*ii*) under arrest on suspicion of a drugs offence and (*iii*) reports being a current cannabis user who is not also using hard drugs, use the estimated BHPS models to predict the individual's values for C_1 and C_2.[63] Calculate the expression (A6.2.7) with no criminal record effect, then recalculate after halving h_1, to give the proportionate reduction in career earnings, using average earnings levels for sectors 1 and 2, taken from the LFS. This is equivalent to changing the baseline estimate of

[62] Note that this implies that, in equation (A6.2.2), the diversion of search activity away from sector 1 exactly offsets the increase in the hazard caused by the fall in the reservation wage; and that the increase in h_2 caused by the reduced reservation wage and increased search effort in sector 2 is exactly offset by the negative impact of the criminal record on the success rate θ_2. There is no empirical evidence to confirm the validity of these assumptions, but they seem reasonable as a first approximation.

[63] Note that the BHPS model for C_2 can also be estimated for the AS sample and used as a check or to re-calibrate the BHPS estimates to allow for selection effects.

$\frac{h_1}{h_1+h_2}$ from C_2 to $\frac{C_2}{2-C_2}$ and the estimate of $\frac{\mu_e}{\mu_u+\mu_e}$ from (1-C_1) to $1-\frac{2C_1}{2-C_2(1-C_1)}$. Calculate the weighted sample mean of this proportionate loss of career earnings, $\bar{L}$.

Step 3 Construct an estimate of the aggregate annual social cost (internal + external) for the inflow of new arrestees as:

$$s = \bar{L} \times N \times f \times \bar{E} \qquad \text{(A6.2.12)}$$

where N is the number of convictions for cannabis possession and supply offences in England and Wales in 2010, f is the proportion of cases which are first-time arrests in the sample of AS respondents who are cannabis users[64] and were arrested on suspicion of a drugs offence. $\bar{E}$ is the level of average earnings in 2010.

Step 4 Assume the scarring effect decays to zero linearly over 10 years, so that the social cost for this cohort of cannabis convicts t years after first conviction is s/(1-t/10). Assume further that the flow of convictions is stable over time, so that the output loss caused by the scarring in the current period, aggregated over all relevant past cohorts of convicts, is:

$$S = \sum_{t=0}^{10} s\left(1-\frac{t}{10}\right) = 5.5\,s \qquad \text{(A6.2.13)}$$

A6.3 Direct and indirect effects on earnings potential

We make a simple distinction between high school graduation and non-graduation. Define $\mu_0^G(a)$ and $\mu_0^N(a)$ to be the expected level of annual earnings at reference age a for a graduate and non-graduate respectively, under policy regime 0 (the status quo). $P_0^E(a)$ and $P_0^L(a)$ are the school graduation[65] rates for people who respectively have and have not used cannabis by age 16 (the "early" and "late" onset groups).

Because cannabis use can have an impact on educational attainment at an early age and another impact on productivity at later ages, we distinguish four population groups, defined in terms of their outcomes at age a under current policy:

(I) *Lifetime abstainer*: no cannabis use prior to age 16 and none at age a;

(II) *Late-onset user*: no cannabis use prior to age 16 but some use at age a;

(III) *Early experimenter*: cannabis onset prior to age 16 but no cannabis use at age a;

(IV) *Sustained user*: cannabis onset prior to age 16 and cannabis use at age a.

[64] But not also users of heroin, crack or cocaine

[65] Defined here as achievement of at least one GCSE pass of grade C or above (normally at age 16).

Before reform, the probabilities of these four outcomes are:

$$\pi_0^{(I)}(a) = (1 - Q)(1 - R_0^L(a)) \tag{A6.3.1}$$

$$\pi_0^{(II)}(a) = (1 - Q)R_0^L(a) \tag{A6.3.2}$$

$$\pi_0^{(III)}(a) = Q(1 - R_0^E(a)) \tag{A6.3.3}$$

$$\pi_0^{(IV)}(a) = QR_0^E(a) \tag{A6.3.4}$$

where Q is the probability of onset of cannabis use before age 17 and $R_0^L(a)$ and $R_0^E(a)$ are the probabilities of being a current cannabis user at age a conditional on late and early onset, respectively, all under the current policy environment.

We assume that reform causes a uniform expansion, at a rate $\lambda = 10\%, 20\%$ or 40%, according to the assumed market response scenario, in the prevalence of early onset and the probability of cannabis use in later life. Thus, post-reform, these probabilities $\pi_0^{(I)}(a) \ldots \pi_0^{(IV)}(a)$ are (approximately) equal to (A6.3.1)-(A6.3.4), but with Q, $R_0^L(a)$ and $R_0^E(a)$ multiplied by a factor $(1 + \lambda)$.[66] This implies that reform will unambiguously reduce $\pi_0^{(I)}(a)$ and increase $\pi_0^{(III)}(a)$ and $\pi_0^{(IV)}(a)$. For plausible values of Q, $\pi_0^{(II)}(a)$ will also increase. Thus $\Delta\pi^{(I)}(a) < 0$, $\Delta\pi^{(II)}(a) > 0$, $\Delta\pi^{(III)}(a) > 0$ and $\Delta\pi^{(IV)}(a) > 0$.

We assume that the impact of policy on school attainment is only the result of changes in the number of people with early onset of cannabis use. Consequently, the probabilities of school graduation conditional on early or late onset are P^E and P^L, which are unaffected by reform. Under policy regime r = 0 or 1, the expected level of annual earnings at age a for someone who remains a member of group I ... IV is:

$$E(\text{earnings at age } a \mid \text{group } j) = \begin{cases} P^L\mu_r^G(a) + (1 - P^L)\mu_r^N(a) & j = \text{I, II} \\ P^E\mu_r^G(a) + (1 - P^E)\mu_r^N(a) & j = \text{III, IV} \end{cases} \tag{A6.3.5}$$

There is an important selection issue relating to the earnings of people who would be in group I or II under existing policy, but in the early onset groups III and IV under the new policy. Such behavioural "movers" are likely to come from the lower part of the earnings distribution and thus would have below-average earnings within groups I and II under status quo policy. They are also likely to have higher-than-average earnings within the early onset group under the reform scenario. There are no estimates of the joint causal impact of early cannabis use on education and lifetime earnings, so we have no way of allowing for this selection effect. Its effect will be to bias upwards our estimates of the net social costs of reform.

[66] Note that this approximation implies a change in prevalence rather greater than the assumed expansion rate λ, so our analysis is again conservative.

Now assume that any reform-induced change in earnings is proportional so that, for anyone who is drawn into cannabis use by reform, $\Delta\mu^G = -g\mu_0^G$ and $\Delta\mu^N = -g\mu_0^N$, where g is a constant revealed to us by past research on the impact of cannabis use in the labour market. By definition, these direct earnings effects only apply to groups II and IV, so the policy-induced change in overall average earnings for the cohort at age a is:

$$\Delta\mu(a) = m_0^L(a)\left\{\Delta\pi^{(I)}(a) + (1-g)\pi_1^{(II)}(a) - \pi_0^{(II)}(a)\right\}$$
$$+ m_0^E(a)\left\{\Delta\pi^{(III)}(a) + (1-g)\pi_1^{(IV)}(a) - \pi_0^{(IV)}(a)\right\} \qquad \text{(A6.3.6)}$$

where Δ means the change from policy regime 0 to regime 1 and $m_0^L(a) = P^L\mu_0^G + (1-P^L)\mu_0^N$ and $m_0^E(a) = P^E\mu_0^G + (1-P^E)\mu_0^N$ are expected earnings for the late and early onset groups. Consequently, the aggregate impact in the population as a whole is:

$$\Delta M = \sum_a N(a)\Delta\mu(a) \qquad \text{(A6.3.7)}$$

where $N(a)$ is the size of the working population aged a.

We implement expression (A6.4.3) in the following stages.

Step 1 Set g to 0 for the central and low estimate, in line with the majority of the research literature. For the upper estimate, assume an impact on earnings of -10% (in line with Van Ours 2007b).

Step 2 Estimate separate non-parametric regressions[67] of annual total earnings on age, for non-disabled working-age adults with and without basic school qualifications, using 2010 LFS data. Use these models to predict $\mu_0^N(a)$ and $\mu_0^G(a)$ at each age.

Step 3 Using data from the 2009/10 BCS, estimate Q as the proportion of respondents with onset of cannabis use at or before age 16.

Step 4 Estimate P^L as the proportion of 2009/10 late onset BCS respondents with school qualifications.

Step 5 For the lower limit of the high-low range, set P^E equal to P^L. For the upper limit, set P^E equal to the proportion of 2009/10 early onset BCS respondents with school qualifications. For the central estimate, use the average of these two values for P^E.

Step 6 Using data from the 2009/10 BCS, estimate $R_0^L(a)$ and $R_0^E(a)$ from separate nonparametric regressions of (last-year) cannabis prevalence on age for the group of respondents with early onset of cannabis use and the remainder of the adult sample.

[67] We use the locally-linear weighted least-squares method, using a tricube weighting function and bandwidth of 0.5.

Step 7 Set $\lambda = -10\%, 5\%, 25\%$ to reflect the market response scenarios of Table 4.5.3 and construct $N(a)$ as the age-specific ONS estimates of the resident population reduced by 10% to allow for non-employability through disability. Use (A6.3.7) to construct low, mid and high estimates of the total gross aggregate earnings loss from cannabis use.