1 Introduction

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Anecdotally, marijuana is a popular product. But it is not a product that is well understood from an economic perspective. What is the size of the marijuana industry? Is it a substitute or a complement for other drugs such as alcohol and tobacco? How sensitive is consumption to changes in its price? By how much would marijuana prices and consumption change if it were decriminalised further and/or legalised? How much tax revenue could be raised from marijuana? These are some of the major issues in the economic analysis of marijuana. In this book we consider in detail these and other economic dimensions of the marijuana industry, including:

- The nature of consumers of the product and how the consumption of marijuana and other drugs are interrelated.
- Intriguing patterns in prices, including quantity discounts, regional disparities in prices and the extent to which marijuana prices have fallen over time.
- The likely size of the industry.
- The price sensitivity of consumption of marijuana, cocaine, heroin, beer, wine, spirits and tobacco.
- The possible implications of decriminalising or legalising marijuana, including the amount of revenue that the government could raise by subjecting it to taxation in a manner similar to that for tobacco and alcohol.

1.1 Economic dimensions of marijuana

The marijuana industry is of interest to economists for several reasons. First, although official data are lacking, available estimates indicate that the industry is of substantial size. For example, approximately one-third of all Australians admit to having tried marijuana and a much larger proportion of young people have done so (see National

Drug Strategy Household Survey, 2005, for details). In addition, expenditure on marijuana in Australia is estimated to be about three-quarters of that on beer and twice wine sales, as discussed in Chapter 4. Although these estimates are subject to considerable uncertainties, the indications are that the marijuana sector is of sufficient size to merit careful investigation.

A second reason why marijuana is of economic interest is that it forms the basis of appealing teaching material, possibly because young people tend to be more intensive users, and because its illicit nature endows marijuana with some form of edgy mystique that captures the imagination of students. Marijuana provides good examples for lively classroom discussions of demand analysis (what are the substitutes for marijuana and what is its price elasticity of demand?), the demand and supply model (the effects of marijuana legalisation on the price and quantity transacted), the role of technological change in lowering the price to consumers (the switch to hydroponic techniques for growing marijuana in the 1990s) and the economics of packaging (why are there substantial discounts for bulk purchases of marijuana?).

A third reason for interest in marijuana relates to public finance issues. As its production and consumption are illegal, marijuana escapes the tax net. Can producers of alcoholic beverages – likely substitutes for marijuana – legitimately argue that on the basis of competitive neutrality, marijuana should be legalised and taxed in a similar manner? Would such a policy be a more effective way to control marijuana consumption than the current prohibition approach? If so, exactly how should marijuana be taxed? The possibilities include a uniform rate applied to marijuana and alcohol, Ramsey optimal taxes that balance revenue requirements with deadweight losses and the use of taxes to correct for externalities in consumption. There are also public policy issues associated with marijuana. Exactly what are the health consequences of marijuana use and to what extent are these genuine external effects that justify policy intervention? What is the case for regulating consumption and what are the least-cost policy instruments?

Finally, the illicit nature of marijuana presents both intriguing challenges and opportunities for research into underground markets. As producers and consumers have incentives to conceal their activities, information on the marijuana industry is not readily available and has to be compiled using unconventional and indirect methods and sources. The criminal aspect of marijuana opens up research possibilities

regarding the impact of expected penalties on consumption, issues of asymmetric information about product quality, risk-return tradeoffs, etc. If conventional microeconomic analysis can be applied to marijuana, a good that is not only illicit but also has mind-altering effects on users, then the economic analysis of marijuana can be viewed as a form of stress-testing of theory.

Research on the workings of drug markets is also of professional interest to groups other than economists. These groups include researchers in public policy (who may be interested in questions such as whether drugs should be legalised and taxed like tobacco and alcohol), law enforcement agencies (how should scarce enforcement resources be allocated?), health professionals (which type of individual is most at risk of abusing drugs?) and government organisations (who are the most vulnerable socioeconomic groups and what are the implications for effective public health campaigns of the relationships between marijuana consumption and other legal and illegal drugs?). Another reason for interest is that there seems to be a distinct change in society's attitudes towards illicit drugs in a number of countries. A more tolerant approach to the use of some drugs is now being reflected in the workings of the police, the courts and parliament in a number of jurisdictions. For example, in the Australian context Wodak and Cooney (2004) argue that:

> [T]he community has gradually come to accept that some form of regulation is the least worst arrangement for unreducible appetites the majority disdain, but a substantial minority desire, such as gambling and prostitution. It is time to seriously consider the hitherto unthinkable: the least worst arrangement for cannabis is taxation and regulation.

This book provides an economic perspective on the marijuana industry and in a number of ways compares and contrasts economic characteristics of marijuana with those of other products. This comparison involves the following elements:

- The identification of individual socioeconomic and demographic characteristics of marijuana users and a comparison with those of users of other legal and illegal drugs.
- A comparison of consumption patterns of marijuana with those of alcohol, tobacco and other drugs to reveal interesting similarities and differences. For example, it is likely that marijuana and alcohol are substitutes in consumption, so that policies that serve to reduce

marijuana use by increasing its price (such as a police crackdown on production) would be likely to encourage drinking. A further example is that, to a first approximation at least, the price sensitivity of the demand for marijuana is the same as that for beer, wine and spirits – each of these products has a price elasticity of approximately minus one-half.

- An analysis of marijuana prices in different regions of Australia reveals a surprising degree of dispersion that is much greater than that of regional incomes, but of the same order as the dispersion of house prices. This finding points to the importance of local processing and distribution costs, in addition to the cost of the raw product, in determining marijuana prices.
- Over time, the relative price of marijuana has decreased substantially, much faster than the prices of many other primary products, which tend to fall at approximately 1–2 per cent per annum on average. We argue that this decrease in prices is likely to be due to productivity improvements in growing marijuana (associated with the adoption of hydroponic techniques) and/or a softening of community attitudes to marijuana use that has led to lower risk of incurring substantial criminal penalties.
- The unit price of marijuana is as much as 50 per cent lower when purchased in the form of an ounce rather than a gram. We show that once this discount is formulated in a manner that is comparable across widely different types of products, it is more or less the same as that available for grocery products, as well as for other illicit drugs. This leads to the elegantly simple pricing rule that a 10 per cent increase in the package size of a product is associated with a 2.5 per cent decrease in the unit price. The fact that such a pricing rule applies to a number of products in addition to marijuana seems to reflect the same basic economic forces at work in a variety of situations.

Thus, although marijuana does have some unique characteristics associated with its illicit status, these do not seem to be sufficient to put the product in a special category for the purposes of economic analysis.

1.2 The economic approach to drugs

The approach to marijuana described above is part of a wider body of research dealing with the operation of drug markets and how

economics contributes to an understanding of their workings. In broad outline, such research starts with the idea that many of the conventional tools of economic analysis can be applied to drugs, so that the commodity does not constitute a special case, notwithstanding that they can have mind-altering effects on consumers and be addictive. As an example, the study by Clements and Johnson (1983) was one of the first to apply the theory of the utility-maximising consumer to the demand for beer, wine and spirits. They tested the three key predictions of consumption theory. First, that the demand for each beverage is negatively related to its price, which is known as the law of demand, or that demand curves slope down. Second, that an equiproportional change in all nominal prices and total expenditure has no impact on the demand for each of the beverages, a condition known as demand homogeneity. Third, that the effect of a one-dollar increase in the price of beverage A on the consumption of beverage B is exactly the same as an identical increase in the price of B on consumption of A, under the condition that real total expenditure on alcohol remains unchanged. This proposition is known as Slutsky symmetry and represents consistency in beverage choice, or rationality associated with utility maximisation. Clements and Johnson find that data from Australia are not inconsistent with these three tenets of consumption theory, a finding that has largely been confirmed for a number of other countries by Selvanathan and Selvanathan (2007), among others.

The papers by Stigler and Becker (1977) and Becker and Murphy (1988) provided a major stimulus to research on the economics of drugs by introducing the concept of rational addiction. According to the search engine Google Scholar, each of these papers has been cited well over 1,000 times. Although imperfect, these citation counts provide some measure of the scholarly influence of this research. Under the Becker–Murphy–Stigler approach, consumption of an addictive good is associated with a stock of consumption capital that enters the utility function to reflect a "learning by doing" process. This stock increases with consumption and depreciates with time, so that current utility depends on past consumption. In Becker and Murphy (1988), the individual's problem is then to choose the consumption path to maximise the present value of utility, appropriately discounted, subject to a resources constraint. Part of the resources constraint involves labour earnings, which are affected by the stock of

consumption capital. This formulation operationalises the idea of rational addiction, with the consumer exhibiting forward-looking behaviour and consciously trading off current benefits from using the addictive good today against its future costs. For addictive goods that are harmful, such as tobacco, current consumption decreases future utility and future labour earnings, whereas the opposite is true for beneficial goods such as going to the gym. This intertemporal utility-maximisation problem leads to a rich set of implications, including that consumption of an addictive good responds less to a temporary change in its price, more to a permanent change and can be subject to abrupt cessation (going "cold turkey") and bingeing behaviour, all results of consistent rational choice. In broad terms, Becker and Murphy establish that addictive goods are not incompatible with rational consumer choice.

Over the last decade and a half, as better data on the consumption of illicit drugs and their prices have become available, a number of econometric studies have been conducted on the demand for drugs. These studies typically use large cross-sectional databases that provide information at the individual level on whether or not drugs are used. Among other issues, this body of research is concerned with measuring the price sensitivity of consumption and the effects of decriminalisation of drugs. A useful survey of this literature was carried out by Pacula *et al*. (2001, Section 6.2), while more recently Pacula (2005) reviewed this type of research as it applies to marijuana. Australian research along these lines that deals with marijuana has been conducted in recent years by Cameron and Williams (2001), Ramful (2008), van Ours and Williams (2006), Williams (2004), Williams and Mahmoudi (2004) and Williams and Skeels (2006).

An important concern in the economics of drugs is whether the current approach of declaring certain drugs to be illegal is the most efficient way to control consumption (assuming it needs to be controlled). Simply passing a law is no guarantee that consumption will cease; indeed, the evidence is that underground markets flourish if demand for drugs is sufficiently high. Major issues are the unintended consequences of prohibition such as the criminality, corruption, violence, disrespect for the law and uncertain product quality associated with underground drug markets. Why not simply legalise, say, marijuana and then control its consumption by taxing it in the same way as alcoholic beverages and tobacco are taxed? This would have the effect

of transferring to the government substantial resources that would otherwise be captured by criminals and the government could then either lower other taxes and/or carry out valuable public expenditure programmes.

One of the first major economists to support the legalisation of drugs was Friedman (1972), who wrote:

> On ethical grounds, do we have the right to use the machinery of government to prevent an individual from becoming an alcoholic or a drug addict? For children, almost everyone would answer at least a qualified yes. But for responsible adults, I, for one, would answer no. Reason with the potential addict, yes. Tell him the consequences, yes. Pray for and with him, yes. But I believe we have no right to use force, directly or indirectly, to prevent a fellow man from committing suicide, let alone from drinking alcohol or taking drugs. I readily grant that the ethical issue is difficult and that men of goodwill may well disagree. Fortunately, we need not resolve the ethical issue to agree on policy. *Prohibition is an attempted cure that makes matters worse – for both the addict and the rest of us*. Hence, even if you regard present policy towards drugs as ethically justified, considerations of expediency make that policy most unwise. [Friedman's emphasis.]

In a similar vein, Becker (2005) argues that:

> the legalisation of drugs combined with an excise tax on consumption would be a far cheaper and more effective way to reduce drug use. Instead of a war [on drugs], one could have, for example, a 200 per cent tax on the legal use of drugs by all adults – consumption by, say, persons under age 18 would still be illegal. That would reduce consumption in the same way as the present war . . .

In a recent paper, Becker *et al.* (2006) analyse ways to reduce the consumption of a particular good, and compare the effects of a ban that makes it illegal with an excise tax. Their comparison emphasises the role of enforcement costs when the good is illegal; greater enforcement leads to higher costs incurred by producers of the illegal good, which, if the market is competitive, are passed onto consumers in the form of higher prices. Thus, greater enforcement activities by the government lead to an increase in prices and a decrease in the quantity consumed but an increase in total outlay on the good if demand is inelastic, as is likely to be the case for drugs. If drug production is a competitive industry and takes place under conditions of constant costs, producers earn no rents and the total outlay by

consumers also represents the value of resources devoted to the production of drugs. This means that a crackdown on drugs resulting from greater enforcement would lead to the surprising result of an increase in the resources devoted to supplying drugs, even though consumption decreases. These additional resources flow into the drugs industry as producers incur costs to avoid detection and punishment. If drugs were legalised and taxed, the government would receive taxation revenue, most of which is not a net cost to the economy but a transfer from drug users to the government. However, under prohibition, what would have been tax proceeds become a real resource cost to the economy as a whole in the form of the higher costs incurred by drug producers. Becker *et al*. thus establish that prohibition is an expensive policy compared with the tax option, a result that holds under fairly general conditions.

This work has profound implications for understanding the workings of drug markets and public policy, which Becker *et al*. (2006) describe in the following terms:

> This analysis in particular helps us understand why the war on drugs has been so difficult to win, why international drug traffickers command resources to corrupt some governments and thwart extensive efforts to stamp out production by the most powerful nation, and why efforts to reduce the supply of drugs lead to violence and greater power to street gangs and drug cartels. To a large extent, the answer lies in the basic theory of enforcement developed in this paper and the great increase in costs of production from punishing suppliers to fight this war. Suppliers who avoid detection make huge profits, which provides them with resources to corrupt officials and gives them incentives even to kill law enforcement officers and competitors.

Calls for decriminalisation/legalisation of drugs have also come from a number of others, such as Buiter (2007), *The Economist* magazine (2001), Miron and Zwiebel (1995), Nadelmann (1988) and Wodak and Cooney (2004), to mention just a few. It still has to be acknowledged that drug legalisation would entail its own costs. As consumption would likely increase following legalisation, there would be higher health costs to users and costs inflicted on third parties caused by driving while under the influence of drugs and other anti-social behaviour. The case for legalisation relies on these costs being less than those of the unintended consequences of prohibition mentioned above.

1.3 Overview of the book

The book contains seven chapters and below we briefly describe the contents of the subsequent chapters.

Chapter 2: Microeconometric evidence on marijuana consumption. This chapter presents an extensive discussion of factors relating to individuals' consumption of marijuana and other drugs (both legal and illegal), using the rich unit-record data from the Australian National Drug Strategy Household Surveys. It highlights recent trends in consumption, the socioeconomic and demographic characteristics of users, the effects of own and related-drug prices, and the interrelationships between marijuana and other drugs via observable and unobservable factors. As individual-level survey data provide information on consumption in the form of binary participation status or discrete levels, the typical econometric strategy involves the use of models with discrete dependent variables. This leads to a discussion of a collection of modern econometric models for the analysis of marijuana consumption. The chapter covers the following issues:

- A probit model with a binary dependent variable is used to study the probability of marijuana participation, in particular its relationship with individual characteristics, own and cross-drug prices, and whether or not marijuana has been decriminalised.
- Anecdotal evidence indicates that users of one drug tend to simultaneously consume other drugs. We thus use multivariate probit models to study marijuana and other legal and illegal drugs. Cross-drug correlations via unobservable factors are important pieces of information that can be used in investigating drug policies in a multi-drug framework and in contributing to discussion of the "gateway" hypothesis, whereby users move from softer to harder drugs.
- A two-part sequential model with an ordered probit is used to study the factors affecting the probability of different levels of consumption. This allows for differentiation of occasional and heavy users and identification of policy implications.
- Other econometric issues can be particularly important for drug data. One special feature of representative surveys of the whole population is that the majority of people are not current drug users. In other words, these databases contain a large number of zeros corresponding to the response "no, I do not use drugs". We use a zero-inflated ordered probit model to separate two types of zero

observations: those corresponding to genuine non-participants for health or legal concerns and those representing zero-consumption participants who respond to economic factors such as price and income. We show that ignoring this difference in the nature of the zeros could result in erroneous policy implications.

Chapter 3: The pricing of marijuana. This chapter first documents the unique data on marijuana prices obtained from the Australian Bureau of Criminal Intelligence. These data are used as a basis to construct index numbers of marijuana prices over time, regions and major product types. Analysis of the prices reveals: (i) a large decrease in prices over the last decade, which we argue is likely to be due to the adoption of hydroponic production techniques and/or more relaxed community attitudes towards marijuana; (ii) an intriguing pattern of regional prices, whereby Australia can be conveniently divided into three regions according to the cost of marijuana; and (iii) marijuana seems to be subject to pricing principles that are very similar to those observed for legal products such as groceries. Using new methods, we apply the economic theory of packaging to understand the existence of substantial quantity discounts that are available when marijuana is purchased in large quantities.

Chapter 4: More on the economic determinants of consumption. This chapter deals with measurement of the price sensitivity of drug consumption as summarised by the price elasticity. It draws a distinction between what is known as participation elasticity, a concept that features prominently in the literature (and used in Chapter 2) when there are only binary consumption data available, and conventional elasticity, which pertains to the price sensitivity of the actual volume of consumption. We present time-series estimates of the volume of marijuana consumption in Australia and use a system-wide approach to estimate demand functions for marijuana and the closely related products beer, wine and spirits. This leads to a matrix of own- and cross-price demand elasticities for these four commodities. Other material in this chapter includes index numbers of consumption and the identification of a useful rule of thumb according to which own-price elasticities are equal to minus one-half. The underlying technical material on the economic theory of the utility-maximising consumer is presented in an appendix, which means that the chapter is self-contained.