THE ECONOMICS OF MARIJUANA CONSUMPTION

by

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Abstract

In economic terms, marijuana is an important, yet little understood and controversial commodity. According to our estimates, spending on marijuana in Australia is about twice that on wine. But this commodity, which has been used by about one-third of the population, generates no tax revenue. This paper explores economic aspects by marijuana consumption, concentrating on the estimation of the amount consumed, its price sensitivity, its interaction with alcohol and the effects of any legalisation. Key findings are (i) the price elasticity of demand for marijuana is about –1/2; (ii) alcohol and marijuana seem to be substitutes, with cross-price elasticities ranging from .1 (for beer with respect to the price of marijuana) to .5 (spirits/marijuana); (iii) according to a survey at UWA, about 50 percent of first-year students have used marijuana; and (iv) legalisation would increase marijuana consumption by about 13 percent, with most of that accounted for by daily and weekly users, and alcohol consumption would fall.

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1. INTRODUCTION

In economic terms, marijuana is an important, yet little understood and controversial commodity. In Australia for example, according to our estimates (to be discussed below), spending on marijuana in the 1990's is about twice than on wine. But this commodity, which is used by something like one-third of the entire adult population, generates no tax revenue. What would happen to the consumption of marijuana if it were legalised? What would happen to alcohol consumption? How much revenue could be generated if marijuana were taxed? What is the price sensitivity of consumption? At a more fundamental level, can the consumption of marijuana be analysed with the conventional utility-maximising calculus? Satisfactory answers to these, and related, questions are not available in the literature.

Drug taking dates back to prehistoric times and is today a major social, economic and political issue that gives rise to great controversy all over the world. Even though governments have attempted, with mixed results, to tackle consumption of illicit drugs, a substantial proportion of the population has taken drugs. The debate concerning the pros and cons of prohibition seems to be intensifying with it now being a daily issue in the media and politics in most Western countries. Advocates of prohibition argue that drugs are illegal because they are harmful to both body and mind. Brown (1995), for example, states that legalisation is not an idea whose time has come: It is nothing more than a surrender to forces that would poison youths and communities. The pro-prohibition view sees the removal of criminal sanctions as only making illicit drugs more widely available and attractive, hence increasing the number of users. This increase would also lead to a larger number of addicts that could not support their drug dependency with legally-acquired income. Therefore, crime could become one way to support their habit. More users would mean more of the violence associated with the ingestion of drugs, and an increase in physical and mental illnesses associated with drug use (Incardi and Saum, 1996).

Prohibitionists argue that marijuana is the gateway that leads to harder drugs. For example, Collins (1999) states that "Dutch supporters of their lenient soft-drug policy argue that cannabis does not inevitably thrust the heavy smoker across a threshold into hard drug use. They are right. There is no compelling physiological link between cannabis smoking and heroin use, and by no means do all heavy pot smokers move on to hard drugs. But in France, for example, 80 percent of heroin addicts also are heavy consumers of marijuana and hashish. Koopman of The Hope rehab center says more than 80 percent of the heroin addicts that his institute has treated developed their habit after first becoming habitual grass smokers." DeSimone (1998) reports evidence of marijuana consumption being a gateway to cocaine. However, David Penington, former head of the Victorian Government's Drug Advisory Committee, argues that marijuana is a gateway to hard drugs for young people *because* it is illegal; in his words, "The reality is that the gateway from marijuana to other drugs is the source of the marijuana … When marijuana is illicit, when its distribution is via an illicit trade, then the young who buy that marijuana also are offered heroin." (Penington, quoted in Malpeli and Martin, 1998.)

An influential body of opinion argues that prohibition of drugs has been ineffective -- the war against drugs has been lost. Knightley (1999) states that drug-taking has now become an established practice in Western culture. It is argued that radical alternatives need to be explored such as drug policies that are consistent with a free society, that is, free will and a free market. The advocates of legalisation argue that referring to prohibited drugs as "controlled substances" is contradictory; in fact, they are now the least controlled substances in the entire economy. Governments have lost control of the distribution and manufacture of these drugs by imposing criminal penalties and pushing these activities underground. Existing drug policies benefit criminals. Law enforcement cannot eliminate the demand for illegal drugs; it only serves to raise the price of drugs, which increases traffickers' profit margins.

Freidman (1972) argues that drug taking is not a criminal matter but a medical matter, and in a free society individuals alone are responsible for their own actions as long as they do not harm others. The role of the government should be to educate

people about the consequences of drug taking, not enforcing criminal restrictions. He also argues that prohibition of drugs is self-defeating and gives an example from history: Alcohol prohibition in the US in the 1920s "undermined respect for the law, corrupted the minions of the law, created a decadent moral climate -- but did not stop alcohol consumption" (Freidman, 1972, p. 104). He questions the underpinnings of current drug policies by asking, "Can any policy, however high-minded, be moral if it leads to widespread corruption, imprisons so many, has so racist effect that it destroys our inner cities, wreaks havoc on misguided and vulnerable individuals and brings death and destruction to foreign countries?" (Freidman, quoted in Knightley, 1999.)

Amongst all illicit drugs, marijuana occupies a unique position (McAllister et al., 1991). It is the most popular illicit drug in Western society, probably in the world; as mentioned previously, something like one third of the adult population have used marijuana. If legalisation of drugs were to be considered, marijuana would probably be at the top of the list. A survey of public opinion on marijuana legalisation in the late 1980s indicated that less than a fifth of Australians favoured legalisation (Sullivan, 1993). However, public opinion seemed to have changed dramatically by the mid 1990s: According to the 1995 Australian National Drug Strategy Household Survey, in all states except Queensland over 40 percent of Australians aged 14 and over supported legalisation.

Interestingly, the Australian Bureau of Criminal Intelligence, a Commonwealth agency, advocates a softening Australia's marijuana laws so that more police resources could be devoted to detecting offences involving hard drugs (ABCI, 1996). While marijuana is now involved in more than 80 percent of drug offences in Australia (Martin, 1998), it is mainly hard-drug users that cause violence and commit theft to support their more expensive habits. The situation in the US is not any different to that in Australia: "Last year [1998] 695,000 people were arrested in America for possessing marijuana. Perhaps ten times that number, nearly 7m, occasionally take a puff. Perhaps only jaywalkers break the law more frequently." (The Economist 1999, p. 92.)

In this paper, we explore economic aspects of marijuana consumption, concentrating in particular on estimating the amount consumed, its interaction with alcohol, its price sensitivity and the likely effects of any legalisation. The structure of the paper is as follows. Section 2 discusses the difficulties in measuring the consumption of illicit drugs. The Cleeland Report (1989), an important early study of drugs in Australia, is reviewed briefly in Section 3. Section 4 deals with the conversion of Australian survey data on the frequency of marijuana consumption into the total quantity consumed; this section also discusses marijuana prices. A comparison of marijuana consumption with that of alcohol, in Section 5, reveals that expenditure on marijuana is roughly equal to that on wine consumption plus spirits, or about three-quarters of beer expenditure. Sections 6 and 7 use several approaches to analyse the price sensitivity of marijuana consumption and its relationship with alcohol. The next three sections employ a specifically-conducted survey of first-year students at The University of Western Australia to estimate the effects of possible legalisation of marijuana -- the effects on consumption of marijuana and on drinking. Concluding comments are contained in the final section.

2. ISSUES IN MEASURING THE CONSUMPTION OF ILLICIT DRUGS

A major difficulty in studying the consumption of illicit goods is one of quality of data. Simply because the activity is illegal usually means that there are no data available from official sources. Information regarding drug seizures or prosecutions for drug offences would obviously be highly imperfect measures of consumption; for example, an intensification of enforcement effort could lead to increased seizures even if consumption remained unchanged. As a result, it is common practice in this area to carry out surveys of consumption. In most countries, surveys on drug usage are the only “substantial and ongoing data gathering tool

available" (Penington Report 1996, p. 10). Although there would seem to be little alternative, this approach is subject to some limitations.

The first problem relates to the illicit nature of the goods in question. Would survey respondents be willing to volunteer accurate information about their participation in an activity that is currently illegal? Even though respondents are usually guaranteed confidentiality, they may still be uncomfortable in revealing their involvement with a criminal act, so that consumption could be understated. The effects of this problem could possibly be minimised by careful design of the questionnaire and by briefing potential respondents appropriately to make it clear that participation is completely voluntary and to reassure them of all issues of confidentiality.

Another concern with consumption surveys is not specific to illicit drugs. Survey respondents are sometimes questioned about their potential behaviour in a situation that has never occurred. For example, we might inquire how alcohol and marijuana consumption would change following the hypothetical legalisation of marijuana and a fall in its price. As Baumol (1968, p. 229) puts it: "People just have not thought out in advance what they would do in these hypothetical situations, and their snap judgements thrown up at the request of the interviewer cannot inspire a great deal of confidence. Even if they attempted to offer honest answers, even if they had thought about their decisions in advance, consumers might well find that when confronted with the harsh realities of the concrete situation, they behave in a manner which belies their own expectations." One way of dealing with this difficulty is to keep the questions in the survey as simple as possible, so that answering them does not require too much thought, effort and introspection. In such a case, the chances of responses being unbiased would have to be higher.

Although the survey approach has its limitations, there is nevertheless some evidence in its favour. Surveys at both the national and international levels on illicit drug consumption indicate a surprisingly high degree of consistency across independent surveys. For example, the 1995 Victorian Drug Household Survey

indicates that 29 percent of Victorians, aged 14 and over, have consumed marijuana, while the 1995 Australian National Household Survey indicates that 31 percent of Victorians, in the same age group, have used it.[1] Similarly, the survey results reported by Sandwijk et al. (1995, referred to in the Penington Report, 1996) indicate that in 1994 27 percent of people 12 years and older have used marijuana in Amsterdam. This agrees well with Dutch results from the Trimbos Institution whose survey indicates that 26 percent of same age group have used marijuana in 1994.[2] This consistency illustrates that the survey approach can yield reliable information on illicit drug usage.

A related area of concern is the price of illicit drugs. There are two issues here, the dispersion of prices and the quality of the product. The illegal nature of the product tends to limit buyer information; advertising, for example, can only be carried out by word of mouth. Consequently, it is likely that there is substantial variability of prices across different sellers at a given point in time. In the case of marijuana, there are several reasons for the dispersion of prices. First, when purchasing larger quantities, e.g. an ounce (28 grams), some dealers sell it in the form of a gross weight. As the bag itself weighs around 4 grams, the consumer pays an ounce price for about 24 grams. On the other hand, some dealers take into the bag weight and sell on a net basis. Second, depending on the season, some dealers sell recently-harvested marijuana, which is still damp. After it is dried, just before it is consumed, marijuana loses about 3 to 4 grams per ounce in weight. Dealers have been known to spray water on marijuana in order to increase its weight and their profit margin. Third, when selling smaller quantities ($25 or $50 purchases), dealers do not use scales, so that the exact quantity of each purchase varies, which, in some cases, depends on the mood of the dealer. Fourth, occasional users tend to pay higher prices than more frequent users. In general, frequent users purchase marijuana in ounces, but occasional users purchase in smaller amounts, e.g., sticks, at a price of $25 (for about

[1] See the Penington Report (1996, p. 17) and National Drug Strategy Household Survey (1995).

[2] Personal communication from The Trimbos Institute, Utrecht, The Netherlands.

.8 grams) or $50 (about 2 grams), which implies per ounce prices of $875 and $700, respectively.

The growing of marijuana has been subject to productivity enhancement by the adoption of hydroponic techniques, which lead to a higher-quality product containing higher THC levels. [3] For example, hydroponically-grown marijuana from northern Tasmania has been analysed as containing 16 percent of THC, while that grown outdoors in the south of the state contained 12.8 percent (Australian Bureau of Criminal Intelligence, 1996). Hydroponically-grown plants use no soil. The hydroponic system manages the plants' growth by creating an optimal climate artificially; it controls the exposure to light, heat and nutrients in order to produce a better product and faster growth. Plants are grown in containers filled with a sterile growing medium -- such as gravel, sand or vermiculite -- and the nutrients, which plants normally absorb from soil, are supplied to the roots through a water-nutrient mixture. The ease of concealment, and near ideal growing conditions which produce good-quality plants, are the main reasons for the shift to hydroponic systems (Australian Bureau of Criminal Intelligence, 1996).[4] The newspaper article in Box 1 reports rapid growth in the number of stores supplying hydroponic activities in the last two years in WA and the situation is probably not too different in other states. Although marijuana grown hydroponically is nominally more expensive than that grown outdoors, this is not necessarily the case when appropriate adjustments are made for its higher quality.

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[3] The content of the main psychoactive chemical *Delta-9-tetrahydrocannabinol* (THC) determines the potency and the quality of marijuana. This is evidenced by the fact that flowers (so-called "heads" or "buds"), which contain more THC than leaves, are considerably more expensive.

[4] According to the Australian Bureau of Criminal Intelligence (1996), "Hydroponic systems are being used to grow cannabis on a relatively large scale. Unlike external plantations, hydroponic cultivation can be used in any region and is not regulated by growing seasons. Both residential and industrial areas are used to establish these indoor sites. Cellars and concealed rooms in existing residential and commercial properties are also used…The use of shipping containers to grow cannabis with hydroponic equipment has been seen in many cases. The containers are sometimes buried on rural properties to reduce chances of detection…Hydroponic cultivation is rare in Queensland and the Northern Territory, where climate and remoteness of the geographic regions enable outdoor crops to be grown relatively easily and undetected."

BOX 1

TECHNICAL PROGRESS IN PLANT PRODUCTION

Suppliers Cash In – But Mum's the Word

WA's hydroponic store owners and suppliers estimate up to 15 percent of their business could come from marijuana growers.

But most surveyed by The West Australian said the industry had been tarnished unfairly by its association with the drug trade and denied they were making a fortune from people chancing their hand at marijuana.

The number of hydroponic stores in WA has doubled in the last two years to nearly 40 shops and there is a modest but expanding industry of about 25 large-scale commercial growers producing everything from cherry tomatoes to orchids.

Store owners and suppliers guessed that anywhere between 5 and 15 percent of sales were for growing marijuana but said there was an unwritten rule that it was never mentioned.

Shaun Reid, who runs The Highlife Company, said: "No one will say that they are doing it because it is an indictable offence. Theoretically, no one grows (hydroponic) marijuana. We get told that they are growing daffodils but you can sometimes assume otherwise."

Mr Reid, who estimated about 10 percent of customers would use the equipment for marijuana growing, said many growers were older smokers scared of dealing with the criminal element.

North Perth's Home Grow Shop manager Lise Bysterveld said that if a customer dropped hints that they were going to use the equipment for marijuana growing, she would try to distance herself from them. "I would say that I do not want to know that," she said.

The industry had enormous potential for commercial vegetable, flower and herb producers, she said.

Canning Vale commercial supplier Aquaponics owner Robert Vanaurich said hydroponics accounted for more than half of the cherry tomatoes grown in WA, up from almost nil 10 years ago.

Source: The West Australian, February 6, 1999, p. 9.

3. THE CLEELAND REPORT

A well-known previous attempt to estimate the consumption of illicit drugs in Australia is contained in the Cleeland Report (1989). In what follows, we set out its approach for marijuana.

To develop their estimates, the Report uses two ingredients, (i) surveys of marijuana usage; and (ii) assumptions about individual usage. Two surveys conducted by Roy Morgan Research in 1988 are used. In the first survey a total of 3,594 people over the age of 14 were interviewed and 6.2 percent indicated that they had used marijuana in the last 12 months. Scaling this up by the relevant population indicates that approximately 780,000 people are marijuana users. In the second survey of 841 people aged 15 to 30 years, 98.5 percent admitted to using marijuana at some stage. The breakdown of the users is as follows:

- 29 percent used marijuana more than once a week;
- 12 percent used once a week;
- 10 percent used once a fortnight;
- 25 percent used once in three months;
- 12 percent used once in six months; and
- 12 percent used once in nine months.

Now comes a key assumption in the Report: It argues that for the purpose of estimating total consumption, only those who use marijuana more than once a week matter. That is, those who consume less frequently than once a week are completely ignored. Accordingly, the Report uses 29 percent of 780,000 marijuana users, or 226,000 consumers, who matter. Next, the Report assumes that these consumers use on average 10 grams (or 0.36 ounces) of cannabis a week, so that annual consumption is estimated to be $(52 \times 10 \times 226{,}000)/1{,}000 = 117{,}520$ kilograms (or 4,197,100 ounces), which the Report rounds up to 120,000 kilograms (or 4,285,700 ounces). At

a street price of $450 an ounce, this represents an expenditure of $1.9 billion p.a. Marks (1992) argues this approach significantly underestimates the number of users. He takes the Report's assumed individual usage figure and scales this up by a more realistic factor to yield estimated expenditure of around $4.1 billion. This represents about 1 percent of GDP in 1988.[5]

4. MARIJUANA CONSUMPTION IN AUSTRALIA, 1988-1995

In this section, we provide estimates of marijuana consumption in Australia for the period 1988-1995. Our starting point is the Australian National Drug Strategy Household Surveys (NDHS) data. These data were collected in the form of self-reported surveys completed by a random sample of the population. To maintain confidentiality, a sealed section of the questionnaire allowed respondents to indicate their usage of drugs without the interviewer being aware of their answers. The NDHS data are given in Table 1 in the form of percentages of people (aged 14 years and over) who consume marijuana, as well as the frequency of consumption. The beginning and ending years in this table are determined by the availability of the NDHS data. A comparison of the NDHS data for 1988 with that used by the Cleeland Report is instructive. According to Table 1, in that year 28 percent of respondents said that they had used marijuana sometime in the past. As discussed in the previous section, in the Cleeland Report survey only 6 percent said that they consumed in the past 12 months. Even allowing for the difference in the wording of two questions ("ever consumed" versus "in the past 12 months"), there seems to be substantial divergence between the two estimates. We are inclined to agree with Marks (1992)

[5] It is of some interest to compare this figure with estimates from the UN World Drug Report (1997, quoted by Access Economics, 1997). This report considers all illicit drugs and estimates that the world turnover is about $US 400 billion in 1994, which is equal to about 1.4 percent of total world output.

TABLE 1

MARIJUANA CONSUMPTION IN AUSTRALIA

(Percentages of respondents)

	1988	1989	1990	1991	1992	1993	1994	1995
Ever used marijuana	28	30	31	33	34	34	35	35
				Frequency of Consumption				
Daily	4	4	5	5	5	5	5	5
Once a week or more	11	11	11	11	10	8	9	9
Once a month or more	7	7	8	8	7	6	7	7
Every few months	11	10	9	8	7	6	6	6
Once or twice year	6	6	7	7	11	14	11	8
Less often	8	7	6	5	6	7	7	6
No longer a user	53	54	55	56	55	54	57	59
Total	100	100	100	100	100	100	100	100

Notes: Respondents are aged 14 and over.

Source: Data for 1988, 1991, 1993 and 1995 are from National Drug Household Surveys, Canberra: Social Science Data Archives, The Australian National University. The intermediate years are estimated by linear interpolation.

that Cleeland underestimated the number of users. On the other hand, if we make some rough adjustments of the frequency of consumption categories to make them comparable, the two data sets seem to be not inconsistent.

Another aspect of Table 1 should also be noted. The number who have ever consumed increases from 28 percent in 1988 to 35 percent in 1995. But this 7 percentage point increase is almost offset by the growth in those who are no longer users; this category rose from 53 percent in 1988 to 59 percent in 1995. These data thus describe a pool of users of roughly the same size (relative to the population), but whose composition is changing with new users constantly replacing the old ones. This would seem to be consistent with elements of experimental drug taking.

Next, we use the data in Table 1, together with the relevant population figures, to estimate the number of users, which are given in Table 2 and Figure 1. These data reveal the following:

- The number of daily and monthly consumers has increased substantially over this period.

- On the other hand, the number of weeklies has grown slowly, while those using every few months have declined.

- The number who consume once or twice a year has almost doubled, from 220,000 to 404,000.

- Those who have ever used marijuana has risen from 3.7 million to 5.1 million, a 38 percent increase. Taking out the “no longer users”, the number of current users increases from $3.7-1.9=1.8$ million to $5.1-3.0=2.1$ million, which represents a more modest increase of 16 percent over the 7 years. By

TABLE 2

ESTIMATED NUMBER OF MARIJUANA USERS AND TOTAL POPULATION

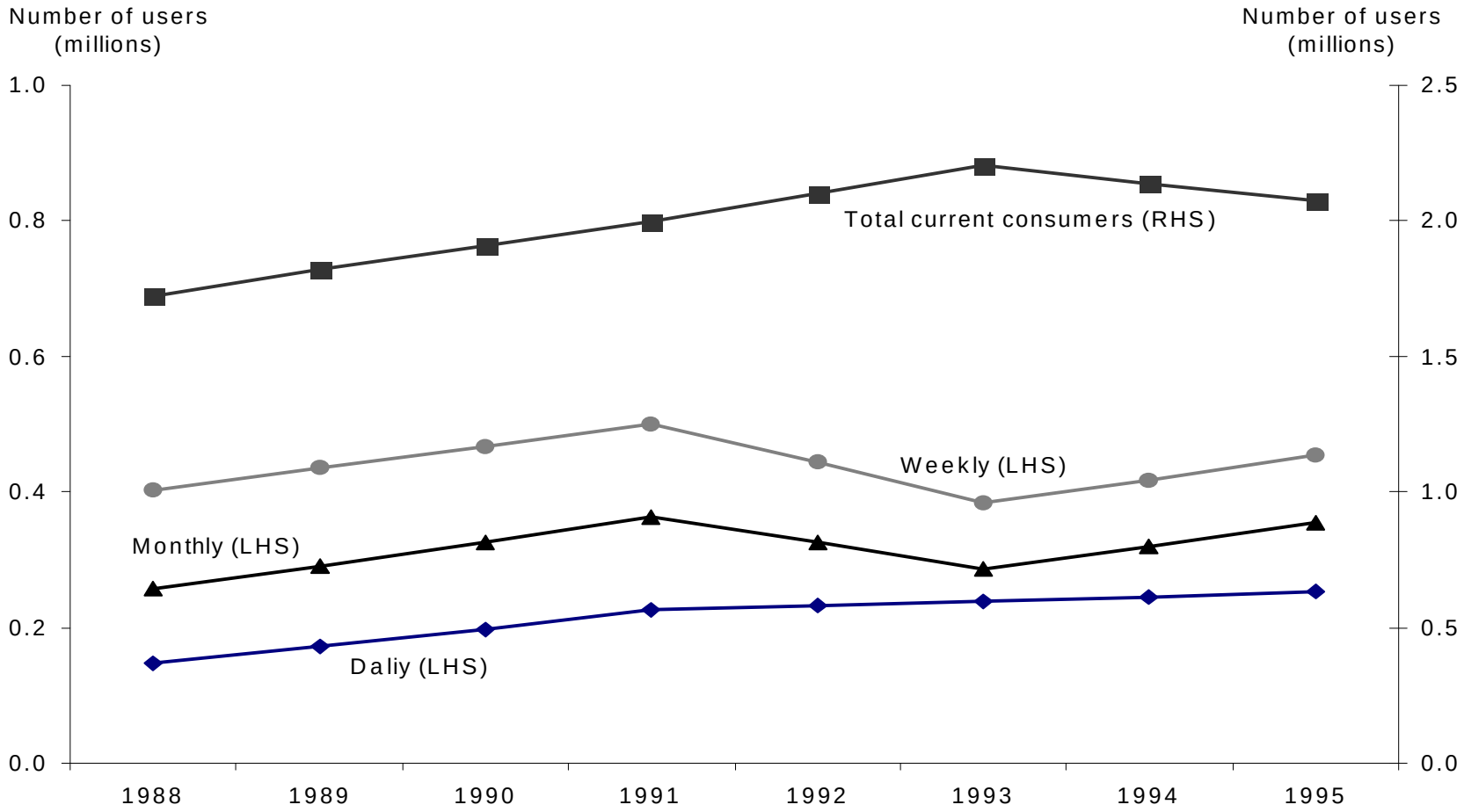
(Thousands of Australians aged 14 and over)

Frequency of consumption	1988	1989	1990	1991	1992	1993	1994	1995
Daily	147	171	198	227	233	239	246	253
Once a week or more	403	435	467	499	443	383	418	455
Once a month or more	256	290	325	363	327	287	319	354
Every few months	403	396	382	363	327	287	295	303
Once or twice year	220	251	283	318	490	670	541	404
Less often	293	277	255	227	280	335	319	303
No longer a user	1,941	2,136	2,334	2,541	2,566	2,585	2,777	2,982
Total	3,663	3,986	4,243	4,537	4,666	4,787	4,948	5,054
Total population	13,082	13,334	13,541	13,748	13,927	14,079	14,244	14,440

Source: Population data are from ABS, Population by Age and Sex, Catalogue No.3201.0.

FIGURE 1

NUMBER OF MARIJUANA USERS, 1988-1995



comparison, the overall population grew by about 10 percent over the same period.[6]

Table 3 presents our "guesstimates" of consumption per user, by frequency of consumption. Unlike the Cleeland Report, we estimate an amount for each type of user group. As can be seen from the table, we make the realistic assumption that the amount consumed by frequent and regular users is considerably more than occasional users. Table 4 combines the information in the previous two tables to give estimated total consumption. Our estimate of total consumption in 1988 is more than 8 million ounces, which is twice that of Cleeland for that year; the main source of the difference is our much larger total number of users, discussed above. The last row of Table 4 gives per capita (14 years and over) consumption. As can be seen, consumption increases from .65 ounces p.a. in 1988 to .78 ounces in 1995.

In calculating expenditure, the price of marijuana is taken to be constant over time at $450 an ounce. There are several pieces of "evidence" that support this approach:

- The Cleeland Report (1989) states that the street price of an ounce of marijuana was $450 in 1988.

- The Illicit Drugs in Australia, Situation Report, produced by the Australian Federal Police (1991), gives a price range of $350 to $800 for 1989 and 1990.

- The Australian Illicit Drug Report by the Australian Bureau of Criminal Intelligence (1996) reports that prices fall in the range of $300 to $700 in 1995.

- The following quotation from an article in The Australian Financial Review (Wyatt, 1997) is not inconsistent with treating the price as a constant at $450: "…according to Marion, a Sydney-based aficionado – who, unlike President Bill Clinton, is known to inhale: 'Last year [1996], marijuana prices fell for the first time since 1980. It's down

[6] This intensification of consumption is consistent with opinion polls regarding the social acceptability of marijuana. As mentioned in Section 1, in the late 1980's, less than a fifth of Australians favoured legalisation (Sullivan, 1993); but by 1995 this had increased to between 40 and 50 percent, depending on the state (NDHS, 1995, 1993).

TABLE 3

ESTIMATED MARIJUANA CONSUMPTION
BY FREQUENCY OF CONSUMPTION

	Consumption per period				
	Weekly	Monthly	Annual		
Frequency of consumption	Grams	Grams	Grams	Kilos	Ounces
Daily	10	43	520	0.520	18.57
Once a week or more	7	30	364	0.364	13.00
Once a month or more	-	4	48	0.048	1.71
Every few months	-	-	3	0.003	0.11
Once or twice year	-	-	1	0.001	0.04
Less often	-	-	1	0.001	0.04
No longer a user	-	-	0	0	0

Note: An ounce is approximately equal to 28 grams, and a kilogram is 1000 grams or 35.7 ounces.

Source: Personal inquiries and guesstimates.

> from $450/ounce to $350/ounce for quality stuff,' she said. Marion's observations are supported by Paul Dillon of the Sydney-based National Drug and Research Centre."

The use of $450/oz has to be qualified as it makes no allowance for improved quality of marijuana over time due to the increased use of hydroponic techniques, discussed in the previous section. Thus, the Cleeland Report price refers to outdoor-grown marijuana, while Wyatt's price is for hydroponic.

TABLE 4

ESTIMATED MARIJUANA CONSUMPTION

Frequency of consumption	1988	1989	1990	1991	1992	1993	1994	1995
				Thousands of ounces				
Daily	2,721	3,183	3,677	4,213	4,333	4,445	4,563	4,693
Once a week or more	5,238	5,657	6,067	6,488	5,762	4,978	5,430	5,913
Once a month or more	440	497	558	622	560	492	548	606
Every few months	43	42	41	39	35	31	32	32
Once or twice year	8	9	10	11	17	24	19	14
Less often	10	10	9	8	10	12	11	11
No longer a user	0	0	0	0	0	0	0	0
Total consumption	8,460	9,398	10,362	11,381	10,717	9,983	10,603	11,271
				Ounces				
Per capita consumption	0.65	0.70	0.77	0.83	0.77	0.71	0.74	0.78

Notes: 1. Totals may not agree due to rounding.

2. Per capita consumption refers to those aged 14 years and over.

Table 5 gives estimated expenditure on marijuana. Our estimate of expenditure in 1988 is $3.8 billion; this is considerably above that of the Cleeland Report, $1.9 billion, but rather close to Marks' estimate of $4.1 billion.

5. COMPARISON WITH ALCOHOL CONSUMPTION

In this section, we present a comparison of the consumption of marijuana with that of three alcoholic beverages, beer, wine and spirits. Details of the source of the alcohol data are given in the Appendix.

The consumption and prices of the three alcoholic beverages and marijuana are presented in Table 6 and Figure 2 plots the consumption data. As can be seen, per capita consumption of beer decreases noticeably over this period, from more than 140 litres in 1988 to just over 120 in 1995. Wine consumption also decreases -- by almost 3 litres to end up 23 litres in 1995. Figure 2 shows that the time paths of these two beverages are both more or less dominated by a continual downward trend. By contrast, spirits consumption is more volatile, first declining substantially, bottoming out in the early 1990s and then more than recovering, to end up in 1995 at 4.1 litres, .1 litres more than consumption in 1988. Marijuana consumption starts off at .65 ounces in 1988, increases steadily until it reaches a peak of .83 ounces in 1991, decreases for the next two years and then increases again in 1994 and 1995 to end up at .78 ounces. This variability in marijuana consumption can be understood in terms of the ingredients of the estimates, as set out in the previous section. There are three interacting factors here, (i) the percentage of people who are current users; (ii) the frequency of consumption; and (iii) the size of the total population. A comparison of the bottom, right-hand panel of Figure 2, which refers to marijuana, with Figure 1, which shows the evolution of the number of users over time, is revealing. As the

TABLE 5

ESTIMATED EXPENDITURE ON MARIJUANA

Frequency of consumption	1988	1989	1990	1991	1992	1993	1994	1995
				Millions of dollars				
Daily	1,225	1,432	1,655	1,896	1,950	2,000	2,053	2,112
Once a week or more	2,357	2,545	2,730	2,919	2,593	2,240	2,444	2,661
Once a month or more	198	224	251	280	252	222	246	273
Every few months	19	19	18	17	16	14	14	15
Once or twice year	4	4	5	5	8	11	9	6
Less often	5	4	4	4	4	5	5	5
No longer a user	0	0	0	0	0	0	0	0
Total expenditure	3,807	4,229	4,663	5,121	4,823	4,492	4,772	5,072
				Dollars				
Per capita expenditure	291	317	344	373	346	319	335	351

Notes: 1. In calculating expenditures, the price of marijuana is taken to be constant over time at $450 an ounce.

2. Per capita consumption refers to those aged 14 years and over.

TABLE 6

QUANTITIES CONSUMED AND PRICES OF
ALCOHOLIC BEVERAGES AND MARIJUANA

Year	Beer	Wine	Spirits	Marijuana
		Quantities		
1988	141.4	25.82	3.993	.6467
1989	141.6	24.32	4.048	.7049
1990	139.9	22.85	3.870	.7652
1991	134.9	23.01	3.614	.8278
1992	127.8	23.23	3.595	.7695
1993	123.8	23.14	3.982	.7090
1994	122.1	23.19	4.168	.7444
1995	120.2	22.96	4.130	.7805
Mean	131.4	23.56	3.925	.7435
		Prices		
1988	2.819	6.190	30.578	450
1989	2.928	6.607	33.315	450
1990	3.116	6.801	36.601	450
1991	3.271	6.883	39.064	450
1992	3.361	7.056	40.532	450
1993	3.478	7.271	41.847	450
1994	3.583	7.597	43.044	450
1995	3.724	7.983	44.254	450
Mean	3.285	7.049	38.654	450

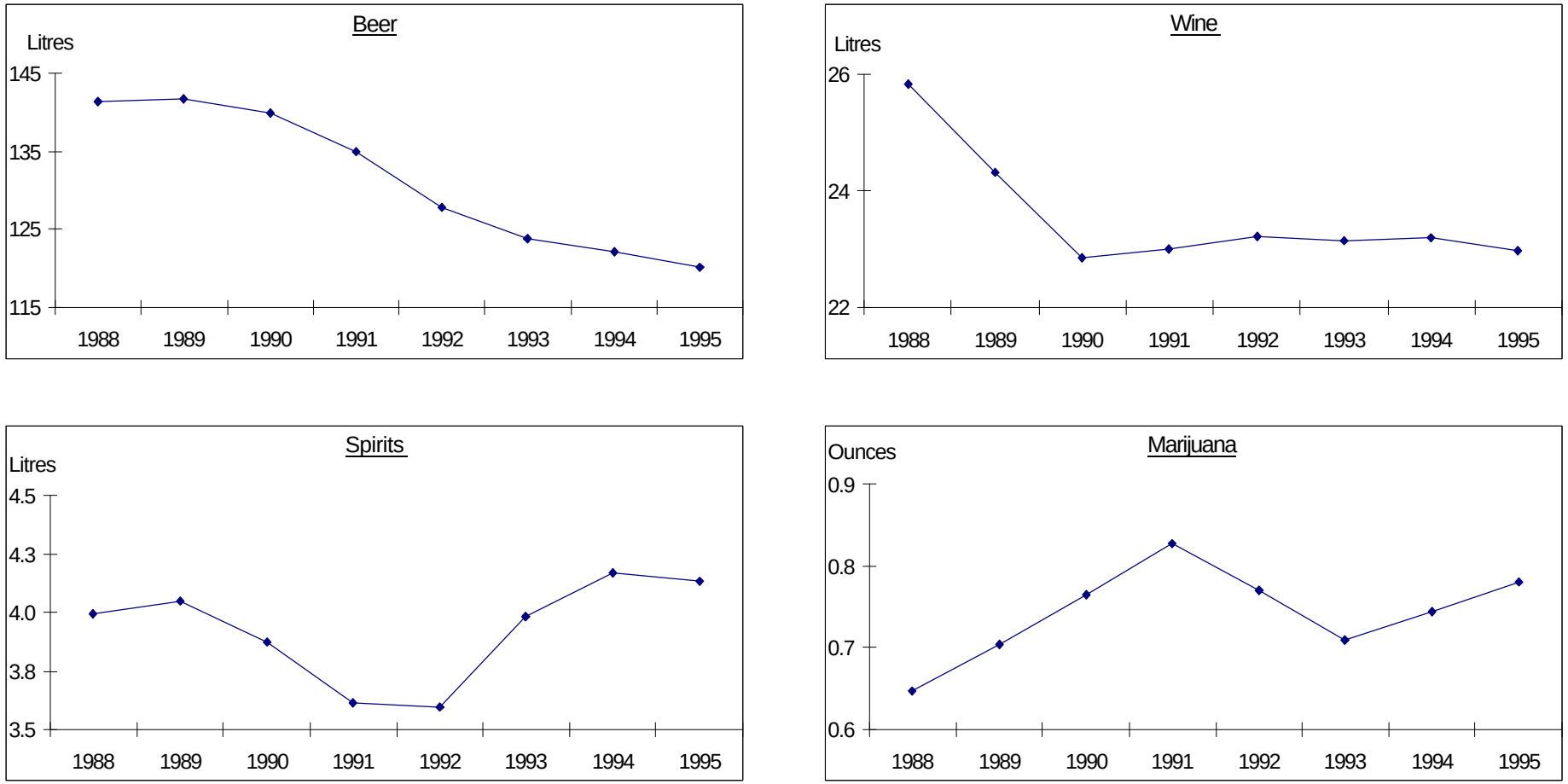
Notes: 1. Quantities are per capita (14 years and over).

2. Quantities consumed of the alcoholic beverages are in terms of litres; and that of marijuana is in ounces.

3. Prices are in dollars per litre for the alcoholic beverages and per ounce for marijuana.

FIGURE 2

QUANTITIES CONSUMED



number of daily users increases monotonically, this cannot explain the variability of total consumption. It is the weekly and monthly consumers that both increase up to 1991, then fall and then rise again -- qualitatively, they have exactly the same time paths as does total consumption. These two groups are sufficiently numerous, and consume sufficient marijuana, to offset the movements in the consumption of all other groups. This conclusion is corroborated by the consumption-by-group data given in Table 4.

Table 7 combines the quantity and price data and presents expenditures on, and budget shares of, the four goods. The budget share is expenditure on the good in question expressed as a fraction of total expenditure on the four goods. Several interesting features emerge from Table 7:

- Marijuana absorbs about 30 percent of expenditure on the four goods.

- Expenditure on marijuana is roughly equal to that on wine plus spirits; and it is about three-quarters of beer expenditure.

- The budget share of wine falls over this period, while that of spirits rises, and by 1995 these two shares are roughly equal.

- The budget share of beer falls by more than 2.5 percentage points, to end up at 38.4 percent in 1995.

Table 8 gives the quantity and price data in terms of log-changes. The upper panel of the table shows that, on average, beer consumption decreases by 2.3 percent p.a., wine decreases by 1.7 percent, spirits increases by .5 percent and marijuana increases by 2.7 percent. Figure 3 shows that the growth in consumption of both spirits and marijuana exhibit considerable volatility. For example, while spirits consumption grows at a mean rate of .5 percent p.a., in 1993 consumption of this beverage increases by more than 10 percent; and in the same year, marijuana declines by more than 8 percent, while its average growth rate is 2.7 percent.

TABLE 7

EXPENDITURES ON AND BUDGET SHARES OF
ALCOHOLIC BEVERAGES AND MARIJUANA

Year	Beer	Wine	Spirits	Marijuana	Total
			Expenditures		
1988	398.41	159.84	122.10	291.02	971.37
1989	414.80	160.70	134.87	317.19	1,027.56
1990	435.91	155.39	141.67	344.36	1,077.32
1991	441.49	158.52	140.76	372.52	1,113.29
1992	429.43	163.93	145.70	346.27	1,085.32
1993	430.66	168.24	166.62	319.06	1,084.58
1994	437.49	176.17	179.40	334.98	1,128.03
1995	447.64	183.32	182.77	351.23	1,164.95
Mean	429.44	165.74	151.79	334.58	1,081.55
			Budget Shares		
1988	41.01	16.46	12.57	29.96	100
1989	40.37	15.64	13.13	30.87	100
1990	40.46	14.42	13.15	31.96	100
1991	39.63	14.22	12.68	33.46	100
1992	39.57	15.10	13.42	31.90	100
1993	39.71	15.51	15.36	29.42	100
1994	38.78	15.62	15.90	29.70	100
1995	38.43	15.74	15.69	30.15	100
Mean	39.74	15.34	13.99	30.93	100

Notes: 1. Expenditures are in terms of dollars per capita (14 years and over).

2. Budget shares are in percentages.

TABLE 8

LOG-CHANGES IN QUANTITIES CONSUMED AND PRICES
OF ALCOHOLIC BEVERAGES AND MARIJUANA

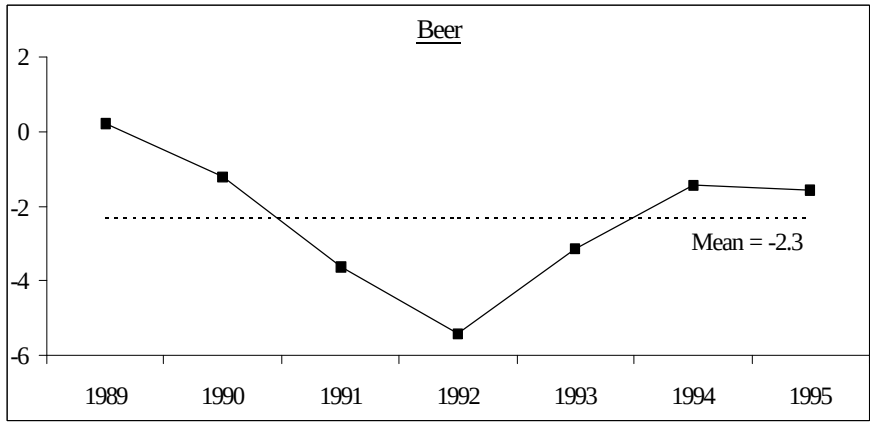
Year	Beer	Wine	Spirits	Marijuana
		Quantities		
1989	.21	-5.98	1.38	8.61
1990	-1.23	-6.26	-4.49	8.22
1991	-3.65	.70	-6.85	7.86
1992	-5.43	.97	-.55	-7.31
1993	-3.13	-.40	10.23	-8.18
1994	-1.42	.22	4.57	4.87
1995	-1.55	-.97	-.91	4.74
Mean	-2.32	-1.67	.48	2.69
		Prices		
1989	3.83	6.51	8.57	0
1990	6.20	2.90	9.41	0
1991	4.86	1.19	6.51	0
1992	2.72	2.49	3.69	0
1993	3.41	3.00	3.19	0
1994	3.00	4.38	2.82	0
1995	3.85	4.95	2.77	0
Mean	3.98	3.63	5.28	0

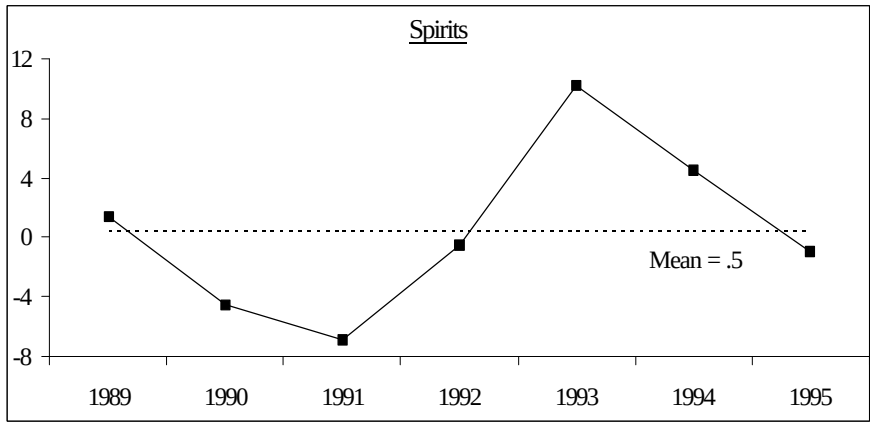
Note: All entries are to be divided by 100.

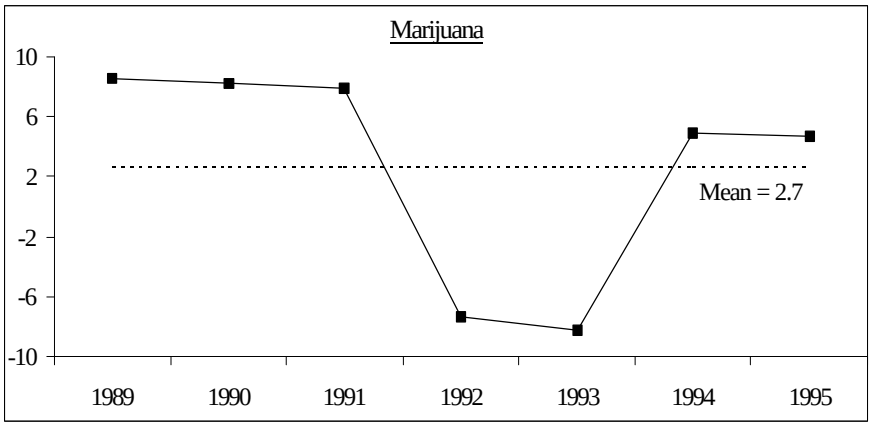
FIGURE 3

QUANTITY LOG-CHANGES

(×100)







6. THE PRICE SENSITIVITY OF CONSUMPTION, PART I: PRELIMINARY EXPLORATIONS

What is the price elasticity of demand for marijuana? By how much would usage rise if marijuana were legalised? How does its consumption interact with that of alcohol? With only eight years of data it should be acknowledged that it is not possible to answer these questions definitely. Nevertheless, it is still possible to make progress and shed some light on these important issues. In this section, we carry out a preliminary analysis of the price sensitivity of consumption; a more formal approach is used in the next section. As alcohol and marijuana share some common characteristics, we shall analyse their consumption jointly.

As a way of summarising the data, we start with price and volume indexes of the alcoholic beverages and marijuana. Let p_{it} be the price of good i in year t and q_{it} be the corresponding quantity consumed per capita. Then, if there are n goods, $M_t = \sum_{i=1}^{n} p_{it} q_{it}$ is total expenditure and $w_{it} = p_{it} q_{it} / M_t$ is the proportion of this total devoted to good i, or the budget share of i. Let $\overline{w}_{it} = \frac{1}{2}\left(w_{it} + w_{i,t-1}\right)$ be the arithmetic average of the budget share over the years $t-1$ and t; and $Dp_{it} = \log p_{it} - \log p_{i,t-1}$ and $Dq_{it} = \log q_{it} - \log q_{i,t-1}$ be the i^{th} price and quantity log-changes. The Divisia price and volume indexes are then defined as

$$(6.1) \qquad DP_t = \sum_{i=1}^{n} \overline{w}_{it} Dp_{it} \ , \qquad DQ_t = \sum_{i=1}^{n} \overline{w}_{it} Dq_{it} \ .$$

The Divisia price index is a budget-share-weighted average of the n price log-changes and thus represents a centre-of-gravity measure of the prices. This index also has a statistical interpretation (Theil, 1967, p. 136): Suppose we draw prices at random such that each dollar of expenditure has an equal chance of being selected.

Then, the budget share $\overline{w}_{it}$ is the probability of drawing Dp_{it} for the transition from year $t-1$ to t, so that the expected value of the prices is $\sum_{i=1}^{n}\overline{w}_{it}Dp_{it}$, the Divisia index. The Divisia volume index has a similar interpretation and measures the overall growth in per capita consumption.

The upper parts of columns 2 and 3 of Table 9 contain DP_t and DQ_t for the three alcoholic beverages plus marijuana (so that $n=4$), while the corresponding lower parts give the indexes for alcohol by itself ($n=3$). For the four goods, on average the price index rises by about 2.9 percent p.a., while the volume index falls by .3 percent p.a. The relationship between the four- and three-good indexes can be illustrated as follows. Write $\overline{W}_{At}=\sum_{i=1}^{3}\overline{w}_{it}$ for the budget share of alcohol as a whole, $DP_{At}=\sum_{i=1}^{3}\left(\overline{w}_{it}/\overline{W}_{At}\right)Dp_{it}$ for the price index of alcoholic beverages and $DP_{AM,t}=\sum_{i=1}^{4}\overline{w}_{it}Dp_{it}$ for the index of alcohol and marijuana prices. Then we have

$$DP_{AM,t}=\overline{W}_{At}\,DP_{At}+\left(1-\overline{W}_{At}\right)DP_{Mt},$$

where $DP_{Mt}=Dp_{4t}$ is the change in the price of marijuana. Accordingly, the price of alcohol and marijuana as a group is simply a budget-share-weighted average of the price of alcohol and that of marijuana. As the price of marijuana is constant, $DP_{Mt}=0$, so that the above equation becomes

$$DP_{AM,t}=\overline{W}_{At}\,DP_{At}\,.$$

From Table 7, the mean value of the budget share of marijuana is 31 percent, so that the alcohol share $\overline{W}_{A}$ is 69 percent, on average. Accordingly, the price index of alcohol and marijuana is about 69 percent of that of alcohol by itself.

TABLE 9

DIVISIA MOMENTS

Year	Price index (×100)	Quantity index (×100)	Price variance ($\times 10^4$)	Quantity variance ($\times 10^4$)	Price-quantity covariance ($\times 10^4$)	Price-quantity correlation
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			A. Alcoholic Beverages and Marijuana			
1989	3.70	1.92	8.49	24.87	-11.53	-.79
1990	4.18	.55	10.97	30.06	-13.67	-.75
1991	2.96	.33	6.39	31.57	-13.71	-.97
1992	1.92	-4.47	1.92	9.34	2.84	.67
1993	2.27	-2.34	2.30	34.02	5.60	.63
1994	2.30	1.63	2.47	7.42	-3.25	-.71
1995	2.70	.52	3.49	7.65	-4.87	-.94
Mean	2.86	-.27	5.15	20.85	-5.51	-.41
			B. Alcoholic Beverages			
1989	5.32	-1.00	3.59	7.62	-1.00	-.19
1990	6.09	-2.96	4.35	4.59	1.44	.30
1991	4.40	-3.34	3.17	5.89	-4.27	-.99
1992	2.86	-3.09	.17	8.05	.27	.23
1993	3.28	.24	.03	27.26	-.40	-.45
1994	3.26	.27	.36	5.70	-.18	-.13
1995	3.85	-1.28	.53	.09	-.01	-.06
Mean	4.15	-1.59	1.74	8.46	-.59	-.18

The indexes defined in equation (6.1) represent weighted first-order moments of the n prices $Dp_{1t},...,Dp_{nt}$ and the n quantities $Dq_{1t},...,Dq_{nt}$. The corresponding second-order moments are the Divisia variances:

$$(6.2) \qquad \Pi_t = \sum_{i=1}^{n} \overline{w}_{it}\left(Dp_{it} - DP_t\right)^2 , \qquad K_t = \sum_{i=1}^{n} \overline{w}_{it}\left(Dq_{it} - DQ_t\right)^2 .$$

These variances measure the dispersion across commodities of the prices and quantities. Columns 4 and 5 of Table 9 give (6.2) for $n = 4$ and $n = 3$. These show that (i) for a given year there is more dispersion in quantities than prices; and (ii) including marijuana has the effect of increasing both variances.

Finally, the Divisia price-quantity covariance is

$$\Gamma_t = \sum_{i=1}^{n} \overline{w}_{it}\left(Dp_{it} - DP_t\right)\left(Dq_{it} - DQ_t\right).$$

Given the tendency of consumers to move away from those goods whose relative prices increase, we expect Γ_t to be negative. This covariance is given in column 6 of Table 9 and, as can be seen, in 5 out of 7 cases (for both $n = 4$ and $n = 3$) it is negative. Column 7 gives the corresponding correlation, $\rho_t = \Gamma_t \big/ \sqrt{\Pi_t K_t}$. When marijuana is included, the mean value of ρ is -.4, which indicates a reasonable degree of strength in the relationship between consumption and prices. However, when marijuana is excluded, this mean falls by one half to -.2, so the relationship is much weaker.

As Dp_{it} is the change in the nominal price of the i^{th} good and DP_t is an index of the change in the prices of all goods (namely, alcoholic beverages and marijuana), $Dp_{it} - DP_t$ is interpreted as the change in the relative price of i. Similarly, as $Dq_{it} - DQ_t$ is the change in the quantity consumed of i relative to the average, this can also be termed the change in the relative quantity of i. Table 10 gives these

TABLE 10

RELATIVE QUANTITIES AND PRICES OF
ALCOHOLIC BEVERAGES AND MARIJUANA

Year	Beer	Wine	Spirits	Marijuana
		Quantities		
1989	-1.71	-7.90	-.55	6.69
1990	-1.79	-6.81	-5.04	7.67
1991	-3.97	.37	-7.17	7.54
1992	-.96	5.44	3.92	-2.84
1993	-.79	1.93	12.57	-5.85
1994	-3.05	-1.41	2.94	3.24
1995	-2.07	-1.49	-1.43	4.21
Mean	-2.05	-1.41	.75	2.95
		Prices		
1989	.12	2.81	4.87	-3.70
1990	2.02	-1.28	5.23	-4.18
1991	1.90	-1.77	3.56	-2.96
1992	.80	.57	1.76	-1.92
1993	1.14	.73	.92	-2.27
1994	.70	2.08	.52	-2.30
1995	1.15	2.25	.07	-2.70
Mean	1.12	.77	2.42	-2.86

Note: All entries are to be divided by 100.

relative price and quantity changes. The means ($\times 100$) are:

	Quantities	Prices
Beer	-2.1	1.1
Wine	-1.4	.8
Spirits	.8	2.4
Marijuana	3.0	-2.9

As in three out of the four cases the quantity change has the opposite sign to the price change, we see again that there is a tendency for consumption of those goods whose relative prices rise to grow slower than average, and vice versa.

To explore further the relationship between the quantities and prices, Figure 4 plots each $Dq_{it} - DQ_t$ against $Dp_{it} - DP_t$ and the solid line is the least-squares regression line. Panel A gives the results when there is an intercept included in each regression equation, which, as the variables are all formulated in terms of change over time, represents a residual trend. The slope of the regression line is interpreted as the price elasticity of demand.[7] As the intercepts do not have a well-defined economic interpretation and as three of the four estimates are insignificantly different from zero at the 5 percent level, in Panel B of the figure they are suppressed. As shown in the figure, the estimated price elasticities in the two cases are:

	With intercepts	Without intercepts
Beer	-.6	-1.5
Wine	-.4	-.7
Spirits	-1.8	-.5
Marijuana	-5.0	-1.3

[7] Under the assumption that the income elasticity is unity. We will come back to this in the next section.

FIGURE 4

RELATIVE QUANTITIES AND RELATIVE PRICES

A. With Intercepts

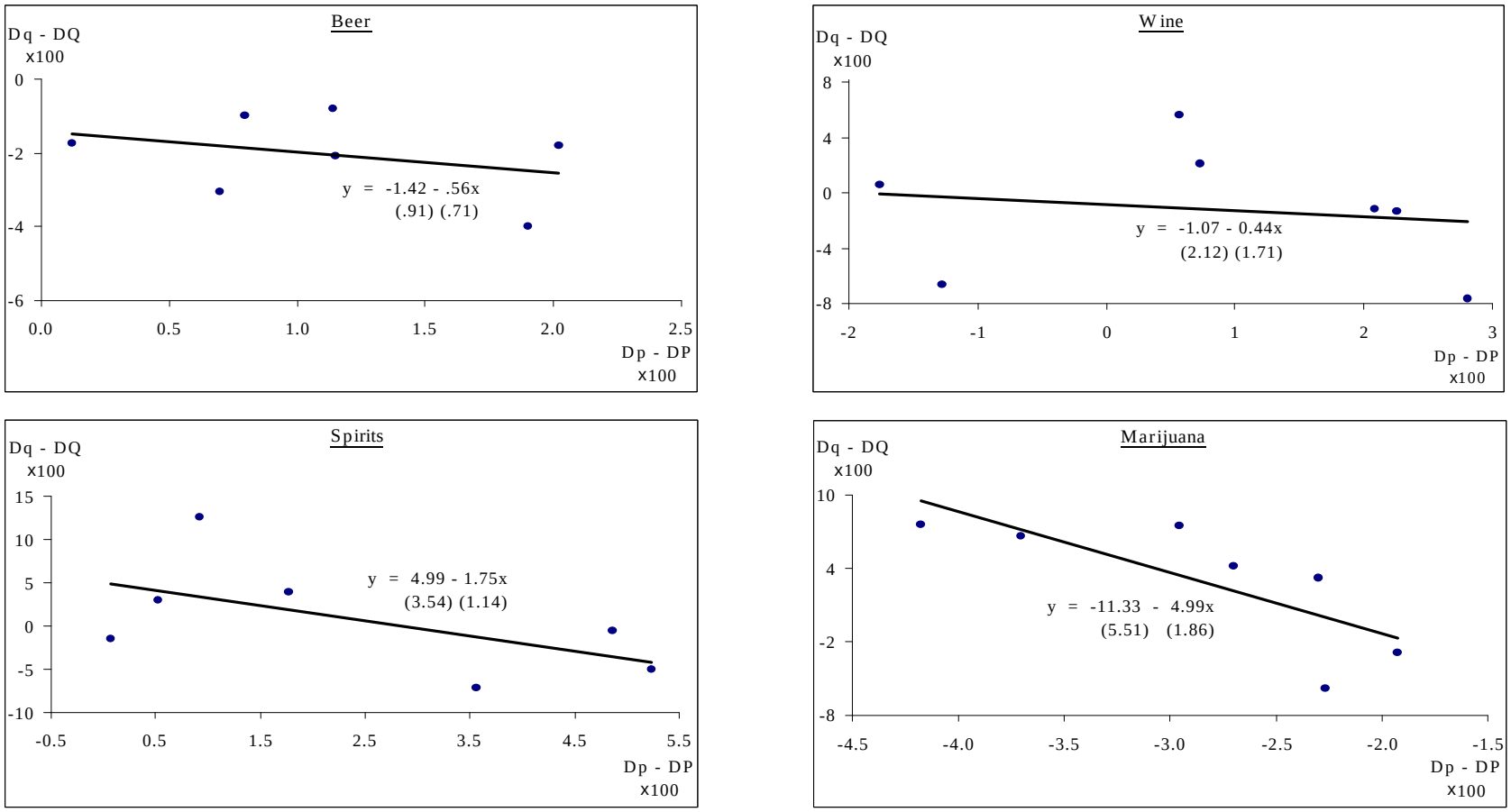


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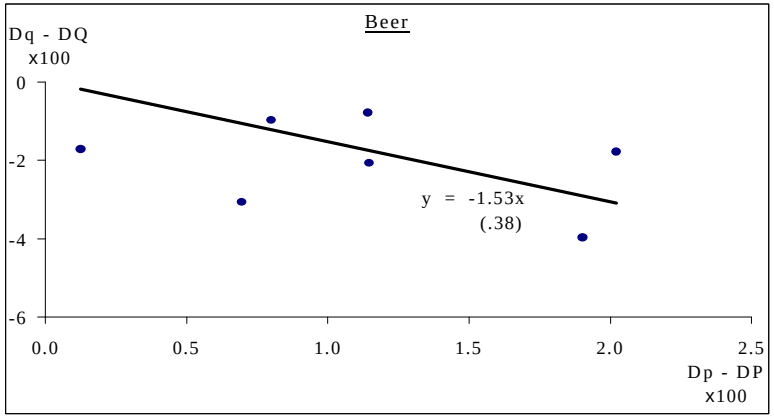
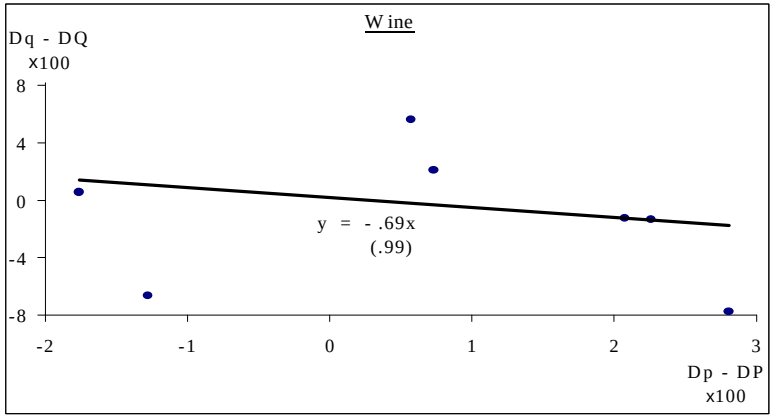
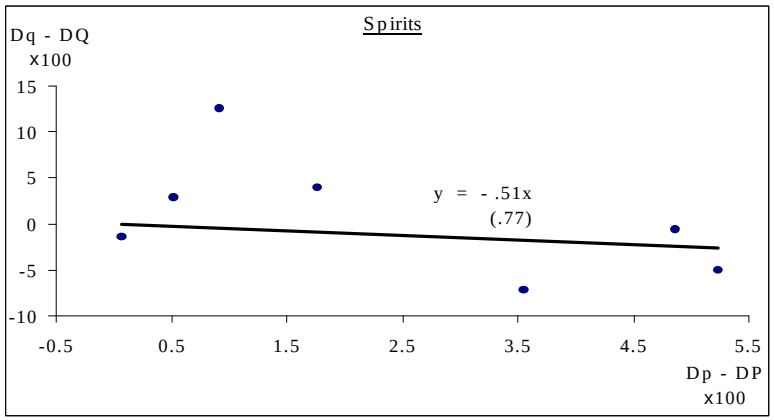
FIGURE 4 (continued)

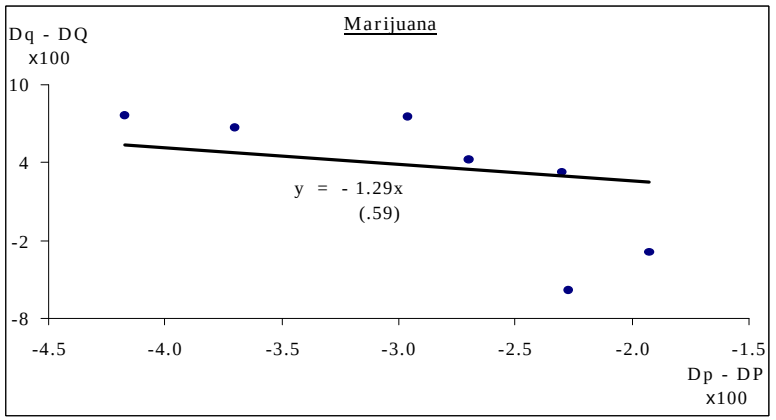
RELATIVE QUANTITIES AND RELATIVE PRICES

B. Without Intercepts









Note: Standard errors are given in parentheses.

Neither set of elasticities is wholly satisfactory. With the intercepts included, the beer and wine elasticities have reasonable magnitudes and agree with prior estimates.[8] On the other hand, the spirits and marijuana elasticities of -1.8 and -5.0 both seem too large (in absolute value). Turning to the case where the intercepts are suppressed, the marijuana elasticity is now more reasonable at -1.3, as is that for spirits. However, the elasticity of beer is now on the high side at -1.5. In the view of the relatively large standard errors given in Figure 4, it should be noted that few of the elasticities, in both cases, are estimated precisely; in large part, this is most likely due to the small sample size. Accordingly, not too much weight should be placed on these estimates.

To conclude this section, we use an alternative way of measuring the degree of interrelationship between the consumption of the four goods. Consider, for example, the consumption of beer and marijuana. Suppose that total consumption of the four goods is held constant, and that for some reason or another beer is subject to a random shock causing its consumption to increase. If at the same time marijuana consumption falls, then, as more of one good compensates for less of the other, it would seem that both goods are capable of satisfying the same type of want of the consumer. In such a case, as these goods are competitive, it would be reasonable to describe beer and marijuana as being substitutes for one another. By a similar argument, goods whose consumption is positively correlated reinforce each other and can be described as complements.[9]

We implement the above idea by computing the correlation coefficients between the relative quantity change in good i, $Dq_{it} - DQ_t$, and that of good j, $Dq_{jt} - DQ_t$. The results, presented in Table 11, indicate that the three alcoholic beverages are all negatively correlated with marijuana and are thus substitutes. Interestingly, for each of the beer, wine and spirits rows, the largest (in absolute

[8] Tu and Ye (1999), using the survey published by Edwards et al. (1994) of more than 40 studies, report the following average price elasticities: Beer -.4, wine -.8 and spirits -.7.

[9] This approach to substitutability/complementarity based on a residual correlations has a long history, going back to Allen and Bowley (1935).

TABLE 11

RELATIVE QUANTITY CORRELATION COEFFICIENTS

Good	Beer	Wine	Spirits	Marijuana
Beer	1.0	.15	.66	-.67
Wine		1.0	.47	-.74
Spirits			1.0	-.92
Marijuana				1.0

value) off-diagonal correlation always involves marijuana; these correlations are beer-marijuana -.7, wine-marijuana -.7 and spirits-marijuana -.9. This finding indicates that there is some strength in the substitutability relationship between alcohol and marijuana. Note also that the three within-alcohol correlations are positive, indicating complementarity. While this sort of behaviour cannot be ruled out, as these correlations are all lower than the others, possibly less weight should be given to this finding.

7. THE PRICE SENSITIVITY OF CONSUMPTION, PART II: A DEMAND SYSTEM

In this section we analyse more formally the price sensitivity of consumption of marijuana, and its interrelation with alcohol, by using a system of demand equations.

The demand system we use is the Rotterdam model due to Barten (1964) and Theil (1965). We choose this model because of its straightforward nature and because it is widely used. The i^{th} equation of this model takes the form

$$\overline{w}_{it} Dq_{it} = \theta_i \, DQ_t + \sum_{j=1}^{n} \pi_{ij} Dp_{jt} + \varepsilon_{it}, \tag{7.1}$$

where $\theta_i = \partial(p_i q_i)/\partial M$ is the marginal share of good i; π_{ij} is the $(i, j)^{th}$ Slutsky coefficient; ε_{it} is a disturbance term; and the other notation is as before. The marginal share θ_i answers the question, When total expenditure increases by \$1, what fraction of this is spent on good i? As total expenditure is allocated to the n goods, it follows that $\sum_{i=1}^{n} \theta_i = 1$. The Slutsky coefficients deal with the substitution effects of a price change and satisfy demand homogeneity, $\sum_{j=1}^{n} \pi_{ij} = 0$ (i = 1,…, n), and symmetry, $\pi_{ij} = \pi_{ji}$ (i, j = 1,…, n). By dividing both sides of (7.1) by $\overline{w}_{it}$, it can be seen that $\theta_i / \overline{w}_{it}$ is the i^{th} income elasticity and $\pi_{ij} / \overline{w}_{it}$ is the $(i, j)^{th}$ price elasticity. As we shall apply (7.1) for i = 1,…, n to a group of goods (alcohol and marijuana), it is to be interpreted as a conditional demand system, which holds constant real total expenditure on the group. The analysis of demand within the group, independent of the consumption of other goods, is valid under the conditions of separability, whereby consumption of the group of goods forms an independent block in the consumer's utility function.[10]

To economise on the number of unknown parameters that have to be estimated, we make the simplifying assumption that tastes with respect to alcohol and marijuana can be characterised by a utility function of the preference independent form. This means that the utility function is the sum of n sub-utility functions, one for each good, $u(q_1,...,q_n) = \sum_{i=1}^{n} u_i(q_i)$. Preference independence (PI) means that the marginal utility of each good is independent of the consumption of all others. The implications of PI are that all income elasticities are positive and all pairs of goods are Slutsky substitutes. The hypothesis of PI has been recently tested with alcohol data

[10] For details, see, e.g., Clements (1987).

for seven countries by Clements et al. (1997) and, using a variety of tests, they find that the hypothesis cannot be rejected.[11]

Under preference independence, the Slutsky coefficients in equation (7.1) take the form (see, e.g., Clements et al., 1995)

$$\pi_{ij} = \phi\theta_i(\delta_{ij} - \theta_j), \tag{7.2}$$

where ϕ is the own-price elasticity of demand for the group of goods as a whole; and δ_{ij} is the Kronecker delta ($\delta_{ij} = 1$ if $i = j$, 0 otherwise). Accordingly, the term involving prices in equation (7.1) becomes $\sum_{j=1}^{n}\pi_{ij}\,Dp_{jt} = \phi\theta_i\left(Dp_{it} - DP'_t\right)$, where $DP'_t = \sum_{i=1}^{n}\theta_i\,Dp_{it}$ is a marginal-share-weighted average of the prices, known as the Frisch price index. Equation (7.1) thus simplifies to

$$\overline{w}_{it}Dq_{it} = \theta_i\,DQ_t + \phi\theta_i\left(Dp_{it} - DP'_t\right) + \varepsilon_{it}. \tag{7.3}$$

This equation for i=1,…n is the Rotterdan model under PI. The disturbances ε_{it} are assumed to have zero means and, again to economise on unknown parameters, have variances and covariances of the form

$$\mathrm{cov}(\varepsilon_{it}, \varepsilon_{jt}) = \sigma^2\,\overline{w}_i(\delta_{ij} - \overline{w}_j), \tag{7.4}$$

where σ^2 is a constant; and $\overline{w}_i$ is the sample mean of $\overline{w}_{it}$. This specification, which has been advocated by S. Selvanathan (1991) and Theil (1987), implies that (i) the variances of the disturbances increase with the corresponding budget shares (for $\overline{w}_i < .5$); and (ii) the covariances between disturbances in different equations are all negative. These are plausible implications.[12]

---

[11] Earlier studies tended to reject PI (see Barten, 1977, for a survey), but it is now understood that the source of many of these rejections was the use of asymptotic tests, which were biased against the null. See S. Selvanathan (1987, 1993).

[12] Covariance structure (7.4) corresponds to sampling from a multinomial distribution with probabilities equal to budget shares.

Before applying (7.3) to the alcohol and marijuana data, we make one further simplification. Rather than attempting to estimate the marginal shares, we shall specify their values. Recalling that the income elasticity is the ratio of the marginal share to the corresponding budget share, we can proceed by considering the values of the income elasticities and the budget shares. Columns 3-5 of Table 12 present some recent estimates of income elasticities for alcohol and we use them as a broad guide in Table 13. In column 2 of this table, beer is taken to have an income elasticity of .5 (so that it is necessity), wine 1.0 (a borderline case) and spirits 2.0 (a strong luxury); we will come back to the elasticity for marijuana. Column 3 gives the four budget shares, which approximate the sample means, while column 4 presents the implied marginal shares, computed as $\theta_i = \eta_i \times w_i$. As the marginal shares have a unit sum, the θ_i for marijuana can be obtained from the other three. Once we have the marginal and budget shares for marijuana, we then obtain its income elasticity of 1.2, which implies that it is a modest luxury.

As θ_i is now known, we write (7.3) as $y_{it} = \phi\, x_{it} + \varepsilon_{it}$, where $y_{it} = \overline{w}_{it}\, Dq_{it} - \theta_i\, DQ_t$ and $x_{it} = \theta_i \left(Dp_{it} - DP'_t\right)$. Since $\sum_{i=1}^{n} \varepsilon_{it} = 0$, one equation is redundant and we write the above for $i = 1,...,n-1$ as $\mathbf{y_t} = \phi\, \mathbf{x_t} + \boldsymbol{\varepsilon_t}$, where $\mathbf{y_t}$, $\mathbf{x_t}$ and $\boldsymbol{\varepsilon_t}$ are all vectors containing the corresponding $n-1$ elements. We estimate the one unknown parameter ϕ by generalised-least squares, i.e., by minimising the sum over $t = 1,...,T$ observations of the quadratic form $(\mathbf{y_t} - \phi \mathbf{x_t})' \sum^{-1} (\mathbf{y_t} - \phi \mathbf{x_t})$, where $\sum$ is the covariance matrix defined by equation (7.4) for $i, j = 1,...,n-1$, namely, $\sigma^2 \left(\overline{\mathbf{W}} - \overline{\mathbf{w}}\, \overline{\mathbf{w}}'\right)$, where $\overline{\mathbf{W}} = \text{diag}\,[\overline{\mathbf{w}}]$ and $\overline{\mathbf{w}} = [\overline{w}_1,...,\overline{w}_{n-1}]'$. It can be shown (Theil, 1987, p. 126) that this amounts to minimising $\sum_{t=1}^{T} \sum_{i=1}^{n} (y_{it} - \phi\, x_{it})^2 \big/ \overline{w}_i$.

The alcohol and marijuana data, as set out in Section 5, yield the following GLS estimate of ϕ:

(7.5) $$\hat{\phi} = -.639\ (.272),$$

TABLE 12

DEMAND ELASTICITIES FOR ALCOHOLIC BEVERAGES

Country (1)	Sample period (2)	Income elasticities			Price elasticity of alcohol as a whole (6)
		Beer (3)	Wine (4)	Spirits (5)	
Australia	1955-85	.81	1.00	1.83	-.50
Canada	1953-82	.74	1.05	1.25	-.42
Finland	1970-83	.45	1.32	1.32	-1.35
New Zealand	1965-82	.84	.88	1.45	-.44
Norway	1960-86	.34	1.48	1.55	-.08
Sweden	1967-84	.21	.69	1.52	-1.43
United Kingdom	1955-85	.82	1.06	1.34	-.54
Mean		.60	1.07	1.47	-.68

Source: Clements et al. (1997).

where the standard error is given in parenthesis. This estimate of the price elasticity of demand for alcohol and marijuana as a whole is more than two standard errors away from zero. In comparison with the prior estimates of this elasticity for alcohol by itself, given in column 6 of Table 12, this estimate seems to be reasonable.

We can now construct the price elasticities. To compute the Slutsky coefficients π_{ij}, we use in (7.2) the estimate of ϕ given in equation (7.5) and the values of the four marginal shares given in column 4 of Table 13. As the $(i, j)^{th}$ price elasticity takes the form $\pi_{ij}/\overline{w}_{it}$, we use the sample means of the budget shares given

TABLE 13

INCOME ELASTICITIES, BUDGET SHARES

AND MARGINAL SHARES

Good	Income elasticity η_i	Budget share w_i	Marginal share θ_i
(1)	(2)	(3)	(4)
Beer	.5	.40	.20
Wine	1.0	.15	.15
Spirits	2.0	.15	.30
Marijuana	1.2	.30	.35
Sum		1.00	1.00

in column 3 of Table 13 to convert the Slutsky coefficients into elasticities and the top panel of Table 14 contains the results. The own-price elasticity of beer is -.3, wine -.5, spirits -.9 and marijuana -.5. In comparison with previous studies,[13] the values of the three alcohol elasticities are reasonable. The only prior estimate of the price elasticity of demand for marijuana is provided by Nisbet and Vakil (1972) who, using US data, find it to lie in the range -.5 to –1.5. Our estimate lies at the lower end of this range. Interestingly, for each alcoholic beverage, the largest cross-price elasticity is for the price of marijuana:

Beer with respect to the price of marijuana .1
Wine with respect to the price of marijuana .2
Spirits with respect to the price of marijuana .5.

[13] See Tu and Ye (1999) for an overview.

TABLE 14

PRICE ELASTICITIES OF DEMAND

Good (1)	Beer (2)	Wine (3)	Spirits (4)	Marijuana (5)
		Compensated		
Beer	-.26	.05	.10	.11
Wine	.13	-.54	.19	.22
Spirits	.26	.19	-.90	.45
Marijuana	.15	.11	.22	-.49
		Uncompensated		
Beer	-.46	-.03	.02	-.04
Wine	-.27	-.69	.04	-.08
Spirits	-.54	-.11	-1.20	-.15
Marijuana	-.33	-.07	.04	-.84

The above price elasticities are "compensated" as they refer to the substitution effects only -- real total expenditure on the four goods is held constant. Alternatively, if we hold nominal total expenditure constant we obtain the corresponding "uncompensated" elasticities; these involve adding back the income effects of the price changes and take the form $\pi_{ij} / \overline{w}_{it} - \overline{w}_{jt} \eta_i$, where η_i is the i^{th} income elasticity. The uncompensated elasticities, which are computed using the information contained in Table 13, are given in the bottom panel of Table 14. The own-price elasticities are now -.5, -.7, -1.2 and -.8 for beer, wine, spirits and marijuana, respectively. An element-by-element comparison of the uncompensated elasticities

with their compensated counterparts reveals two major differences: (i) When the income effects are included, the elasticities involving the price of beer (given in column 2) are all (algebraically) much lower; this is due to the high budget share of beer of about 40 percent. (ii) The four uncompensated elasticities of spirits (given in the row for that good) are all much smaller than the compensated versions due to the high income elasticity of spirits of 2.

8. LEGALISATION OF MARIJUANA

Suppose the consumption of marijuana were legalised. What would happen to consumption? As the elimination of criminal sanctions would have the effect of lowering the "full price" of marijuana, consumption would be expected to increase. But, on the other hand, the disappearance of the "forbidden fruit" characteristic of marijuana could tend to lower consumption. This section, which is based on Daryal (1999), explores these issues. We start with a brief review of previous research and then report the results of a specifically-conducted survey of marijuana consumption patterns of young adults.

Several studies have analysed the impact of decriminalisation in the US where marijuana consumption has been decriminalised in some states.[14] Table 15 summarises the findings of these studies. Studies using data pertaining to the whole population (Model, 1993, Saffer and Chaloupka, 1995, 1998) find a significant increase in marijuana consumption due to decriminalisation. By contrast, the three other studies involving youths only (Johnston et al., 1981, Theis and Register, 1993,

[14] Decriminalisation of marijuana removes criminal penalties associated with the possession of small amounts for personal use. Legalisation involves a further step whereby all sanctions are removed, so that the status of marijuana would be like that of alcohol or tobacco and perhaps have restrictions on advertising and the sale to minors.

TABLE 15

ASPECTS OF PRIOR STUDIES OF MARIJUANA CONSUMPTION

Author	Data	Does decriminalisation increase marijuana consumption significantly?	Relationship between alcohol and marijuana
Johnston et al. (1981)	Surveys of US high school seniors, 1975-80	No	-
DiNardo and Lemieux (1992)	Surveys of US high school seniors, 1980-89	-	Substitutes
Model (1993)	US Drug Abuse Warning Network, 1975-78	Yes[1]	Substitutes[1]
Theis and Register (1993)	US National Longitudinal Survey of Youth, 1984-88	No	Inconclusive
Saffer and Chaloupka (1995)	US National Household Surveys on Drug Abuse, 1988-91	Yes[2]	Inconclusive
Pacula (1997)	US National Longitudinal Survey of Youth, 1984	No	Complements
Chaloupka and Laixuthai (1997)	Surveys of US high school seniors, 1982-89	-	Substitutes
Pacula (1998)	US National Longitudinal Survey of Youth, 1983-84	-	Complements
Saffer and Chaloupka (1998)	US National Household Surveys on Drug Abuse, 1988-91	Yes	Mostly complements

Notes: 1. Indirect evidence from hospital emergency room data.

2. Probability of marijuana usage increases by 8 percentage points.

Pacula, 1997) find that decriminalisation has no significant impact. Evidently, as the general population consume less marijuana than the young, their consumption is more sensitive to changes in its legal status. It is also to be noted that the studies in Table 15 all use data from the US. Unfortunately, there exist no similar studies of marijuana consumption in Australia; as Australians are among the heaviest consumers of marijuana in the world, this would seem to be a substantial gap in the existing literature. We will return to the last column of Table 15 in the next section.

The data used in our analysis were collected by way of a survey in 1998 of students enrolled in the first-year unit at UWA, Macroeconomics, Money and Finance 102. Table 16 gives the characteristics of the students enrolled in the unit and the respondents to the survey. Table 17 shows that 53 percent of all respondents have used marijuana, while 47 percent claimed to have never consumed it.[15] Consumption of marijuana is higher amongst males than females -- 60 percent of male students have consumed it, compared to 46 percent of females. The hypothesis of independence of consumption and gender is rejected at the 5 percent significance level on basis of a chi-square test.

Information on the frequency of consumption is given in the lower part of Table 17. Consider first the results for "all" users, given in the last column. Weekly consumption is the most popular frequency, while only a small proportion consume marijuana daily. Interestingly, 20 percent are no longer users; these people tried it at some stage and have not used it in over a year. The most popular frequency for males is weekly (33 percent), whereas for females it is occasional (28 percent). Both daily and weekly consumption of marijuana is considerably higher among males than females; however, the hypothesis of independence of gender and the frequency of consumption cannot be rejected at the 5 percent significance level on the basis of a chi-square test. Accordingly, the frequency of consumption does not differ significantly between males and females.

[15] William Jefferson Clinton, the President of the USA, says he has smoked marijuana, but claims "not to have inhaled." This seems sufficiently far-fetched that we did not judge it to be worthwhile to include this as a possibility in our survey.

TABLE 16

CHARACTERISTICS OF STUDENTS ENROLLED
IN MACROECONOMICS, MONEY AND FINANCE 102
AT UWA AND THE SAMPLE

Characteristic	Enrolled in unit	Sample
Number of students	582	327
Number of respondents	-	281
Response rate (percent)	-	86
Sex (percent)		
Male	52	48
Female	48	52
Age (years)		
Median	18	-
Mean	19	-
Origin (percent)		
Local	75	-
International	25	-

Source of the enrollment data: Unit coordinator and lecturer Paul Miller.

Our survey reveals that (i) more males consume marijuana than do females; and (ii) around 50 percent of respondents are users. Bearing in mind that the mean age of our respondents is 19 years (see Table 16), these findings are consistent with results from the 1995 Australian National Drug Strategy Household Survey (NDHS) quoted in the Penington Report (1996, p. 13). Table 18 compares frequency of consumption from the 1995 NDHS with our estimates. As can be seen, the proportions of daily and occasional users are very similar in both surveys. However,

TABLE 17

USAGE OF MARIJUANA

(Percentages of respondents)

	Male	Female	All
Ever used marijuana	60	46	53
Frequency of Consumption			
Daily	9	1	6
Weekly	33	25	30
Monthly	17	25	21
Occasional	21	28	23
No longer	20	21	20
Total	100	100	100

the proportions that consume marijuana on a weekly or monthly basis are considerably higher in our survey; and the proportion who are “no longer users” is much lower in our study. The reason for these differences is probably because the NDHS covers the entire population, not only young adults, who make up our survey. The results of the two surveys seem to say something interesting about the lifetime profile of marijuana consumption: If you are a daily or occasional user when young, then as you age and become part of the general population, you stay a daily or occasional user, at least on average. By contrast, the majority of weekly and monthly users stop using marijuana as they mature and presumably get more involved with work and family life.

TABLE 18

FREQUENCY OF MARIJUANA
CONSUMPTION IN TWO SURVEYS

(Percentage of respondents)

	Survey	
Frequency of consumption (1)	1995 NDHS (2)	Current study (3)
Daily	5	6
Weekly	9	30
Monthly	7	21
Occasional	20	23
No longer	59	20
Total	100	100

Sources: 1. Column 2 is from the last column of Table 1 with "every few months", "once or twice a year" and "less often" interpreted as "occasional".

2. Column 3 is from the last column of the lower part of Table 17.

Our survey asked, "Suppose marijuana is legalised. Assume there is no price change. How much would your consumption of marijuana change?" Table 19 presents the responses, cross-classified by type of consumer and gender. All the estimated consumption changes are positive and the majority are significant at the 5 percent level. These findings do not support the "forbidden fruit" idea, whereby consumption could fall with legalisation as it may eliminate an attractive characteristic of marijuana. As indicated by the last entry in row 6, for all users,

TABLE 19

PERCENTAGE CHANGE IN CONSUMPTION OF MARIJUANA DUE TO LEGALISATION

(Standard errors are in parenthesis)

Type of consumer (1)	Males (2)		Females (3)		All (4)	
1. Daily users	21.25	(14.8)	.00	(.00)	18.89	(13.7)
2. Weekly users	8.15*	(4.07)	11.18*	(5.08)	9.32*	(3.19)
3. Monthly users	6.79*	(3.38)	9.12*	(4.07)	8.06*	(2.79)
4. Occasional users	10.88*	(4.27)	3.89*	(1.96)	7.29*	(2.35)
5. No longer a user	4.69	(4.67)	.00	(.00)	2.50	(2.48)
6. All users	9.09*	(2.28)	6.19*	(1.78)	7.79*	(1.49)
7. Non-users	.19	(.18)	.38	(.24)	.30*	(.15)
8. All types	5.55*	(1.42)	3.07*	(.86)	4.27*	(.82)

Note: The symbol "*" denotes significant at the 5 percent level.

marijuana consumption is estimated to increase by approximately 8 percent following legalisation. As the estimated increase in consumption of those who currently are non-users is less than 1 percent (row 7, column 4), legalisation does not draw in a substantial number of new users.[16] In general, males are relatively more responsive to legalisation than are females; the consumption of all males is estimated to increase by 6 percent, while that of all females increases by 3 percent (see row 8). Considering the differing types of consumer, daily users (row 1) have the largest response to

[16] This result contradicts previous findings from the US National Commission on Marijuana and Drug Abuse Surveys, conducted in 1972 and 1973. These surveys indicate that 8-12 percent of non-user youths (and 3-4 percent of non-user adults) would become users if marijuana were decriminalised (Theis and Register, 1993). It should, however, be noted that this survey refers to a period more

legalisation, as expected, but this is not significant at the 5 percent level. The estimated rise for weekly, monthly and occasional users (males and females) is estimated to be 9, 8, and 7 percent, respectively, all of which are significant at the 5 percent level. None of the females who are no longer users say that their consumption will increase with legalisation, whilst for males in this category, consumption increases by 5 percent (see row 5). Going down columns 2-4, it can be seen that, in general, more frequent users are more responsive to legalisation than are less frequent users, as one would expect.

9. DRINKING AND LEGALISATION

The previous section analysed the effects of legalisation on marijuana consumption. Evidence from the UWA survey indicates that there would be some increase in consumption. As we have seen that alcohol and marijuana consumption are interrelated, it is also relevant to ask, What would legalisation do to drinking? If alcohol and marijuana were substitutes, then there would likely to be a tendency for drinking to fall when marijuana increases as a result of legalisation; and conversely if alcohol and marijuana were complements. As shown by the last column of Table 15, prior studies of the relationship between the two types of goods are not unanimous -- three find substitutability, two/three complementarity and two are inconclusive.[17] In this section, which is based on Daryal (1999), we use additional information from the UWA survey to obtain some direct results on the effects of legalisation on drinking.

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than 25 years ago, and since then drug-taking attitudes and behaviour may have changed substantially.

[17] Note that the positive compensated cross elasticities involving the price of marijuana given in the upper panel of column 5 of Table 14 indicate substitutability. But this is an implication of the assumption of preference independence, which was invoked to reduce the number of unknown parameters in order to make the estimation of the demand model feasible with the limited amount of data. On the other hand, the negative residual correlations for marijuana, reported in Table 11, indicates substitutability.

Our survey asked, "Suppose marijuana were legalised, would your alcohol consumption change?" The responses to the question are summarised in Table 20. As can be seen from column 2, for each type of consumer the majority say that their alcohol consumption would not change with legalisation, which points towards the two substances being neither substitutes nor complements, but independent in consumption. Alcohol consumption of daily smokers is by far the most responsive, with 33 percent saying that it would increase with legalisation and 11 percent saying it would fall (see the first entries in columns 3 and 4). The responses of weekly, monthly and occasional users are all quite similar. One way of measuring the "net position" of each type of consumer is to simply subtract the "decreases" from the "increases" and column 5 contains the results. This column reveals that following legalisation, the increase in the alcohol consumption outweighs the decrease in the case of the daily users by $33-11=22$ percentage points, implying that alcohol and marijuana are complements for this group. For all other users, the decrease in alcohol consumption outweighs the increase, meaning that the two substances are substitutes.

Table 21 gives the cross tabulations of the responses to the questions "Have you ever consumed marijuana?" and "Suppose marijuana were legalised, would your alcohol consumption change?" We use a chi-square statistic to test the hypothesis that alcohol and marijuana consumption are independent. This yields a chi-square value of 13.51, which is significant at the 5 percent level, so we reject the hypothesis of independence.[18] Although there is a significant relationship between alcohol and marijuana consumption, this result cannot establish whether the two substances are substitutes or complements.

[18] Due to the small number of observations in some cells of Table 21, caution is appropriate in interpreting this result.

TABLE 20

THE EFFECT OF MARIJUANA LEGALISATION
ON ALCOHOL CONSUMPTION

(Percentages of respondents)

Type of consumer	None	Increase	Decrease	Increase less decrease
(1)	(2)	(3)	(4)	(5)
Daily users	56	33	11	22
Weekly users	82	4	14	-10
Monthly users	81	6	13	-7
Occasional users	77	3	20	-17
No longer a user	97	0	3	-3
All users	82	5	13	-8
Non-users	95	4	1	3
All types	87	5	8	-3

Note: For a given row, the sum of columns 2, 3 and 4 equals 100.

10. ALCOHOL AND THE MARGINAL UTILITY OF MARIJUANA

This section builds on the results of the previous section regarding the effects of legalisation on alcohol consumption. We attempt to gain some additional insights into this problem by adopting a different approach whereby the effects of legalisation on the consumption of marijuana are combined with the price elasticities of demand for alcohol.

TABLE 21

CHANGE IN ALCOHOL CONSUMPTION AND
PREVALENCE OF MARIJUANA USAGE

(Percentages of respondents)

Have you ever consumed marijuana?	Change in alcohol consumption due to legalisation			Total
	Increase	Decrease	No change	
Yes	3	7	43	53
No	2	1	44	47
Total	5	8	87	100

In conventional consumption theory, the consumer chooses the quantity vector $\mathbf{q} = [q_1,...,q_n]'$ to maximise the utility function $u(\mathbf{q})$ subject to the budget constraint $\mathbf{p}'\mathbf{q} = M$, where $\mathbf{p}' = [p_1,...,p_n]$ is the price vector, and M is total expenditure ("income" for short). This leads to a system of Marshallian demand equations of the form $\mathbf{q} = \mathbf{q}(M,\mathbf{p})$. Consider now an extended version of this theory in which some scalar shift variable s affects tastes, so that the utility function now becomes $u(\mathbf{q},s)$. The associated demand equations now take the form $\mathbf{q} = \mathbf{q}(s,M,\mathbf{p})$, which we approximate as

$$(10.1) \qquad Dq_i = \alpha_i Ds + \eta_i DM + \sum_{j=1}^{n} \eta'_{ij} Dp_j , \qquad i=1,...,n ,$$

where D is the log-change operator; α_i is the elasticity of the consumption of good i with respect to the shift variable s; η_i is the i^{th} income elasticity; and η'_{ij} is the $(i,j)^{th}$ uncompensated price elasticity.

Let η_{ij} be the $(i,j)^{th}$ compensated price elasticity and $w_i = p_i q_i / M$ be the budget share of i. This compensated elasticity is related to its uncompensated counterpart via the Slutsky equation, $\eta_{ij} = \eta'_{ij} - w_j \eta_i$. Defining the change in real income as $DQ = DM - \sum_{i=1}^{n} w_i \, Dp_i$, the Slutsky equation then implies that (10.1) can be expressed in terms of DQ and compensated price elasticities as:

$$Dq_i = \alpha_i \, Ds + \eta_i \, DQ + \sum_{j=1}^{n} \eta_{ij} \, Dp_j , \qquad i=1,...,n . \tag{10.2}$$

We interpret the shift variable s as a binary variable reflecting the legalisation of marijuana, such that Ds takes the value 0 (for illegal) or 1 (legal). We can then write (10.2) under the legalised regime as

$$Dq_i = \alpha_i + \eta_i \, DQ + \sum_{j=1}^{n} \eta_{ij} \, Dp_j , \qquad i=1,...,n . \tag{10.3}$$

To preserve the budget constraint, the coefficients of equation (10.3) satisfy $\sum_{i=1}^{n} w_i \, \alpha_i = 0$, $\sum_{i=1}^{n} w_i \, \eta_i = 1$, $\sum_{i=1}^{n} w_i \, \eta_{ij} = 0$, $j=1,...,n$. The coefficient α_i in (10.3) is now interpreted as the log-change in consumption of good i resulting from legalisation, real income and prices remaining constant.

Let goods be ordered such that marijuana is the fourth and consider the marginal utility of that good, $\partial u / \partial q_4$. Suppose that legalisation causes this marginal utility to increase by $c \times \partial u / \partial q_4$, where $c > 0$. Thus we have

$$d\left(\log \frac{\partial u}{\partial q_4} \right) = c . \tag{10.4}$$

In this situation, it can be shown (Theil, 1975, pp. 205-206) that the intercept in (10.3) involves the term c and the relevant cross-price elasticity according to the following relationship:

$$\alpha_i = -c\,\eta_{i4}, \qquad i=1,\ldots,n. \tag{10.5}$$

In words, the change in consumption of good i due to legalisation of marijuana is proportional to that good's elasticity of demand with respect to the price of marijuana, with factor of proportionality (the negative of) c, defined in equation (10.4). This is an attractive result because it provides a formal link between the effect of legalisation and the substitutability between the good in question and marijuana. The possibility of such a link was suggested at the beginning of the previous section. Equation (10.5) also preserves the budget constraint as $\sum_{i=1}^{n} w_i\,\alpha_i = -c\sum_{i=1}^{n} w_i\,\eta_{i4} = 0$, where the last step follows from the aggregation constraint $\sum_{i=1}^{n} w_i\,\eta_{ij}$, given below equation (10.3). Accordingly, rule (10.5) serves to reallocate the fixed amount of income among the n goods, following legalisation.

The coefficient c in (10.5) can be estimated as $-\alpha_i/\eta_{i4}$, with α_i interpreted as the increase in marijuana consumption due to legalisation and η_{i4} as the (compensated) own-price elasticity of demand for marijuana. We use the legalisation effects given in Table 19, together with the estimated price elasticity of -.49, from Table 14. This yields a c-estimate for each type of consumer, and Table 22 contains the results. Under certain conditions, these marginal-utility changes, after switching their signs, can be interpreted as equivalent price changes, i.e., the fall in the price of marijuana that would yield the same increase in consumption as would legalisation.[19] As can be seen, legalisation causes the marginal utility of marijuana to increase by between 43 percent (for daily users who are male) to zero (female daily users and females who are no longer a user); averaging over all types of consumers, of both sex, the marginal utility increases by 9 percent.

[19] For a budget-constrained utility maximum, each marginal utility is proportional to the corresponding price: $\partial u/\partial q_i = \lambda p_i$, where λ is the marginal utility of income. It then follows that $d(\log \partial u/\partial q_i) = d(\log\lambda) + d(\log p_i) = d(\log p_i)$ if λ is constant.

TABLE 22

CHANGE IN THE MARGINAL UTILITY OF MARIJUANA FOLLOWING LEGALISATION

(Percentage changes)

Type of consumer	Male	Female	All
Daily users	43.37	.00	38.55
Weekly users	16.63	22.82	19.02
Monthly users	13.86	18.61	16.45
Occasional users	22.20	7.94	14.88
No longer a user	9.57	.00	5.10
All users	18.55	12.63	15.90
Non-users	.39	.78	.61
All types	11.33	6.27	8.71

Next, to estimate the change in consumption of the alcoholic beverages following legalisation, we use in equation (10.5), for i = beer, wine and spirits, the above c-estimates, together with the cross-price elasticities given in column 5 of Table 14. The results are given in Table 23 where, for convenience, the changes in marijuana consumption are reproduced from Table 19. For a given type of consumer, a budget-share-weighted average of the change in consumption of the four goods is zero, by construction. The key results of this table are:

- For each user group, it is always the consumption of spirits that falls the most with legalisation. Next is wine, and then comes beer. This result reflects the

TABLE 23

EFFECTS OF LEGALISATION ON THE CONSUMPTION OF ALCOHOLIC BEVERAGES AND MARIJUANA

(Percentage changes)

Good	Male	Female	All	Good	Male	Female	All
	A. Daily users				E. No longer a user		
Beer	-4.77	.00	-4.24	Beer	-1.05	.00	-.56
Wine	-9.54	.00	-8.48	Wine	-2.11	.00	-1.12
Spirits	-19.52	.00	-17.35	Spirits	-4.31	.00	-2.30
Marijuana	21.25	.00	18.89	Marijuana	4.69	.00	2.50
	B. Weekly users				F. All users		
Beer	-1.83	-2.51	-2.09	Beer	-2.04	-1.39	-1.75
Wine	-3.66	-5.02	-4.18	Wine	-4.08	-2.78	-3.50
Spirits	-7.48	-10.27	-8.56	Spirits	-8.35	-5.68	-7.15
Marijuana	8.15	11.18	9.32	Marijuana	9.09	6.19	7.79
	C. Monthly users				G. Non-users		
Beer	-1.52	-2.05	-1.81	Beer	-.04	-.09	-.07
Wine	-3.05	-4.09	-3.62	Wine	-.09	-.17	-.13
Spirits	-6.24	-8.38	-7.40	Spirits	-.17	-.35	-.28
Marijuana	6.79	9.12	8.06	Marijuana	.19	.38	. 30
	D. Occasional users				H. All types		
Beer	-2.44	-.87	-1.64	Beer	-1.25	-.69	-.96
Wine	-4.88	-1.75	-3.27	Wine	-2.49	-1.38	-1.92
Spirits	-9.99	-3.57	-6.69	Spirits	-5.10	-2.82	-3.92
Marijuana	10.88	3.89	7.29	Marijuana	5.55	3.07	4.27

values of the cross elasticities of the three beverages with respect to the price of marijuana: Spirits-marijuana .45, wine-marijuana .22, beer-marijuana .11.

- The largest fall in alcohol consumption is for the daily users, as this group experiences the largest increase in the marginal utility of marijuana (see Table 22). The effects for weekly, monthly and occasional users are not too dissimilar.

- For all types of consumers, legalisation is estimated to cause beer consumption to fall by about 1 percent, wine by 2 percent and spirits by 4 percent.

The results of Table 23 refer to the UWA survey which is heavily slanted towards young adults. It can be made more representative of the whole population by reweighting. Consider per capita consumption of good i, q_i. This is a weighted average of per capita consumption of that good by each group of consumers, q_{ic}, $c \in \mathbf{C}$, the set of consumer groups. That is, $q_i = \sum_{c \in \mathbf{C}} w'_{ic} q_{ic}$, where the weight $w'_{ic} = N_{ic} / N_i$, with N_{ic} the number of consumers in group c and $N_i = \sum_{c \in \mathbf{C}} N_{ic}$ is the total number of consumers. It then follows that

$$d(\log q_i) = \sum_{c \in \mathbf{C}} w_{ic}\, d(\log q_{ic}), \tag{10.6}$$

where the new weight is defined as

$$w_{ic} = w'_{ic} \frac{q_{ic}}{q_i} = \frac{Q_{ic}}{Q_i}, \tag{10.7}$$

where $Q_{ic} = N_{ic}\, q_{ic}$ is total consumption of i by group c and $Q_i = N_i\, q_i = \sum_{c \in \mathbf{C}} Q_{ic}$ is total consumption by all groups. In words, the weight w_{ic} is simply group c's share in total consumption of the good in question.

We interpret $d(\log q_{ic}) \times 100$ as (approximately) the percentage change in consumption of good i by group c following legalisation. Thus, we can use the results contained in Table 23 for $d(\log q_{ic})$ on the right-hand side of equation (10.6). For marijuana, the total consumption weights defined in equation (10.7) can be derived from our estimates of consumption by group given in Table 4; see columns 2 and 3 of Table 24 for details. Using these two sources of information, we can then evaluate (10.6) for i = marijuana and the result is given in the last entry of column 5 of Table 24. Accordingly, we estimate that per capita consumption of marijuana would increase by 13 percent as a result of legalisation. But it needs to be emphasised that this estimate spreads the total increase over the whole population and, in effect, masks the large heterogeneity of consumption of marijuana; as revealed by column 3 of Table 24, daily and weekly users by themselves account for as much as 94 percent of total consumption. The estimation of the effect of legalisation on total alcohol consumption would require similar disaggregated data, but at present this information is not available.

11. CONCLUDING COMMENTS

This paper has investigated economic aspects of part of the illicit drug industry, namely, the determinants of the demand for marijuana. Special attention has been devoted to the measurement of the amount of marijuana consumed, the price responsiveness of consumption, the interaction of marijuana with alcohol and the impacts of possible legalisation. In view of the large number of people who have used marijuana and the fact that, in Australia at least, expenditure on it is about twice that on wine, it is surprising that more is not known about these intriguing matters.

The main findings of the paper are as follows:

TABLE 24

MARIJUANA CONSUMPTION AND LEGALSIATION:
REWEIGHTED EFFECTS

Type of consumer	Consumption Q_{ic} (Thousands of ounces)	Consumption share w_{ic} (Percent)	Effect of legalisation (Percentage change)	Weighted effect (3)×(4) (Percentage change)
(1)	(2)	(3)	(4)	(5)
Daily users	4,693	42	18.89	7.93
Weekly users	5,913	52	9.32	4.85
Monthly users	606	5	8.06	.40
Occasional users	57	1	7.29	.07
No longer a user	0	0	2.50	.00
Non-users	0	0	.30	.00
Total	11,271	100	-	13.23

Sources: 1. Column 2 is from the last column of Table 4 with “every few months”, “once or twice a year” and “less often” interpreted as “occasional”.

2. Column 4 is from the last column of Table 19.

- Per capita consumption of marijuana in Australia has increased from .65 ounces in 1988 to .78 in 1995. Expenditure of marijuana in 1995 was a little over $5 billion (equivalent to about 1 percent of GDP), or $351 per capita.

- Expenditure on marijuana is roughly equal to that on wine plus spirits; and it is about three-quarters of beer expenditure.

- The law of demand holds with respect to beer, wine, spirits and marijuana -- for those goods whose prices rise faster than average, consumption grows slower than average, and vice versa.

- The own-price elasticity of demand for marijuana is about $-1/2$.

- The elasticities of demand for the three alcoholic beverages with respect to the price of marijuana are:

Beer - marijuana	.1
Wine - marijuana	.2
Spirits - marijuana	.5.

- About 50 percent of first-year students at UWA have used marijuana, with males being heavier users than females.

- The UWA survey reveals that for all types of users, legalisation would cause marijuana consumption to increase by approximately 8 percent. In general, more frequent users are more responsive to legalisation than are less frequent users. Legalisation would not draw in a substantial number of new users.

- In most cases, legalisation of marijuana lowers drinking. Spirits consumption falls the most, then wine and then beer.

- Reweighting the results from the UWA survey to reflect the whole population reveals that legalisation would cause marijuana consumption to increase by about 13 percent, with most of this accounted for by daily and weekly users.

APPENDIX

THE ALCOHOL DATA

This appendix follows the approach of Clements and Johnson (1983) in deriving the data for alcohol consumption, prices and expenditures.

Table A1 gives per capita consumption and price indexes of beer, wine and spirits. Population (14 years and over), total consumption expenditure and expenditure on alcoholic beverages are contained in Table A2. Column 7 of this table contains the alcohol budget share, the proportion of total consumption expenditure absorbed by the three alcoholic beverages.

As no data are directly available for expenditure on the three alcoholic beverages individually, we construct them as follows. According to the information derived from the Australian Bureau of Statistics' Household Expenditure Survey (HES), average weekly expenditure in 1991 by all households on beer is \$9.52, \$3.42 on wine and \$3.05 on spirits; see Table A3 for details. Hence, the conditional budget shares are $.596\ [= 9.52 / (9.52 + 3.42 + 3.05)]$ for beer, .214 for wine and .190 for spirits. We use these shares to split total alcohol expenditure into the three beverages. From column 6 of Table A2, in 1991 expenditure on alcohol is \$740.77 per capita per annum. Thus in 1991 per capita expenditure on beer is $.596 \times 740.77 = \$441.49$, on wine $.214 \times 740.77 = \$158.52$ and on spirits $.190 \times 740.77 = \$140.76$. From Table A1, beer consumption in 1991 is 134.9 litres per capita, so that the implied price of a litre of beer is $441.49 / 134.9 = \$3.27$. This is to be compared with the value of the beer price index in that year of 109.4 (from column 3 of Table A1). It follows that to form a (current-price) expenditure series for beer, we need to multiply the quantity by the price index given in Table A1 and then multiply the result by $3.27 / 109.4$ for each year. The resulting expenditure series is then consistent with the HES data and is given in column 2 of Table A4.

Using the same procedure for wine and spirits, we multiply the product of quantity and price index by $\frac{158.35/23.01}{101.2}$ for wine and $\frac{140.76/3.614}{112.2}$ for spirits. Columns 3 and 4 of Table A4 contain the results. Total expenditure on the three beverages is given in column 5 of Table A4; this is exactly equal to total expenditure given in the last column of Table A2 for 1991, and approximately equal for the other years. The price per litre of each beverage is calculated by dividing expenditure (given in Table A4) by consumption (Table A1) and the results are contained in Table A5.

The quantities and prices for the three alcoholic beverages given in Table 6 are from Tables A1 and A5.

TABLE A1

PER CAPITA ALCOHOL CONSUMPTION AND PRICE INDEXES

(Quantities in litres; price indexes have base year 1989/90=100)

	Beer		Wine		Spirits	
Year	Quantity	Price index	Quantity	Price index	Quantity	Price index
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1988	141.4	94.2	25.82	91.1	3.993	87.8
1989	141.6	97.9	24.32	97.2	4.048	95.7
1990	139.9	104.2	22.85	100.0	3.870	105.1
1991	134.9	109.4	23.01	101.2	3.614	112.2
1992	127.8	112.4	23.23	103.8	3.595	116.4
1993	123.8	116.3	23.14	107.0	3.982	120.2
1994	122.1	119.8	23.19	111.7	4.168	123.6
1995	120.2	124.5	22.96	117.4	4.130	127.1

Notes: 1. Quantities and price indexes have been converted from financial years into calendar years by averaging adjacent financial years.

2. "Per capita" consumption refers to consumption divided by the number of Australians aged 14 and over.

3. In the original source, per capita spirits consumption is given in terms of litres of alcohol. The estimated volume of consumption of this beverage is calculated by multiplying litres of alcohol by 2.5.

Sources: Consumption data are from ABS, Apparent Consumption of Foodstuffs, Catalogue No. 4306.0 (various issues). Price data are from ABS, Consumer Price Index, Catalogue No. 6401.0 (various issues).

TABLE A2

POPULATION, TOTAL CONSUMPTION EXPENDITURE AND EXPENDITURE ON ALCOHOLIC BEVERAGES

Year	Population (Millions)	Total consumption expenditure		Expenditure on alcohol		Alcohol budget share (×100)
		Total ($m)	Per capita ($)	Total ($m)	Per capita ($)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1988	13.08	185,095	14,148	8,351	638.34	4.51
1989	13.33	206,070	15,454	8,942	670.60	4.34
1990	13.54	223,195	16,483	9,684	715.18	4.34
1991	13.75	235,921	17,160	10,184	740.77	4.32
1992	13.93	248,412	17,836	10,443	749.78	4.20
1993	14.08	260,288	18,487	10,988	780.39	4.22
1994	14.24	274,446	19,267	11,905	835.74	4.34
1995	14.44	292,522	20,258	12,798	886.28	4.38

Notes: 1. Expenditures have been converted from financial years into calendar years by averaging.
2. Population refers to Australians aged 14 and over.

Sources: Population is from ABS, Population By Age and Sex, Catalogue No. 3201.0 (various issues). Total consumption expenditure and expenditure on alcohol are from ABS, Australian National Accounts: National Income, Expenditure and Product, Catalogue No. 5204.0 (1995-96).

TABLE A3

AVERAGE WEEKLY HOUSEHOLD EXPENDITURE

ON ALCOHOLIC BEVERAGES

(Dollars per household)

Year	Beer	Wine	Spirits	Total
1988/89	9.74	3.07	2.96	15.77
1993/94	9.29	3.76	3.13	16.18
1991	9.52	3.42	3.05	15.98

Note: The data for 1991 are estimated by averaging over 1988/89 and 1993/94.

Source: ABS, Household Expenditure Survey: Australia, 1988/89 and 1993/94, Catalogue No. 6535.0.

TABLE A4

PER CAPITA EXPENDITURES ON ALCOHOLIC BEVERAGES

(Dollars)

Year (1)	Beer (2)	Wine (3)	Spirits (4)	Total (5)
1988	398.41	159.84	122.10	680.35
1989	414.80	160.70	134.87	710.37
1990	435.91	155.39	141.67	732.96
1991	441.49	158.52	140.76	740.77
1992	429.43	163.93	145.70	739.06
1993	430.66	168.24	166.62	765.52
1994	437.49	176.17	179.40	793.05
1995	447.64	183.32	182.77	813.73

Source: See text.

TABLE A5

PRICES OF ALCOHOLIC BEVERAGES

(Dollars per litre)

Year	Beer	Wine	Spirits
1988	2.819	6.190	30.578
1989	2.928	6.607	33.315
1990	3.116	6.801	36.601
1991	3.271	6.883	39.064
1992	3.361	7.056	40.532
1993	3.478	7.271	41.847
1994	3.583	7.597	43.044
1995	3.724	7.983	44.254

Source: See text.

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