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QUALITY-CONSTANT ILLICIT DRUG PRICES

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DISCUSSION PAPER 12.22

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Abstract:

Background: Efforts to improve understanding of drug policy are hindered by the unavailability of adequate data. Price data present a promising way of monitoring the workings of drug markets. The pricing of illicit drugs is complicated by several issues, especially, quantity considerations, quality bought and where the transaction occurs. Appropriate analytical techniques can be used to construct price indexes that remove the effects of these variables. This paper sheds light on the drug markets in Australia by using price data between 1999 and 2009.

Methods: We estimate a hedonic price function, which relates the price of illicit drugs in Australia for the period 1999 to 2009, to the composition/type of drug, the region the drug was purchased in and the size of the quantity transacted. This approach has the effect of stripping out the impact of these variables to measure constant-quality drug prices over time. This entails the use of the regression coefficients to control for confounding influences on prices.

Results: We find drug prices, on average, have remained relatively stable over the past decade, increasing less than 4% in nominal terms over the whole period. As this is much less than the overall rate of inflation, real drug prices have declined substantially. We estimate that a 10-percent decrease in size of a transaction leads to a 1.5-percent increase in the unit price.

Conclusion: Prices provide valuable information on the workings of illicit drug markets. In real terms (that is, inflation adjusted), drugs have become noticeably cheaper, which presumably has lead to an increase in consumption. We find strong evidence for the existence of a distinct market for each drug and region. Quantity discounts are substantial, so the price per unit rises as the quantity transacted gets smaller. We also find some indication that the forces of competition moderate drug prices.

Conflict of Interest

None

Introduction

Effective drug policy has been constrained by many factors including the unavailability of adequate measures of the problem. A better understanding of the way drug markets operate is urgent. Data on seizures, the number of arrests and people in treatment are notoriously suspect and reveal little about fundamental issues, the drivers of consumption and production. A deep appreciation of the workings of these markets, including the impact, if any, of policy initiatives, is frustrated by the lack of appropriate data. Since illicit drugs are traded in retail markets not unlike private sector markets for conventional consumer products, price data provide an alternative avenue for monitoring drug markets, predicting future trends and guiding policy decisions.

Price data for illicit drugs contains substantial heterogeneity. Several different drugs are available and their prices per unit weight vary widely, the quality and quantity transacted (quantity discounts are substantial) differ substantially and typically drugs are sold in many distinct geographic locations at different prices. Consequently, it is difficult to define "the price" of an illicit drug as it is partly determined by these factors. Hedonic pricing models can be employed to construct a reliable index of illicit drug prices as they explicitly control for these variables. We estimate a hedonic price function, relating the price of illicit drugs in Australia for the ten-year period 1999-2000 to 2008-09, to the composition/type of drug, the region the drug was purchased in and the quantity transacted. This allows tracking the changes in drug prices over time, with the impact of the extraneous factors stripped out. We refer to these as "quality-constant prices" as they are purely attributable to the passage of time.

The clandestine nature of drug markets confers further challenges and obstacles to obtaining reliable price measures of illicit drugs. The data to be used are by no means perfect; indeed they are poor compared to those available for licit enterprises. As there are no official sources of drug prices we use price data extracted from a source that does not seem to have previously been systematically analysed, viz, the Australian Crime Commission's *Illicit Drug Data Reports*. The lack of information in drug markets further complicates measuring constant quality prices. For example, illicit drugs are rarely sold in their pure form with diluents introduced at various stages of the distribution process as purity varies in response to changes in supply and demand. Hence, we begin with a discussion of the key issues surrounding the pricing of illicit drugs, followed by the empirical results and a discussion of our most significant findings.

Issues in drug pricing

For any given product, no one will know all the prices quoted by various buyers and sellers at any given time, unless the market is centralised. The most favourable price is ascertained by canvassing different buyers and sellers – that is, by "searching". The amount of price dispersion is therefore a manifestation and measure of the amount of ignorance in a market and is not due to product heterogeneity (Stigler, 1961). Advertising, the usual means of identifying buyers and sellers and reducing search costs is not available in illegal industries. High levels of ignorance typically characterise drug markets so equilibrium prices display greater dispersion than licit goods. Since search costs associated with locating a seller are high and proportional to the number of sellers approached, most buyers are content to buy from the first dealer they find. Against this background, there are some important issues in understanding drug prices.

Drugs are sold in common quantities familiar to the buyer and seller and most buyers know the "going rate" for a given quantity (Caulkins, 2006 and Caulkins and Reuter, 1998). Prices are in multiples of $5 to minimise the time taken to complete a transaction to reduce the risk of arrest. So whilst the nominal price may remain relatively constant over time at the retail level the seller varies the quantity prior to sales. As transactions typically occur without a measurement device, sellers can vary the weight per labelled quantity in response to changes in supply and demand conditions. Consequently, the nominal price of each transaction must be adjusted for the quantity transacted to obtain the effective price.

A further issue is that illicit drugs are rarely sold in pure form. Diluents are introduced at various stages of the distribution process as sellers vary purity in response to changing market conditions (ACC, 2003). Since the industry is illegal few of the usual means of quality assurance are available to consumers. Although dealers may build rapport with regular clients the turnover of dealers can be quite rapid. This, combined with the haste with which transactions are performed and the small quantities usually involved, means testing purity may not be viable. This makes drugs 'experience' goods, meaning certain attributes of the drug, namely purity can only be observed after purchase and consummation and even then consumers' evaluation of purity is imperfect (Clements and Zhao, 2008). Ideally drugs are properly measured in terms of their expected 'price per pure gram' (Caulkins, 1994). That is:

$$\text{Price per pure gram (\$)} = [\text{Nominal price (\$)} / \text{Expected purity (\%)}] \div \text{Weight (g)}$$

To measure price changes purely attributable to the passage of time a quality-adjusted price index must be constructed. With respect to illicit drugs, 'quality' is abstract, best grasped as the embodiment of any variables that are determinants of price. Most striking is the high price per unit weight of drugs. On a per ounce basis, pure cocaine and heroin, for example, cost more than gold. A related issue is that the per-unit cost of drugs rises as the lot size declines (Caulkins and Reuter, 1998). Accordingly, the quantity transacted also needs to be controlled for to properly measure quality-adjusted drug prices. Furthermore, as the prices of different drugs vary enormously, the composition of the drug market must be allowed for.

The high value to weight ratio makes drugs highly tradable commodities. If drug markets operated like licit drug markets arbitrage would tend to eliminate price differences between jurisdictions. Given information flows are highly imperfect and lateral transactions costly, the limits to arbitrage mean that drug prices show great geographic variation. In the United States it has been observed that drug prices usually rise with increasing distance from the source, whether it is from a point of import or domestic production and have greater variation in markets with larger geographical size (Caulkins, 1995). Prices also follow an urban hierarchy with larger cities tending to be the leaders with lower prices. Thus the location in which an exchange of drugs occurs determines to some extent the price paid so this variable must be included in a quality-adjusted price index.

Data

We use price data published in Australian Crime Commission's (ACC) annual *Illicit Drug Data Report (IDDR)*[1] for the decade 1999-2000 to 2008-09. The data are collected from Australian Federal, State and Territory police services and is based on information supplied by covert police units and police informants (ACC, 2007). Prices usually reflect those paid during undercover buys or drug busts (ACC, 2007).

Prices for heroin, cannabis, cocaine, amphetamine-type stimulants and phenethylamines (ecstasy) are reported in each jurisdiction in Australia for a range of quantities the drugs are commonly transacted in at the retail level, including some data on the prices paid for large quantities such as an ounce and half-catti (350g). For the years 1999-2000 to 2002-03 prices are quarterly, beyond this an annual price is given.

[1]First published 1991-92; prior to 2002-03 the *Illicit Drug Data Report* was called the *Australian Illicit Drug Report* and prior to 2001-02 the Australian Bureau of Criminal Intelligence, the antecedent organisation of the ACC, produced it.

The *IDDR* often reports a single value for each price. In almost two thirds of cases an upper and lower bound is given so the data is consolidated by taking the mid-point of each price range. Quarterly observations for the years 1999-2000 to 2002-03 were annualised to make the dataset consistent across years. Observations are treated as outliers if they are either (i) less than one half of the mean of price for the corresponding jurisdiction, drug and quantity; or (ii) greater than twice the mean. 23 outliers were detected, removed, the mean recomputed, and the observations replaced with the new means.

To facilitate comparing prices across quantity groups, price observations were converted to dollars per gram. Phenethylamine prices were listed per tablet so the per-gram price was calculated assuming a tablet weight of 0.29g. This estimate seems to be consistent over time (ACC, 2007).

If there were no missing observations then the total price observations would be given by the product of the number of years the data spans, 10, the number of regions in Australia, 8 states and territories, the 5 drug types and the number of quantities each drug is commonly transacted in. This would represent 3200 price observations. Just over 50 percent of possible observations are missing, as indicated by Table 1. Table 2 contains the mean drug prices.

Hedonic modeling:

We estimate a hedonic price function, relating the price of illicit drugs in Australia for the ten-year period 1999-2000 to 2008-09, to the composition/type of drug, the region the drug was purchased in and the quantity transacted. Denoting the price of drug type *i* purchased in region *j* in year *t* as p_{ijt}, the quantity transacted as q_{it} and letting T_{ti} be a time indicator variable equal to 1 in year *t* and zero otherwise and drug type and region also be given by 0 – 1 dummy variables $d_i\,(i = 1,2,...5)$ where 1 = amphetamine, 2 = cannabis, 3 = cocaine, 4 = heroin, 5 = phenethylamine and r_j $(j = 1,2,...8)$ where 1 = ACT, 2 = NSW, 3 = NT, 4 = QLD, 5 = SA, 6 = TAS, 7 = VIC, 8 = WA, respectively. In this context the hedonic price equation takes the form[2]:

[2] The choice of functional form of a hedonic price function is an unresolved issue. It is not restricted by economic theory but the market environment that generates the equilibrium price determines which form is most appropriate. Diewert, W. (2003) argues in favour of a double log specification. We regress log price on log quantity with the advantage that α represents the elasticity of price with respect to quantity. We use the identity function for the other characteristics as they are given by 0-1 indicator variables. The intercept term is dropped from the specification to prevent collinearity arising from the extensive use of dummy variables.

(1) $$\ln p_{ijt} = \alpha \ln q_{it} + \sum_{i=1}^{5} \beta_{1i} d_i + \sum_{j=1}^{8} \beta_{2j} r_j + \sum_{t=1999}^{2008} \beta_{3t} T_{ti} + \mu_{ijt}$$

where the α's and β's are the unknown parameters to be estimated and μ_{ijt} is a standard disturbance term.

In a multiple regression equation the least squares estimate of a parameter refers to a change in one right-hand variable, all others being held fixed. Therefore the difference in the quality-adjusted natural logarithm of drug prices is found by taking differences of the time dummy variable coefficient estimates, the β_{3t}'s. Similarly the extent to which the variables quantity, drug type and region explain market prices is found by examining the original least squares (OLS) estimates of the parameters α, β_1's and β_2's respectively.

Empirical results:

Table 3 presents the results of estimating various hedonic models for drug prices. The estimate of β_{1i} reflects the response of the price of drug *i* relative to the base drug cannabis. The estimate of β_{2j} reflects the price in region *j* relative to the base region Victoria. For example, the log of the relative price of cocaine to cannabis is 2.91 (Table 2 column 2). The percentage difference in price is given by $\left(\exp\left(2.91\right)-1\right)\times 100 = 17.4\times 100 = 1{,}740\%$ meaning the quality-adjusted unit price of cocaine is 1,740% higher than the quality-adjusted unit price of cannabis, in Victoria. All other drug and region dummy variable coefficients are interpreted in this way. All drug dummy variables were significant and positive indicating cannabis is the cheapest drug in Australia. Heroin is most expensive, followed by cocaine, amphetamines and phenethylamines. The sum of a drug coefficient and regional coefficient provides an estimate of the price of the drug in that region[3].

As the coefficient of the time variable is β_{3t}, the difference between any two β_{3t}'s represents the logarithm of the price in the first year relative to the second, which can be converted to a percentage difference as above. Across all drugs, a rise of just 3.87% in the quality-adjusted price occurred over the decade. These are nominal prices and the rise is less than the 30.3% increase measured by the CPI for the same period. The total quality-adjusted price change, listed in Table 4, is different for each drug; the time paths of prices are given in

[3] Sensitivity analysis was used to check the robustness of the results. Tables A1 to A3 give the results of estimating the hedonic function for each drug, region and year respectively. These results are broadly consistent with those discussed in the text.

Figure 1. The price of phenethylamines declines steadily, cocaine rise steadily whilst prices of heroin, cannabis and amphetamines behave erratically. It seems reasonable to deduce there is a separate market for each drug.

Regional disparities

Regional dummies were significant indicating drug prices are not equalised across regions. Broadly speaking, the largest states Victoria and NSW are cheapest and are likely to be the pricing leaders. With the exception of cocaine in Queensland, the price of all drugs in Queensland, WA and NT are significantly higher than Victoria. Prices in WA and NT are very high; heroin is 215% more expensive in NT, compared to Victoria. Prices in Tasmania, ACT and SA, although not statistically significantly different from Victoria, are still economically significant as we observe prices tend to rise with increasing distance from NSW and Victoria.

Cannabis prices exhibit the most regional variation. This reflects that cannabis is locally produced and difficult to conceal and transport over long distances due its lower value to weight ratio and pungent odour. Cocaine prices are the most equalised. For phenethylamines, amphetamines and heroin, unexploited opportunities to profit would seem to exist. However, there may be barriers to inter-regional trade that prevent this from occurring or, in other words, there are substantial costs to be paid that prevent price differentials from being arbitraged away. Prices in WA and NT are so high the differential cannot only reflect transport costs. Inter-regional trade is not risk free, but whether the risk is large enough to warrant such a premium is uncertain. It is likely a substantial component of the overall price of drugs reflects local distribution factors, which differ significantly across regions. This is further evidenced by Table 5 which shows that price differences are not uniform across regions. Prices have increased greatly in the remote regions WA, Tasmania and NT, fallen in Queensland and remained relatively constant in the remaining regions.

The discount elasticity

The coefficient α in (1) is interpreted as the size elasticity of the unit price, or the proportionate discount for bulk purchases (to be referred to as the "discount elasticity" for short). Across all drugs the estimated value is -0.15 meaning a 10% increase in the package size is associated with a 1.5% reduction in the unit price.

Following Caulkins and Padman (1993), the discount elasticity can be given the following interpretation. Price (p) and package size (q) are related by $\log p(q) = \gamma + \alpha \log q$ where γ is an intercept and α is size elasticity. Then

(2) $\quad p(q) = [\exp(\gamma)]q^{\alpha}$.

Suppose initially 28g of drug is purchased so $q = 28$ and $p(28)$ is the price. If the ounce is then split into 28 one-gram packages, so $q = 1$, now the revenue from these 28 packages is $28 \times p(1)$, where $p(1)$ is the price of a one-gram package. We define the ratio of this revenue to the cost of an ounce as the markup factor $\delta = [28 \times p(1)] / p(28)$. More generally, let $\phi > 1$ be the conversion factor that transforms the larger quantity q into a smaller one, q / ϕ, so that in the previous example $\phi = 28$. Thus we have the following general relationship between prices of different package sizes, the markup and conversion factors:

(3) $\quad \phi \times p(q / \phi) = \delta \times p(q)$.

Writing (2) as $p(q / \phi) = \exp \gamma (q / \phi)^{\alpha}$, so that the LHS of (3) can be written as $\phi \exp \gamma (q / \phi)^{\alpha}$ and RHS of (3) as $\delta \exp \gamma (q^{\alpha})$. Accordingly, equation (3) can be expressed as $\phi (q / \phi)^{\alpha} = \delta q^{\alpha}$, which implies

(4) $\quad \alpha = 1 - (\log \delta / \log \phi)$.

Hence we have related size elasticity to the markup factor and the conversion factor in going from a larger package size to a smaller one. As the markup increases, so does the quantity discount and the (proportionate) increase in the total price resulting from a unit increase in package size is lower. In other words the size elasticity α decreases with the markup. To illustrate the workings of (4) consider our estimate of $\alpha = -0.15$ and let $\phi = 28$, then $\delta = \exp(-(-0.15) \log 28) = 1.65$ which implies a 65% markup in moving from ounces to grams across all drugs. This value seems reasonable.

Including sensitivity analysis gives 24 estimates of α (all significant at the 0.001 level) listed in Table 6 closely centered about -0.15. Clements (2006) uses Australian cannabis data from 1990 to 1999 and estimates discount elasticities centered about -0.25. Our estimates are also consistent with Caulkins and Padman's (1993), for a variety of illicit drugs which range -0.28 to -0.1 and are comparable to estimates for airfares and groceries[4].

[4] Poon (2010) estimates the discount elasticity for international airfares out of Perth, Western Australia and groceries in the Australian supermarket Coles to be -0.37 for both consumables.

Since the larger is α in absolute value, the higher is the markup; a lower $|\alpha|$ indicates a more competitive market. The results in Table 6 suggest the amount of competition in each drug market is different; cannabis has the least, cocaine the most. Similarly, α is not the same across regions, further evidence of local factors determining price. Again, this is probably attributable to the stronger information flows in the more populous areas. In fact the markup in the NT is twice that in Victoria. The estimates of α fall over time suggesting drug markets have become more competitive and/or efficient probably resulting from strengthened information flows that prevent sellers from quoting very high prices. This effect may not be unique to drug markets.

The estimates of α stay within a narrow band of -0.21 to -0.11 suggesting that drug markets are constrained by forces of competition: higher markups attract more competitors, which serves to erode profits and brings the markup back down again; and vice versa when markups fall too low.

Conclusion

There are a large number of illegal drugs on the market which sell in varying sizes, are of varying quality and are sold in different locations at different prices. This heterogeneity presents a major problem in policy discussions regarding "the" price of drugs. As a solution to this problem, we introduced a hedonic pricing model to construct an index of illicit drug prices in Australia. This approach explicitly controlled for the mix of drugs, over regions and quantities transacted, giving rise to a unique "quality-adjusted" index of prices. This index can be used, to accurately measure price changes over time. The index revealed prices increased by less than 4% between 2000 and 2009. As this is substantially less than the corresponding rate of inflation, in real terms drugs have noticeably become cheaper. Price changes are not uniform across the 5 drugs analysed. The prices of cocaine and amphetamines have increased substantially, phenethylamines fallen substantially, whilst heroin and cannabis have remained relatively stable, indicating that there is a separate market for each drug.

We also uncovered strong evidence for the existence of distinct regional drug markets. Equilibrium prices and their dispersion are not the same across Australia nor do they follow the same pattern over time. We found that quantity discounts for bulk purchases are substantial and vary across Australia, also pointing to the importance of local distribution

factors determining price. Our estimates of the discounts point to market forces such as competition, too being important determinants of price.

Price data for illicit drugs contains great heterogeneity. The hedonic function is a useful data compression technique that provides structure to a substantial proportion of this volatility as it reduces the heterogeneity to one index (or a set of indexes) that are derived from the estimated regression parameters. As this method requires information only on prices and a limited number of characteristics, it is an attractive way of shedding light on the workings of drug markets – evidence on markups, quantity discounts, how to define the relevant market, whether relative prices are increasing or decreasing etc.

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Table 1

MISSING DATA

Drug	Number of observations		Percentage missing
	Maximum	Present	
Amphetamine	720	389	46.0
Cannabis	480	226	52.9
Cocaine	480	179	62.7
Heroin	1,120	376	66.4
Phenethylamine	400	251	37.3
Total	3,200	1,421	55.6

Table 2

MEAN DRUG PRICES IN AUSTRALIA, 1999-2008

(Dollars per gram)

	Drug			
Purchase weight (grams)	Amphetamines	Cannabis	Cocaine	Heroin
0.05	-	-	-	1075
0.1	565	-	717	-
0.25	-	-	-	513
0.1-0.3	-	-	-	960
0.4-0.6	-	-	-	479
0.6-0.8	-	-	-	484
0.7	241	-	-	-
1	263	27.9	317	447
2	272	-	-	-
3.5	181	-	-	367
7	158	16.9	252	-
10	-	-	-	351
14	-	13.3	-	342
28	145	11.9	243	325
350	-	-	-	299
448	115	8.05	200	243
700	-	-	-	178
1000	131	6.43	182	128

	Phenethylamines				
Purchase quantity – number of tablets	1	10	25-100	100-1000	>1000
Dollars per gram	44.2	33.8	28.5	22.8	17.7

Table 3

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, 1999-2008, (t-values in parentheses)

	Model						
Variable	1	2	3	4	5	6	7
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intercept		2.93 (77.20)			3.05 (104.18)	5.45 (71.48)	
Size	-0.15 (-39.65)	-0.15 (-39.81)	-0.26 (-24.71)	-0.15 (-37.53)	-0.15 (-37.74)	-0.26 (-24.76)	-0.25 (-23.55)
Drug dummies × 100 (Base = Cannabis)							
Cocaine	291.11 (75.85)	290.95 (76.07)		287.86 (71.92)	287.33 (72.10)		
Amphetamines	250.49 (77.77)	250.29 (77.87)		248.84 (73.30)	248.54 (73.37)		
Phenethylamines	181.57 (51.75)	181.17 (51.89)		179.53 (48.52)	178.88 (48.59)		
Heroin	315.98 (93.81)	315.59 (94.09)		312.34 (89.87)	311.85 (90.10)		
Regional dummies × 100 (Base = VIC)							
NSW	-5.50 (-1.48)	-5.12 (-1.39)	1.93 (0.18)			2.36 (0.22)	
QLD	8.22 (2.12)	8.53 (2.21)	15.54 (1.40)			15.78 (1.43)	
SA	0.44 (0.11)	0.52 (0.13)	-0.45 (-0.04)			0.22 (0.02)	
WA	33.69 (9.58)	33.87 (9.68)	26.27 (2.61)			25.78 (2.58)	
TAS	6.67 (1.61)	6.91 (1.67)	-66.23 (-5.66)			-66.21 (-5.68)	
NT	32.05 (7.04)	32.19 (7.09)	-30.85 (-2.39)			-31.08 (-2.42)	
ACT	3.48 (0.95)	3.93 (1.08)	-13.77 (-1.31)			-13.93 (-1.33)	
Time dummies × 100							
1999	288.38 (59.26)		554.91 (49.32)	300.44 (68.16)			548.51 (58.88)
2000	290.64 (57.49)		548.77 (45.02)	301.21 (65.83)			542.70 (53.32)
2001	296.28 (61.90)		542.85 (47.30)	307.77 (72.87)			535.91 (57.91)
2002	296.36 (63.74)		544.23 (49.89)	308.88 (75.50)			539.54 (62.36)
2003	290.41 (60.89)		532.56 (46.59)	305.29 (72.04)			527.53 (56.47)
2004	294.03 (57.45)		545.01 (43.56)	307.53 (67.11)			539.04 (51.79)
2005	292.75 (60.68)		543.00 (47.10)	302.82 (70.07)			537.28 (56.91)
2006	291.30 (60.20)		546.17 (48.05)	303.00 (69.70)			546.27 (59.40)
2007	295.64 (62.14)		550.26 (49.37)	306.27 (73.08)			543.71 (61.58)
2008	292.18 (62.34)		542.02 (49.65)	301.32 (70.86)			534.97 (59.19)
$\overline{R}^2$	0.92	0.92	0.32	0.91	0.91	0.32	0.28

Notes: 1.Sample size = 1,421

Table 4

TOTAL CHANGE IN QUALITY-ADJUSTED DRUG PRICES, 1999-2008

Product	Percentage change
All drugs	+3.87
Cannabis	+7.48
Cocaine	+39.70
Amphetamines	+31.30
Heroin	+2.70
Phenethylamine	-30.41
CPI	+30.3

Notes: 1. Percentage change estimated from time dummy variable coefficients in Tables 2 and A1.
2. Prices are quality adjusted where quality comprises drug composition, region and transaction quantity.
3. Source of CPI data: ABS, Analytical Measures of Consumer Price Inflation, Cpi-Analytical-Series-1.Xls, 2010

Table 5

TOTAL CHANGE IN QUALITY-ADJUSTED DRUG PRICES 1999-2008, BY REGION

Region	Percentage change
QLD	-15.82
SA	-3.73
ACT	-4.01
VIC	-2.74
NSW	+5.54
NT	+18.38
TAS	+22.99
WA	+30.98

Notes: 1.Price change is quality-adjusted where quality comprises quantity transacted and drug type.

Table 6

DISCOUNT ELASTICITIES AND IMPLIED PRODUCER MARKUP FOR ILLICIT DRUGS IN AUSTRALIA

(standard errors in parentheses)

Source	Discount elasticity		Implied producer markup $(\delta - 1) \times 100$
All drugs and all regions	-0.151	(0.004)	64.8
Drug			
Cannabis	-0.204	(0.006)	94.7
Cocaine	-0.112	(0.007)	44.3
Amphetamines	-0.180	(0.009)	82.2
Phenethylamines	-0.131	(0.006)	54.2
Heroin	-0.122	(0.005)	49.2
Region			
VIC	-0.123	(0.008)	49.2
NSW	-0.141	(0.011)	59.4
QLD	-0.174	(0.010)	76.2
SA	-0.137	(0.014)	64.8
WA	-0.145	(0.006)	59.4
TAS	-0.170	(0.013)	76.2
NT	-0.214	(0.017)	101.3
ACT	-0.163	(0.009)	70.4
Year			
1999	-0.167	(0.013)	74.5
2000	-0.182	(0.015)	83.4
2001	-0.162	(0.014)	71.6
2002	-0.156	(0.011)	68.2
2003	-0.157	(0.012)	68.7
2004	-0.168	(0.017)	75.0
2005	-0.142	(0.011)	60.5
2006	-0.144	(0.011)	61.6
2007	-0.129	(0.008)	53.7
2008	-0.130	(0.008)	54.2
Standard Deviation	0.0255		
Unweighted mean	-0.154	0.0052	67.1
Weighted mean	-0.151	0.0018	65.4
Median	-0.153		66.5

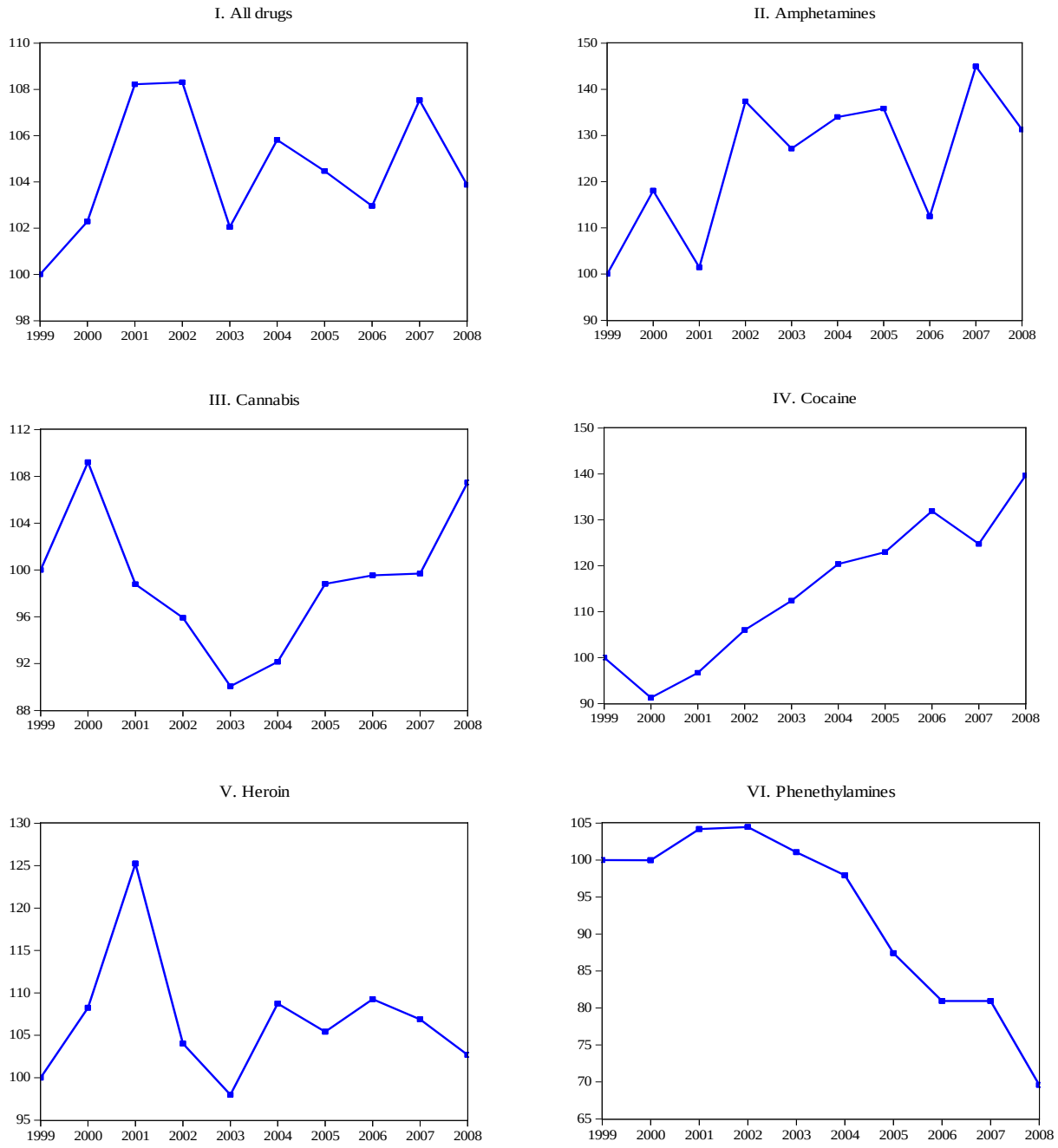
Notes: 1. These elasticities are estimated from the equation $\ln p_{iq} = c + \alpha \ln q_i +$ product dummies, where p_{iq} is the unit price of product i sold in the form of package size q.

2. The weights for the weighted means in the second last row are proportional to the reciprocals of the standard errors.

FIGURE 1

INDEX OF QUALITY-ADJUSTED PRICE LEVELS, ACROSS DRUG TYPE

(Current year dollars; base = 1999 normalised to 100)



Notes: 1. Price levels are the exponents of the time dummy coefficients in Table 3 for panel I and Table A1 for the remaining panels. Price levels are indexed to the base year 1999, which is normalised to 100.
2. Price levels are quality-adjusted where quality comprises drug composition, region, and transaction quantity.

APPENDIX

Table A1

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, ACROSS DRUG TYPES

(t-values in parentheses)

Variable	Type of Illicit Drug				
	Cannabis	Cocaine	Amphetamines	Phenethylamines	Heroin
(1)	(2)	(3)	(4)	(5)	(6)
Size	-0.20 (-36.93)	-0.11 (-15.53)	-0.18 (-19.27)	-0.13 (-22.46)	-0.12 (-22.98)
Regional dummies × 100 (Base = VIC)					
NSW	25.71 (4.33)	-3.78 (-0.56)	-36.86 (-3.90)	8.12 (1.62)	2.03 (0.38)
QLD	21.50 (3.08)	-14.64 (-1.92)	1.23 (0.13)	14.58 (2.85)	17.87 (3.36)
SA	12.92 (2.02)	-2.23 (-0.26)	-23.65 (-2.28)	4.80 (0.91)	12.86 (2.43)
WA	41.53 (8.37)	14.54 (2.08)	31.19 (3.52)	23.86 (4.81)	47.40 (9.51)
TAS	8.21 (1.69)	-17.14 (-1.53)	-6.14 (-0.62)	27.58 (5.06)	5.21 (0.62)
NT	28.49 (5.21)	8.62 (0.66)	7.40 (0.71)	45.52 (8.20)	114.98 (11.30)
ACT	4.26 (0.84)	12.46 (1.71)	8.21 (0.83)	16.23 (3.14)	-6.09 (-1.22)
Time dummies × 100					
1999	306.84 (52.68)	568.59 (62.17)	535.27 (50.11)	474.67 (90.59)	593.23 (115.08)
2000	315.65 (47.93)	559.46 (70.85)	551.87 (51.17)	474.63 (79.18)	601.15 (100.68)
2001	305.61 (56.52)	565.23 (70.90)	553.31 (54.17)	478.77 (87.59)	615.74 (103.52)
2002	302.68 (56.14)	574.42 (74.18)	567.03 (58.66)	479.03 (94.32)	597.19 (108.44)
2003	296.38 (53.55)	580.26 (63.86)	559.31 (56.97)	475.71 (89.26)	591.21 (101.67)
2004	298.68 (47.47)	587.14 (56.22)	564.54 (54.89)	472.59 (66.91)	601.62 (102.58)
2005	295.19 (54.48)	589.27 (72.94)	565.90 (56.01)	461.21 (79.64)	598.50 (102.23)
2006	306.38 (46.54)	596.29 (78.93)	547.02 (56.36)	453.53 (87.16)	602.08 (103.75)
2007	306.53 (51.06)	590.71 (76.40)	572.40 (59.16)	453.53 (87.16)	599.88 (107.28)
2008	314.05 (56.25)	602.02 (82.35)	562.50 (55.96)	438.42 (86.88)	595.89 (108.06)
$\overline{R}^2$	0.87	0.62	0.54	0.76	0.70
Sample size	226	179	389	251	376

Table A2

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, BY REGION

(t-values in parentheses)

Variable	Region							
	VIC		NSW		QLD		SA	
(1)	(2)		(3)		(4)		(5)	
Size	-0.12	(-14.94)	-0.14	(-12.40)	-0.17	(-17.69)	-0.14	(-9.47)
Drug dummies × 100 (Base = Cannabis)								
Cocaine	307.05	(34.42)	271.49	(20.82)	259.99	(24.02)	286.71	(16.82)
Amphetamine	270.51	(36.43)	203.39	(16.36)	241.39	(23.83)	227.32	(15.53)
Phenethylamines	187.51	(23.21)	161.29	(12.09)	165.12	(16.13)	169.35	(11.02)
Heroin	320.99	(42.45)	294.45	(23.62)	304.42	(29.88)	313.82	(21.88)
Time dummies × 100								
1999	276.97	(32.51)	308.94	(17.86)	328.66	(27.56)	288.54	(16.61)
2000	281.81	(26.44)	303.56	(20.66)	331.88	(27.07)	290.68	(18.71)
2001	286.08	(31.21)	315.30	(22.13)	330.67	(30.86)	296.11	(14.59)
2002	283.13	(32.84)	327.77	(21.29)	305.36	(25.52)	308.92	(19.07)
2003	280.84	(30.80)	306.99	(17.23)	312.13	(26.54)	285.28	(15.68)
2004	291.62	(25.37)	307.92	(16.05)	308.60	(24.92)	295.97	(14.86)
2005	270.15	(31.37)	303.28	(21.06)	315.12	(23.80)	318.94	(18.44)
2006	270.86	(27.86)	308.40	(21.83)	316.59	(27.78)	300.73	(18.58)
2007	265.14	(27.34)	312.00	(22.20)	314.69	(29.20)	314.52	(19.54)
2008	274.19	(33.07)	314.33	(22.31)	311.44	(28.95)	284.74	(14.19)
$\overline{R}^2$	0.93		0.84		0.92		0.85	
Sample size	207		198		168		152	

Table continued next page

Table A2 (continued)

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, BY REGION

(t-values in parentheses)

Variable	Region							
	WA		TAS		NT		ACT	
(1)	(6)		(7)		(8)		(9)	
Size	-0.15	(-23.54)	-0.17	(-13.28)	-0.21	(-12.56)	-0.16	(-18.66)
Drug dummies × 100 (Base = Cannabis)								
Cocaine	282.86	(44.45)	268.40	(20.83)	258.22	(13.48)	313.38	(42.22)
Amphetamine	257.83	(46.27)	248.98	(34.70)	238.90	(22.53)	270.91	(39.43)
Phenethylamines	167.78	(26.52)	188.46	(23.11)	194.39	(16.89)	194.12	(26.49)
Heroin	324.86	(56.79)	310.84	(28.91)	382.44	(21.63)	300.54	(45.73)
Time dummies × 100								
1999	307.20	(41.46)	291.01	(30.03)	314.04	(19.77)	288.34	(31.40)
2000	309.96	(39.15)	294.99	(31.10)	332.16	(21.50)	293.07	(26.79)
2001	318.81	(42.91)	294.04	(32.49)	325.23	(23.85)	306.29	(38.11)
2002	324.52	(49.67)	307.47	(32.72)	333.57	(23.82)	293.22	(38.63)
2003	323.91	(49.57)	309.33	(32.37)	321.53	(24.45)	292.83	(36.25)
2004	339.11	(46.21)	311.44	(31.72)	323.78	(21.58)	293.88	(38.00)
2005	319.06	(41.38)	303.45	(28.77)	348.31	(25.93)	295.63	(35.96)
2006	328.32	(49.20)	305.99	(23.24)	295.66	(16.18)	287.94	(35.59)
2007	333.72	(45.45)	303.69	(31.67)	357.24	(25.87)	299.14	(37.24)
2008	334.19	(41.98)	311.70	(32.00)	330.91	(21.71)	284.25	(34.22)
$\overline{R}^2$	0.96		0.96		0.94		0.95	
Sample size	247		139		102		208	

Table A3

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, OVER TIME

(t-values in parentheses)

Variable	Year									
	1999		2000		2001		2002		2003	
(1)	(2)		(3)		(4)		(5)		(6)	
Intercept	3.06	(22.50)	3.48	(20.00)	3.11	(22.98)	2.93	(28.65)	2.90	(28.83)
Size	-0.17	(-12.68)	-0.18	(-11.96)	-0.16	(-11.71)	-0.16	(-14.16)	-0.16	(-13.67)
Drug dummies × 100 (Base = Cannabis)										
Cocaine	274.27	(15.26)	235.03	(15.45)	265.39	(19.49)	284.11	(26.02)	292.25	(27.37)
Amphetamines	218.54	(16.19)	209.81	(15.57)	239.97	(21.50)	263.20	(30.04)	262.19	(32.52)
Phenethylamines	183.49	(13.21)	154.69	(10.11)	189.54	(14.88)	198.86	(21.33)	199.50	(22.27)
Heroin	304.97	(23.90)	282.76	(20.36)	328.84	(28.98)	319.04	(34.44)	314.98	(35.17)
Regional dummies × 100 (Base = VIC)										
NSW	-8.22	(-0.55)	-23.54	(-1.70)	-12.20	(-0.90)	7.90	(0.73)	-13.23	(-1.06)
QLD	22.73	(1.67)	7.71	(0.50)	3.08	(0.22)	-8.69	(-0.78)	-1.44	(-0.14)
SA	-6.96	(-0.52)	-30.52	(-1.93)	-23.29	(-1.37)	3.58	(0.33)	-20.21	(-(1.76)
WA	19.52	(1.59)	2.89	(0.20)	15.55	(1.14)	30.07	(3.23)	33.22	(3.87)
TAS	-5.25	(-0.37)	-30.79	(-1.87)	-21.46	(-1.46)	4.22	(0.37)	9.45	(0.89)
NT	40.04	(2.59)	16.12	(0.85)	13.02	(0.82)	29.58	(2.31)	18.08	(1.64)
ACT	0.10	(0.01)	-13.10	(-0.76)	-2.52	(-0.18)	-1.35	(-0.14)	1.82	(0.19)
$\overline{R}^2$	0.88		0.88		0.91		0.93		0.95	
Sample size	143		118		144		166		140	

Table continued next page

Table A3 (continued)

ESTIMATES OF HEDONIC PRICING MODELS FOR ILLICIT DRUGS IN AUSTRALIA, OVER TIME

(t-values in parentheses)

Variable	Year									
	2004		2005		2006		2007		2008	
(1)	(7)		(8)		(9)		(10)		(11)	
Intercept	2.98	(15.84)	2.73	(25.90)	2.96	(24.96)	2.74	(29.67)	2.88	(36.09)
Size	-0.17	(-9.75)	-0.14	(-12.36)	-0.14	(-13.51)	-0.13	(-15.56)	-0.13	(-16.07)
Drug dummies × 100 (Base = Cannabis)										
Cocaine	297.10	(16.09)	306.90	(28.53)	298.50	(28.19)	299.19	(36.36)	309.55	(37.36)
Amphetamines	264.67	(19.74)	265.68	(27.94)	232.65	(23.59)	263.44	(36.43)	252.33	(33.61)
Phenethylamines	187.65	(11.19)	187.39	(16.68)	162.15	(15.66)	171.18	(21.60)	153.29	(20.69)
Heroin	320.19	(21.52)	323.41	(30.99)	313.14	(30.70)	315.20	(40.02)	309.90	(38.53)
Regional dummies × 100 (Base = VIC)										
NSW	-25.67	(-1.26)	-6.44	(-0.62)	-4.17	(-0.42)	7.83	(0.94)	2.20	(0.30)
QLD	-11.41	(-0.68)	11.77	(0.86)	10.36	(0.95)	18.39	(2.01)	7.76	(0.97)
SA	-18.61	(-1.00)	24.97	(2.28)	4.15	(0.39)	27.36	(3.01)	-1.02	(-0.10)
WA	39.74	(2.41)	37.43	(3.37)	39.22	(4.15)	52.63	(6.21)	47.23	(5.82)
TAS	5.96	(0.32)	17.01	(1.25)	27.14	(1.86)	16.57	(1.73)	20.52	(2.36)
NT	4.64	(0.22)	48.47	(3.80)	22.93	(1.48)	55.07	(5.10)	47.38	(4.37)
ACT	-5.88	(-0.36)	16.25	(1.48)	3.67	(0.35)	19.41	(2.33)	1.67	(0.22)
$\overline{R}^2$	0.91		0.93		0.92		0.95		0.95	
Sample size	112		138		146		160		154	

Table A4

MEAN DRUG PRICES IN AUSTRALIA, 1999-2008

(Dollars per gram, standard deviation in parentheses)

A. Amphetamine - purchase weight (grams)

Region	0.1	0.7	1.0	2.0	3.5	7.0	28.0	448.0	1000.0
ACT	580	333	298	275	210	43	157	84	125
NSW	692	-	198	204	69	173	43	82	101
NT	623	-	310	-	152	-	159	112	-
QLD	580	143	266	300	163	185	140	100	-
SA	482	-	266	360	140	-	131	153	175
TAS	490	200	245	238	214	164	168	-	-
VIC	455	257	211	257	150	147	145	121	154
WA	614	273	312	-	346	235	216	154	98
Mean	565	241	263	272	181	158	145	115	131

B. Cannabis - purchase weight (grams)

	1.0	7.0	14.0	28.0	448.0	1000.0
ACT	23.1	13.9	12.8	10.8	6.7	5.0
NSW	26.0	-	-	12.9	10.3	-
NT	33.4	-	14.1	11.0	8.6	-
QLD	26.7	-	-	12.2	8.5	-
SA	28.8	21.4	14.3	13.0	6.4	-
TAS	25.0	13.3	12.1	11.2	7.8	6.4
VIC	22.6	14.3	8.8	9.4	7.0	6.5
WA	37.7	21.4	17.9	14.3	9.1	7.8
Mean	27.9	16.9	13.3	11.9	8.05	6.43

C. Cocaine – purchase weight (grams)

	0.1	1.0	7.0	28.0	448.0	1000.0
ACT	775	373	249	274	195	170
NSW	528	283	177	221	180	174
NT	-	413	-	214	-	-
QLD	500	272	231	220	-	-
SA	500	308	-	253	-	172
TAS	-	300	250	-	-	-
VIC	1000	277	250	261	181	200
WA	1000	307	357	259	243	193
Mean	717	317	252	243	200	182

D. Heroin – purchase weight (grams)

	0.05	0.25	0.1-0.3	0.4-0.6	0.6-0.8	1.0	3.5	10	14	28	350	448	700	1000
ACT	1000	417	574	377	451	346	306	400	260	239	300	279	-	-
NSW	-	440	556	359	369	346	357	-	357	289	286	205	235	103
NT	1900	-	2917	-	-	583	-	-	-	464	-	-	-	-
QLD	500	560	838	760	836	464	346	-	-	289	357	179	-	-
SA	1000	400	648	365	-	455	452	350	-	292	291	-	157	150
TAS	1000	-	500	500	381	458	-	-	-	-	-	223	-	-
VIC	850	-	621	391	307	383	280	303	332	295	221	218	143	130
WA	1275	750	1028	600	560	538	463	-	420	410	341	351	-	-
Mean	1075	513	960	479	484	447	367	351	342	325	299	243	178	128

E. Phenethylamines – purchase quantity (number of tablets)

	1	10	25-100	100-1000	>1000
ACT	41.4	43.3	28.6	22.1	17.3
NSW	46.5	29.2	25.4	17.5	13.1
NT	60.8	35.0	37.5	34.2	20.0
QLD	43.6	38.3	25.9	20.2	12.9
SA	38.6	25.3	29.0	20.0	15.8
TAS	45.7	39.2	28.8	23.2	20.0
VIC	34.2	27.2	24.6	18.9	20.0
WA	43.1	32.9	28.1	26.5	25.1
Mean	44.2	33.8	28.5	22.8	17.7

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