DRUG POLICY MODELLING PROJECT
MONOGRAPH 09

HEROIN MARKETS IN AUSTRALIA: CURRENT UNDERSTANDINGS AND FUTURE POSSIBILITIES

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THE DRUG POLICY MODELLING PROJECT

This monograph forms part of the Drug Policy Modelling Project (DPMP) Monograph Series. Drugs are a major social problem and are inextricably linked to the major socio-economic issues of our time. Our current drug policies are inadequate and governments are not getting the best returns on their investment. There are a number of reasons why: there is a lack of evidence upon which to base policies; the evidence that does exist is not necessarily analysed and used in policy decision-making; we do not have adequate approaches or models to help policy-makers make good decisions about dealing with drug problems; and drug policy is a highly complicated and politicised arena.

The aim of the Drug Policy Modelling Project (DPMP) is to create valuable new drug policy insights, ideas and interventions that will allow Australia to respond with alacrity and success to illicit drug use. DPMP addresses drug policy using a comprehensive approach, that includes consideration of law enforcement, prevention, treatment and harm reduction. The dynamic interaction between policy options is an essential component in understanding best investment in drug policy. Stage One has: a) produced new insights into heroin use, harms, and the economics of drug markets; b) identified what we know about what works (through systematic reviews); c) identified valuable dynamic modelling approaches to underpin decision support tools; and d) mapped out the national policy-making process in a new way, as a prelude to gaining new understanding of policy-making processes and building highly effective research-policy interaction.

This monograph (No. 09) approaches drug markets from an economic perspective. It outlines central economic concepts in an accessible form for the non-economist, then reviews four key aspects of the Australian heroin drug market. These are: measuring the size of the heroin market; heroin prices; the heroin distribution network (using a risk and prices framework); and the relationship bteween heroin price and harm (in this case overdose). The monograph sets out to summarise the existing information and data, and identify what we don't know about the heroin drug market. The authors conclude with a number of insights about the heroin market in Australia. We have much information to inform our understanding but it appears to be under-utilised. The amount of heroin consumed may be substantially less than is commonly thought (potentially attributable to the heroin 'shortage'). Price is responsive to market changes - large increases in heroin price occurred with the decreased availability of heroin. The authors also demonstrate a strong relationship between heroin price and non-fatal heroin overdose - as price increases, overdoses decrease. Future research into heroin markets in Australia could provide more detailed examination of causal relationships (and move away from descriptive research).

Monographs in the series are:

01. What is Australia's "drug budget"? The policy mix of illicit drug-related government spending in Australia
02. Drug policy interventions: A comprehensive list and a review of classification schemes
03. Estimating the prevalence of problematic heroin use in Melbourne
04. Australian illicit drugs policy: Mapping structures and processes
05. Drug law enforcement: the evidence

06. A systematic review of harm reduction

07. School based drug prevention: A systematic review of the effectiveness on illicit drug use

08. A review of approaches to studying illicit drug markets

09. Heroin markets in Australia: Current understandings and future possibilities

10. Data sources on illicit drug use and harm in Australia

11. SimDrug: Exploring the complexity of heroin use in Melbourne

12. Popular culture and the prevention of illicit drug use: A pilot study of popular music and the acceptability of drugs

13. Scoping the potential uses of systems thinking in developing policy on illicit drugs

DPMP strives to generate new policies, new ways of making policy and new policy activity and evaluation. Ultimately our program of work aims to generate effective new illicit drug policy in Australia. I hope this Monograph contributes to Australian drug policy and that you find it informative and useful.

Alison Ritter

Alison Ritter
Director, DPMP

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TABLE OF CONTENTS

Introduction **1**
Outline of the monograph 1
An economics primer **2**
Measuring the heroin market **7**
Quantity 7
Previous quantity estimates 7
The number of heroin users 8
Quantities of heroin consumed 9
Total quantity consumed 11
Total quantity imported 12
Heroin prices **14**
Sources of price information 14
Price 15
Prices over time 19
Price mark-ups/ quantity discounting 21
Expenditure on heroin 22
The current state of market measurement 23
Understanding the Australian heroin distribution network **24**
Revenues ("value added") at the various market levels 25
The "risk and prices" model 26
Heroin supply cost components 27
Compensation for time spent supplying drugs 28
Compensation for the risks of incarceration and violence 28
Operational expenses and proprietors' return to capital (i.e. profit) 29
Applying the "risk and prices" model 30
The relationship between heroin prices and overdoses **31**
Data used 31
Methods and analysis 32
The potential for the further use of high-frequency price data 33
Conclusion **34**
Key insights 34
Future research 35

References 36
Appendix 1: Constructing the Heroin Price Series for Victoria 41
Appendix 2: Estimation of prices at different quantities (weights) 49

LIST OF TABLES

Table 1: Previous estimates of the amount of pure heroin consumed in Australia 8
Table 2: Estimates of the impure heroin consumed in Australia, 2003 11
Table 3: Estimates of the pure heroin imported into Australia, 2003 12
Table 4: Heroin prices at different quantities 21
Table 5: Estimates of the expenditure on heroin in Australia, 2003 23
Table 6: Estimated revenues at different levels of the distribution network 26
Table 7: Prices of caps and grams 49
Table 8: Prices of ounces, half-cattis and cattis 50
Table 9: Price of kilograms 50
Table 10: Purity assigned to heroin weights 50
Table 11: Heroin prices at different quantities 51

LIST OF FIGURES

Figure 1: Basic market diagram (L) and the effect of a shift in the demand curve (R) 2
Figure 2: Basic market diagram (L) and the effect of a shift in the supply curve (R) 3
Figure 3: Frequency of Victoria Police seizures by impure weight, 1998 to Feb/2004 10
Figure 4: Heroin purity and (gram) price by jurisdiction, 1998-99 to 2003-04 (ACC) 18
Figure 5: Price paid, unadjusted for purity, Victoria, 1998 to Feb/2004 20
Figure 6: Price per pure gram, Victoria, 1998 to Feb/2004 20
Figure 7: Heroin prices and overdoses (definitely heroin), Victoria, 1998 to 2004 32
Figure 8: Actual Monthly Ambulance Calls to What Would Be Predicted Based on Price Trends from a Constant Elasticity Model (eta = -1.12) 33
Figure 9: Mean, median and modal price for a gram of heroin (unadjusted for purity) 47
Figure 10: Mean and median purity for heroin 47
Figure 11: Average Mass of Seizures in 0.8 to 1.2 Gram Range (Quarterly) 48

INTRODUCTION

This monograph brings together what is currently known about heroin markets in Australia, and what insights are possible from using this information. While heroin use has been of major concern in Australia and various market indicators are reported regularly, comprehensive examinations of the Australian heroin market have been rare.

Drug researchers have documented a range of characteristics relevant to heroin demand and supply, such as frequency of use, price, purity at retail levels and availability. Law enforcement agencies have periodically recorded additional information on supply characteristics, such as the price of quantities of heroin above retail level, the amounts of heroin seized and the number of heroin-related arrests. In the Australian context much of the analysis of this information has been descriptive, with little consideration given to the underlying relationships and interactions between variables.

Academic economists have published a small number of refereed papers on Australian illicit drug markets, although nearly all have been on marijuana, presumably because it is easier to study marijuana use patterns, not because it is the substance that causes the greatest social costs. Heroin, with a relatively small number of users who are hard to survey and many unknowns surrounding its supply, does not easily lend itself to the techniques or use of data sources normally favoured by economists. These complexities make application of accepted economic models and principles invaluable, but at the same time make heroin data inconvenient for purposes of testing general economic theories or for developing new methods.

By taking a systematic approach – via the adoption of an economic framework – to considering what is known about how heroin is bought and sold throughout its distribution chain in Australia, we seek to generate insights into Australia's heroin market and to identify what information is required to develop a more refined understanding of this market.

Outline of the monograph

The monograph is set out as follows. Some central economics concepts are covered in the next section, to motivate the analysis that follows and to assist those unfamiliar with how economists frame market analysis. The third section covers information on the measurement and dimensions of heroin markets in Australia. In the fourth section, this information is combined with an economic model of heroin supply to develop some understanding of how heroin is distributed, and what impact law enforcement may have on the prices charged. In the fifth section, price information is analysed together with heroin-related overdose numbers to show that price can be a powerful indicator of the harms that result from heroin use. We conclude with a number of key insights, and identify future research projects that would enhance our understanding of the operation of heroin markets in Australia, and how governments can best minimise the negative consequences of their operation.

AN ECONOMICS PRIMER

With little interaction between economists and drug researchers, many of the implicit understandings about markets shared by economists remain unfamiliar to the latter group. For that reason, it is worth providing some background on the worldview inherent in the analyses that follow.

There are many economic concepts relevant to understanding drug markets, including notions of agglomeration economies, transaction costs, full (including non-monetary) costs of consumption, discounting, principal-agent problems, and so on. However, perhaps the most elemental idea is that of a supply curve and a demand curve intersecting at a market equilibrium, which occurs at the market-clearing price and quantity.

The starting point of this analysis is that the market for heroin, despite its illicit status and addictive nature, shares characteristics with other markets that economists study. In particular, heroin markets can be described as having demand and supply schedules, or curves, that indicate how much consumers would like to purchase and how much suppliers would like to provide, respectively, each as a function of the market price.

Most markets conform to the “laws” of demand and supply, meaning that the demand curve slopes down and the supply curve slopes up. For the demand curve, this means that when the price rises, the amount consumers wish to buy and use declines (and vice versa; assuming that nothing about the users change). On the other hand, the amount suppliers are willing to produce and sell will increase when the price rises (and vice versa; assuming nothing about the suppliers or the conditions they face changes). When aspects of the markets change – the rapid decrease in 2001 in the amount of heroin that was available in Australia being the starkest recent example – prices change to ensure the amount supplied will soon equal the amount demanded. Thus prices effectively coordinate the actions of buyers and sellers so that in the long and even the medium run there are not physical shortages or excess inventories.

These ideas are commonly summarised in diagrams such as the one on the left hand side in Figure 1. The “laws” of demand and supply are described by curves that detail how much would be provided and desired at each available price. The observed price and quantity is determined by where the demand and supply curves intersect. (The figures are drawn with straight lines, but in general the supply and demand curves can be curves.)

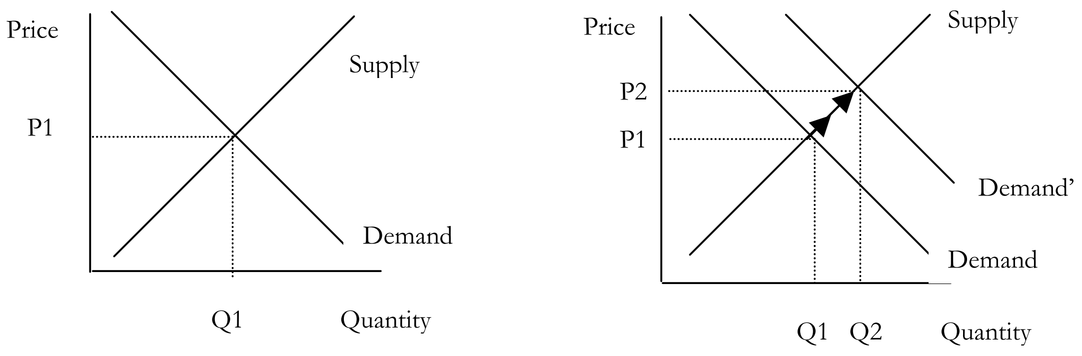


Figure 1: Basic market diagram (L) and the effect of a shift in the demand curve (R)

When the underlying considerations, costs, alternatives or incentives of buyers or sellers change, then either one or both of the demand and supply relationships will change. For example, Figure 1 shows how this economic model would depict an increase in the amount demanded at each price, which might occur because of changes in public perceptions about the drug (seen to be less harmful, more fun, more 'cool', etc.) or because users develop dependence. This *shift in the demand curve* results in a *movement along the supply curve.* There are several things worth noting:

1. The quantity traded increases, but not as much as the increase in quantity demanded at the same price. This is because price increases, absorbing some of the increase in the amount demanded.
2. More is supplied even though there are no changes to costs and incentives faced by suppliers (i.e. no change to the supply curve).
3. The nature of the demand and supply relationships matter to the extent to which price changes and quantity changes. In the above example, the same change in demand could, just by changing the supply curve, lead to an increase in quantity but no change in price at one extreme, or an increase in price but no change in quantity at the other.

It is worth repeating this exercise for a shift in the supply curve. An upward movement in the supply curve, as shown in Figure 2, means that producers and distributors are willing to supply less at each price, maybe due to the cost at which they purchase heroin from their suppliers increasing (opium crops failing, suppliers getting arrested or retiring). This *shift in the supply curve* results in a *movement along the demand curve*, and it can be observed that:

4. Again, the magnitude of the change in the supply relationship is only partially translated into a decrease in the quantity traded.
5. Less is demanded even though there are no changes to costs and incentives faced by consumers (i.e. no change to the demand curve).
6. The nature of the demand and supply relationships again matter as to the extent to which price changes and quantity changes.

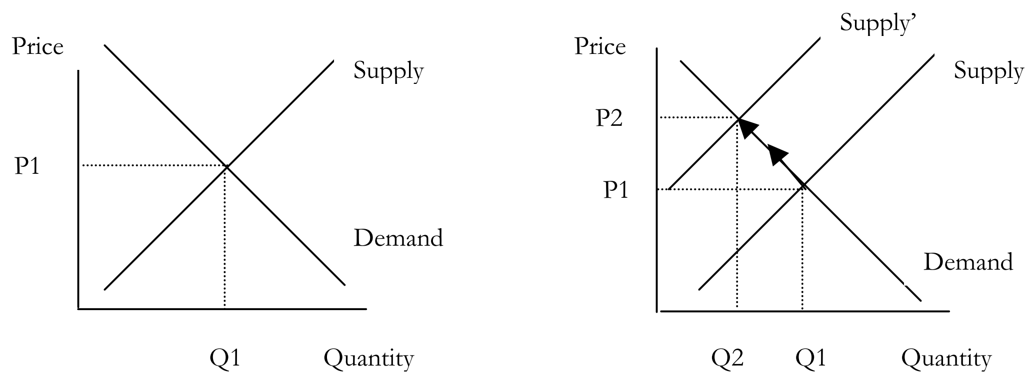


Figure 2: Basic market diagram (L) and the effect of a shift in the supply curve (R)

If the two examples are considered together, it can be seen that knowing only what has happened to the price would not be enough to know what underlying changes are occurring in the market. Price has increased in both cases, yet for very different reasons. Alternative scenarios can be developed where quantity changes in the same direction because of a shift in either the demand and supply curve. As a result, an understanding of both price and quantity is vital to understanding what is happening in a market.

This economic framework is useful for drug policy analysis for at least two broad reasons. First, it allows one to assess fairly directly the effects of programs designed to reduce supply by observing their effects on price. Many demand-reducing interventions can be assessed using the familiar tools of evaluation research. In contrast, many interventions designed to constrain supply, such as national enforcement programs and statewide laws, do not offer opportunities for formal assessments or trials. However, researchers have looked for the signature of enforcement program success in changes in market price and/or purity (e.g., Crane et al., 1997; Yuan & Caulkins, 1998).

Second, inasmuch as price affects quantities demanded, efforts to monitor and trend changes in demand via metrics related to consumption (such as prevalence, overdoses, ambulance call-outs, etc.) have to control for changing market conditions to avoid reaching incorrect conclusions. As long as the supply curve is not perfectly flat, there is not a one-to-one correspondence between measures of consumption and the underlying level of demand.

Before considering heroin in terms of this framework, it is important to address four issues: 1) Do heroin users adjust consumption rates in response to changes in price?; 2) Do heroin suppliers collectively adjust quantities produced in response to changes in price; 3) Is it really reasonable to think of one market for heroin?; and 4) Does the market price and quantity produced adjust fast enough to justify a particular focus on the long-run equilibrium point identified by the intersection of the supply and demand curves?

1) Do heroin users respond to changes in price (slope of the demand curve)

With regard to the first point, whether price affects consumption, the key issue is the addictive nature of heroin. To the lay reader, it may seem to limit the application of economic analysis, as it has often been thought that people addicted to heroin will consume the same amount, irrespective of the price being charged for it. However, although there is not direct evidence from Australia about heroin, it seems that people addicted to drugs do change the amount they use in response to changes in the price.

Change in use as a result of change in price has been found in the numerous studies of the price elasticity of demand for different illicit drugs. The price elasticity of demand is the percentage change in quantity in response to a percent change in price (i.e. $E = \Delta\%Qty \ / \ \Delta\%Pr$). If a 1% increase in price decreases quantity by 1%, then the elasticity of demand is said to be -1. If the good has an elastic demand, then quantity will decrease by more than the price increases. In these cases, the absolute value of the elasticity is more than one (eg. if a 1% increase in price leads to a 2% decrease in quantity then $E = -2\%/1\% = -2$). If the good has an inelastic demand, then the quantity will decrease by less the change in price, and the elasticity will be less than one (eg. a 1% increase in price leads to a 0.5% decrease in quantity then $E = -0.5\%/1\% = -0.5$).

The idea that heroin users do not change the amount they want to use is equivalent to the elasticity of demand being zero or close to zero. However, when Manski, Pepper and Petrie (2001) reviewed US studies in this area, including ones estimating heroin elasticities, they found the estimates of the price elasticity of demand for various illicit drugs ranged between –0.6 and –2.5. While the degree of responsiveness varied, in all studies there was a change in demand in response to a change in price. Australian econometric studies of the demand for marijuana by

Williams (2004) and Zhao and Harris (2004) support this finding, as does Weatherburn, Jones, Freeman and Makkai's (2003) study of Sydney injecting drug users' behaviour in 2001, where they found users decreased their heroin use in response to an increase in the heroin price. In summary, it seems that price does affect the demand for heroin and that market analysis is an important tool for understanding policy impacts.

2) Do costs of supplying heroin increase as quantity increases? (slope of the supply curve)

Although there is a considerable body of empirical work documenting that the consumption of dependence-inducing substances, including illicit drugs, responds to price changes, there is not a comparable literature estimating the slope of the supply curve (i.e., the elasticity of supply). The main defence of the idea of modelling aggregate supplier behaviour via a supply curve is the observation that, at least above the retail level, drug suppliers pursue their activities for the same reason that legitimate business people do – to make money – and the idea that the greater monetary returns offered by higher prices should elicit greater effort and, hence, greater production, has generally not been controversial.

The main theoretical controversy concerning the supply curve is whether it, in fact, slopes upwards for illicit drugs. The rationale for an upward-sloping supply curve is that as more of a good has to be produced, more expensive inputs have to be used (e.g. more costly or less productive workers). However, it is possible that the characteristics of supplying heroin mean that this is offset by "external economies of scale". The notion of an external economies of scale is that, as the quantity suppliers bring to the market increases, their unit costs of production may decline, leading to an inverse relationship between production volume and cost. Most familiar scale economies are internal. The more cars a manufacturer produces, the more efficient that producer can be, but no other auto company gets more efficient just because someone else is producing at high volume. For illicit drug markets, however, it has been hypothesized that there are two important external economies of scale, whereby increasing sales volume for the market as a whole reduces everyone's production cost.

The first argument, from Kleiman (1993), goes by the name "enforcement swamping". The idea is that enforcement risk is an important part of drug suppliers' cost of production (as is discussed later in the monograph) and that the larger the volume of market activity, the lower the risk per drug supplier because the same amount of enforcement effort is diluted over a larger number of targets. This is akin to individual small fish being safer when swimming in a large school than when swimming with just a few other fish. The second factor is the idea that a denser market allows customers (including mid-level suppliers buying from higher-level suppliers) to comparison shop more easily, which makes it harder for suppliers to extract "monopoly rents". To the extent that these external economies of scale are important, they would tend to reduce or even overwhelm the familiar tendency for the price per unit suppliers demand to increase as the market volume increases.

There is not enough evidence to understand the role of external economies of scale. In any case, most of the insights we are concerned with here depend primarily on the location of the supply curve, rather than its shape (although the slope of the supply curve will affect the extent of changes in price and quantity).

3) Is it reasonable to speak of just one market for heroin?

We have characterised the situation as one where there is one market-clearing price and quantity. This might seem to fly in the face of such obvious observations as that prices can be higher in some states than in others and, at an ever more local level, there can be distinct retail markets.

However, this is not a problem per se, as an analogy might illustrate. Oil is clearly more expensive in some parts of the globe than in others, nevertheless analysts routinely speak of "the price of oil" by reference to one of the standard price benchmarks. What these analysts are recognizing is that even though prices everywhere are not the same, they are linked. When economists speak of "a" market-clearing price for "the" heroin market, they are not imagining that heroin sells for the same price everywhere or that there are not physically separated clusters of market activity. Rather, they are assuming prices are linked in all of these separate submarkets sufficiently tightly that it is sensible to think in terms of a single benchmark price.

There has not been a great deal of empirical work whose primary goal was to evaluate the extent to which this "law of one price" holds in illicit drug markets. ONDCP (2004a) observed broadly similar long-run trends in drug prices across the larger US cities, so at some level the law of one price probably holds, but at the same time there seems to be more diversity in illicit drug prices than there are in many licit goods (Reuter & Caulkins, forthcoming).

In addition to considering the supply of and demand for heroin at a point in time as occurring only at one price and quantity, by only looking at "the heroin market" there is an assumption that the use and supply of heroin can be analysed without any consideration given to the supply and use of other drugs. This is a clearly a simplification, as other drugs are substitutes for heroin. For example, Weatherburn et al. (2003) found that, of the 165 Sydney heroin users they surveyed after the heroin "shortage", a majority (56%) stated they were using more of other drugs to make up for reductions in their heroin use.

In this and other situations, characterising the heroin market as self-contained means some market dynamics could be missed (Manski et al., 2001). This is a necessary simplification, as it is complex to even consider heroin by itself. However, it should be recognised as such, and the heroin market will be affected by any large changes in related markets (eg. amphetamines).

4) Is the long-run equilibrium reached soon enough to make it relevant?

Economists typically focus attention on market equilibria, implicitly assuming that prices and quantities sold adjust fast enough to external shocks to make the intersection of the supply and demand curve a singularly important point for understanding market behaviour. Again, there has not been much empirical work explicitly testing this idea. Caulkins (1994, 1997) found some circumstantial evidence that US cocaine and crack market equilibriation is slow enough to have disequilibrium manifest in some annual data, and slow adjustment to equilibrium is one appealing explanation for why US cocaine and heroin prices fell during the 1980s even as enforcement intensity increased, but there is not yet sufficient evidence concerning speed of adjustment in illicit drug markets to draw definitive conclusions or to dethrone the traditional microeconomic assumption of rapid adjustment.

MEASURING THE HEROIN MARKET

As suggested in the economic primer, ideally one would gather complete information about the entire “schedule” of quantities that would be purchased and that would be brought to market as a function of price (the demand and supply curve, respectively), but all we can readily observe is the current equilibrium (intersection of those two curves) and, with the help of some econometrics, the slopes of those two curves in the vicinity of that current equilibrium.

We begin here by trying to characterize quantitatively the current equilibrium, specifically to estimate the quantities traded, the prices paid and the amount of money expended on heroin in Australia. There is neither a comprehensive nor systematic understanding of demand and supply determinants. As a consequence, it is simpler to first estimate Australian heroin quantities and prices, before considering our current state of knowledge about how they are determined and affected by the actions of drug users, sellers and governments.

It is useful to understand a couple of characteristics about heroin and the way it is supplied. First, all heroin supplied in Australia is grown overseas, either in the Golden Triangle (Burma, Laos and Thailand), the Golden Crescent (Afghanistan) or in Central and South America. Burma is the primary source of heroin for the Australian market (Australian Crime Commission (ACC), 2005). It is mainly the purest type of heroin (Grade No. 4), which is white powder and readily injected (ACC, 2005).[1] Analysis of Victorian Police forensic data, which is discussed below, suggests that approximately 90% of retail-level heroin is in compressed (“rock”) form.

Quantity

An estimate of the quantity of heroin annually consumed in Australia is made for 2003, which is the most recent year for which reasonable amounts of data were available (although it should be noted that some of the data are for 2002 or for the 2003/04 financial year). There have previously been several estimates of the quantity of heroin consumed or imported into Australia. Nearly all have been consumption-based estimates that combine information about the number of heroin users with information about their per capita consumption rates to arrive at a total estimate.

Previous quantity estimates

Weatherburn and Lind (1995) estimated that the annual consumption of pure heroin in Australia was between 1.0 and 4.8 tonnes in 1993 and 1994. A summary of each component of the estimate is provided in Table 1. Hall, Ross, Lynskey, Law and Degenhardt (2000) used new prevalence estimates together with the same assumptions about dose frequencies and quantity to calculate that between 2.1 and 2.4 tonnes (i.e. metric tons) of pure heroin was consumed in Australia in 1997 (also summarised in Table 1).

Hall, Degenhardt and Reuter (2004), in summarising past estimates, cite estimates by The National Crime Authority (2001, cited in Hall et al., 2004) that heroin consumption was between 6.7 and 8 tonnes per year and Interpol (1999, cited in Hall et al., 2004) that three to four tonnes of heroin enter Australia each year.[2] Hall et al. (2004) concluded that annual Australian heroin consumption in the late 1990s was between two and eight tonnes.

1 Grade 3 heroin is tan-coloured, granular and known as brown rock; Grades 1 and 2 are unprocessed raw heroin and rarely encountered in Australia) (ACC, 2005).

2 The Interpol estimate did not seem to be based on consumption, however it is not clear upon what basis it was developed.

Table 1: Previous estimates of the amount of pure heroin consumed in Australia

Study	Bound of estimate	Regular users		Recreational users		Amount of pure heroin per dose	Estimate
		Number	Frequency of use	Number	Frequency of use		
Weatherburn & Lind (1995)	Lower	36,000	17.5 per wk	72,000	0.5 per wk	0.03 grams	1.0 tonnes
	Higher	150,000	17.5 per wk	450,000	1 per wk	0.03 grams	4.8 tonnes
Hall et al. (2000)	Lower	74,000	17.5 per wk	148,000	0.5 per wk	0.03 grams	2.1 tonnes
	Higher	74,000	17.5 per wk	222,000	1 per wk	0.03 grams	2.4 tonnes

It is worth developing a new "ground-up" consumption-based estimate for several reasons. First, there have been dramatic changes in purity-adjusted heroin prices and heroin-related overdoses since these estimates were made, and we have every reason to believe that quantities consumed change when prices change so dramatically. In addition, the assumptions and approaches involved in the above estimates are not always clear, particularly around whether an estimate is for pure or impure heroin and on what basis they determined to use ranges on some values but not others.

The number of heroin users

Much epidemiological research focuses only on "problematic", "regular" or "frequent" heroin users, rather than all heroin users. While the labels applied to the more frequent users of heroin varies from study to study, there seems to be a consistent focus on users who are typically daily, or near-daily, injectors of heroin, and of other opioid and sedative drugs when heroin is not available (Hall et al., 2000). Given this focus and the fact that such frequent users account for the great majority of consumption, it is most convenient to consider the number of frequent heroin users before extending the estimate to include less regular users.

Frequent (regular, dependant or problematic) heroin users

Dietze, Hickman and Kimber (2005) discusses the problems with using household surveys to derive estimates the prevalence of frequent heroin, and the range of indirect estimation techniques available to epidemiologists. Their estimate for the prevalence of problematic heroin use in Melbourne is combined with an estimate by Degenhardt, Rendle, Hall, Gilmour and Law (2004a) of the number of regular heroin users in New South Wales to develop an estimate of the number of frequent heroin users in Australia.

This was better than developing an Australian estimate by extrapolating figures from one jurisdiction, which has been what is normally done (Dietze et al., 2005). However, there are important differences in the two studies that should be noted. Dietze et al. (2005) applies a capture-recapture method to ambulance attendances at drug-related events to estimate the number of problematic heroin users in Melbourne in 2003/04. Degenhardt et al. (2004a) estimates the number of current regular heroin users in New South Wales in 2002 using information on the number of opioid-induced deaths, ambulance attendances at suspected overdoses, pharmacotherapy clients and drug offence arrests. While combining estimates from different years is not ideal, it was not expected to lead to too much additional variation, as there were only small changes to other heroin usage indicators between 2002 and 2003 (Breen, Degenhardt, Roxburgh, Bruno, Fetherston, Jenkinson, Kinner, Moon, Proudfoot, Ward & Weekley, 2004).

Dietze et al. (2005) estimated that there were 11,541 problematic heroin users in Melbourne in 2003/04, with a low estimate of 7,851 and a high estimate of 17,373. Degenhardt et al. (2004) estimated that there were 19,900 regular heroin users in New South Wales in 2002, with a low estimate of 17,800 and a high estimate of 43,900. These estimates were averaged and extrapolated to other Australian jurisdictions on the basis of the number of fatal overdoses in 2003 (Degenhardt, Roxburgh & Black, 2004b). That yielded an estimate of the number of regular heroin users in Australia in 2003 of 41,401, with a range between 33,827 and 80,847. These numbers will be used in the development of a consumption-based estimate.

Infrequent (occasional or recreational) heroin users

Regular heroin users are normally given the most attention in epidemiological estimates, but a complete estimate of heroin consumption should also take into account less regular heroin users. Like "frequent" heroin users, there are a number of labels applied to these users: "infrequent", "occasional", "recreational" or "non-dependent" being the most common. These users are characterised as people who generally inject heroin between once a week and once a fortnight, in social settings.

Weatherburn and Lind (1995) applied simple ratios of the number of recreational to regular heroin users to estimate that there were between 72,000 and 450,000 recreational users in Australia. Hall et al. (2000) used earlier HCV studies to estimate that there were between 148,000 and 222,000 non-regular heroin users in Australia. More recently, the Hepatitis C Virus Projections Working Group (2002) estimated that there were between 120,000 and 210,000 occasional injecting drug users (most of whom inject heroin).

The numbers may have changed significantly since these estimates were made. Instead of using those directly, an alternative way of accounting for the consumption of heroin by occasional users is to assume that it has remained a steady proportion of total heroin consumption. Hall et al. (2000) used prevalence estimates in combination with injecting frequencies to calculate that between 5% and 15% of heroin was consumed by occasional users. It is a large range (the upper estimate is three times the lower estimate), which increases the likelihood that the proportion has remained within it. The consumption-based estimate will be calculated on the basis of this 5% to 15% range, with a 10% proportion applied to the main estimate.

Quantities of heroin consumed

In surveys of drug users, respondents are not asked the weights of heroin they consume. Instead, they are normally asked on what days they use heroin or the number of times they inject over a week or a month. The latter information can be combined with information on the amount in each injection to estimate an average amount consumed.

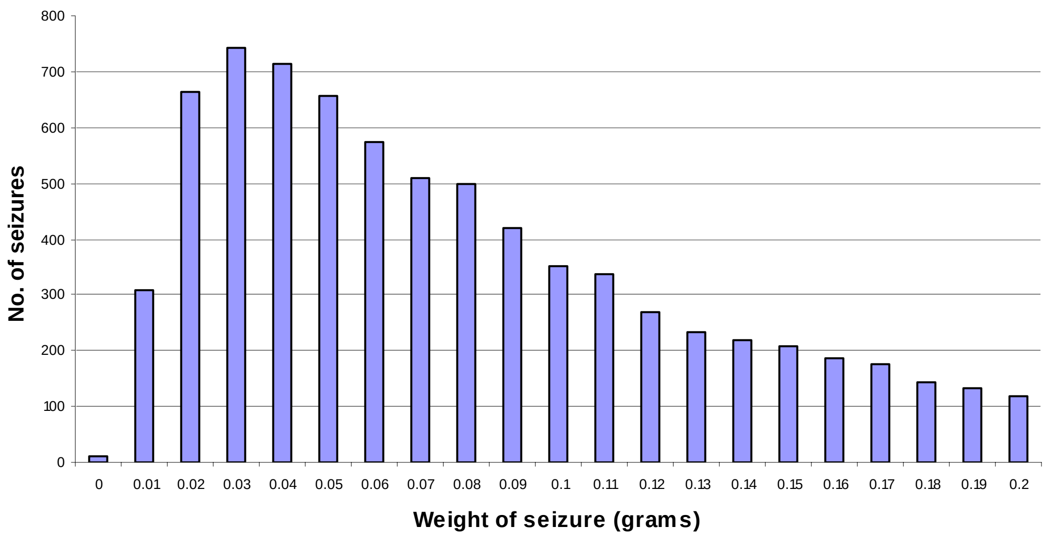
Frequency of heroin use

Weatherburn and Lind (1995) estimated that regular users inject 2-3 times per day and used an average of 17.5 times per week in their estimate. This was adopted by Hall et al. (2000), and subsequently by Degenhardt et al. (2004a). Dietze, Richards, Rumbold, Aitken, Day, McGregor, and Ritter (2003) interviewed a convenience sample of 1001 regular injecting drug users recruited from sites in Melbourne, Sydney and South Australia. Participants had to be over 18 years of age and to be using heroin at least monthly. They were asked about their frequency of heroin use for the past week and the past month. Respondents had used an average of 11.2 times over the past week and 49.2 times over the past month, with a standard deviation in both cases greater than the average. Using information from both Dietze et al. (2003) and Weatherburn and Lind (1995), it is assumed that regular heroin injectors inject between 11 and 21 times per week, with the main estimate using the mid-point of that range (16 injections per week).

Amount used per injection

Heroin "caps" are typically used in a single injection (Darke, Topp, Kaye & Hall, 2002; Breen et al., 2004). However, it is not clear how much heroin is in a cap. While the ACC uses a weight range of between 0.1 and 0.3 of a gram of impure heroin for a "cap" (e.g. ACC, 2005), most other information sources suggest that caps generally weigh less than this.

Maher and Dixon (1999: 490) describes caps as "small units weighing between 0.02 and 0.03 grams". Heroin seizure data collected by the Victoria Police Forensic Science Centre (VFSC) for offences recorded between 1998 and February 2004 supports this (This dataset is discussed in detail in Appendix 1). The number of seizures at the various weights between 0 and 0.2 grams is shown in Figure 3. Rather than seeing a peak at 0.1 or 0.2 grams, 0.03 grams is the most common seizure weight. Weatherburn and Lind (1995) do not provide a weight for impure heroin, but it seems it was close to 0.05 grams if their assumption of 0.03 of pure heroin is combined with an estimate of the average purity in their sample (taken from their frequency distribution of the purity of heroin samples).



Source: VFSC data and author calculations

Figure 3: Frequency of Victoria Police seizures by impure weight, 1998 to Feb/2004

The uncertainty surrounding the weight in a cap of heroin was considered directly in the 2003 Illicit Drug Reporting System (IDRS), where injecting drug users were asked the weight of a cap of heroin. Of the 14% of respondents who felt they could comment on this question, just over half (54%) thought it was 0.1 of a gram, with other respondents giving a wide range of responses that placed the weight of a cap anywhere between 0.025 of a gram to 0.25 grams (Breen et al., 2004).

In summary, there is some doubt about the weight of a cap and thus the weight in a dose. Given the forensic analyses place it at approximately 0.05 of an impure gram, this weight is used as the main estimate of a dose. A range of between 0.03 and 0.12 grams of impure heroin per injection is used (the lack of forensic support for higher doses means the range is truncated at that end).

Total quantity consumed

These elements can be brought together to develop an estimate of the amount of heroin consumed in Australian each year. The following formula is applied:

Annual heroin consumed = [Regular users * Injections/wk * 52 * Weight injected] / Proportion of total consumption that is by regular users

The "best" estimate is:

Annual heroin consumed = [41,401 * 16 * 52* 0.05] / 0.9
= 1,913,646 grams = 1.9 tonnes

In previous studies, such as Weatherburn and Lind (1995), the ranges were calculated by using all of the "low" values together to produce the lower bound and all of the "high" values to develop an upper bound. However, this is unduly conservative in the sense that it allows all four uncertain factors (the number of regular injectors, the number of injections per week, the weight per injection and the proportion of heroin consumed by regular users) to simultaneously be at their lowest level and at their highest level. There is little reason to believe that the uncertainties surrounding these factors are strongly related to each other. Therefore, the four factors were viewed as being independently equally likely to be distributed between the lower and upper ends of their ranges, which are provided in Table 2. Using a triangle probability distribution with the main estimate as the mode of the distribution, a 95% confidence interval for the total quantity of heroin consumed was 1.4 to 6.0 tonnes (total weight, not pure weight).[3]

Table 2: Estimates of the impure heroin consumed in Australia, 2003

Variables	Low	Main	High
Regular users	33,827	41,401	80,847
Frequency of use (injections per week)	11	16	21
Frequency of use (injections per year)	52	52	52
Proportion of total consumption that is by regular users	95%	90%	85%
Weight per injection (g)	0.03	0.05	0.12
95% confidence interval from simulations (20,000 runs)			
Annual weight (g)	1,440,616	1,913,646	6,036,334
Annual weight (tonnes)	1.44	1.91	6.04

Source: Degenhardt et al. (2004a, 2004b), Dietze et al. (2003), Dietze (2005) and author calculations

It is important to translate these values into an estimate of the amount of pure heroin consumed. While the compressed form of heroin in Australia means there is minimal "cutting" at the retail level, there are large differences between the purity of heroin at the retail and import level and

3 If instead parameter values were modeled as being uniformly distributed across those ranges, then the 95% confidence interval would run from 1.3 to 8.2 tonnes.

any discussion of the heroin market that includes higher market levels is best conducted in terms of pure heroin.

Our impure consumption estimate is converted to pure heroin using Victorian data, on the assumption that it is similar to Australian purity levels, which seems reasonable on the basis of Figure 4 (in the next section). The VFSC dataset contains 1187 retail-level purity observations for 2003. The average purity is 23.8%, which means an estimate for the annual consumption of pure heroin is 456 kilograms. The range for the annual consumption of pure heroin is between 343 and 1,437 kilograms.[4]

An annual consumption level of 456 kilograms of pure heroin is substantially less than has been presumed in the past, and the plausible "low-end" range is far less than has been contemplated in other studies. This is partially due to the heroin shortage (significantly lower heroin purity as well as lower numbers of heroin users), but also because it is possible that an injection might be of a much smaller quantity than was previously thought.

Total quantity imported

It is possible to use the consumption-based estimates to estimate the quantity of heroin imported into Australia. In addition to being consumed, heroin imported into Australia may also have been seized by law enforcement, so the quantity imported is estimated by combining the consumption-based estimate with seizure figures from the Australian Crime Commission. As the amount seized varies significantly from year to year, and heroin importers may smooth their response to seizures (i.e. maintain an average inventory over time), an estimate for the amount imported is based on seizure averages from the past three years for which information is available (2001-02, 2002-03 and 2003-04 are used) (ACC, 2003, 2004, 2005).

State and territory police services seized 57 kilograms of impure heroin in 2001-02, 103 kilograms in 2002-03 and 33 kilograms in 2003-04. Analysis of the VFSC data suggests that, by weight, approximately 70% of seizures during this period were of a retail purity of approximately 25%, while approximately 30% were larger seizures with a purity of approximately 50%. Over the same period, the amount of impure heroin seized by Australian Federal Police was 427 kilograms in 2001-02, 337 kilograms in 2002-03 and 68 kilograms in 2003-04. This is generally of a purity of about 70%, according to the AFP purities figures provided in the ACC reports. The average amounts of impure and pure heroin these figures translate into are provided in Table 3.

Table 3: Estimates of the pure heroin imported into Australia, 2003

	2001/02	2002/03	2003/04	Average
State and territory police				
Impure heroin seized (g)	56,989	103224	32839	64,351
Pure heroin seized (g)	18,521	33,548	10,673	20,914
Australian Federal Police				
Impure heroin seized (g)	426,703	337,113	67,883	277,233
Pure heroin seized (g)	298,692	235,979	47,518	194,063
Pure heroin imported into Australia				
Main estimate				670,563
Low estimate				557,948
High estimate				1,652,062

Source: ACC (2003, 2004, 2005), Table 2 (above), and author calculations

4 The standard error is small (0.25%), so using confidence intervals on that estimate would make little difference to the bounds of the estimate.

The amount of pure heroin imported into Australia is potentially significantly higher than the amount consumed, with the main estimate being that approximately 670 kilograms was imported into Australia in 2003. An estimate of the amount consumed can be important for giving some context to the seizures that are being made by the authorities; it is an aspect of the analysis we will return to when considering the heroin distribution network in Australia.We now turn to the other key market measure: price.

HEROIN PRICES

Another key element of market information is the price of heroin. Price is commonly measured in terms of "price per pure gram" for heroin. In addition to increasing the nominal price charged for a certain quantity of a drug, in times of reduced supply, sellers may alternatively reduce the purity or decrease the weight (as they are only approximate for retail purchases). (This behavior has been observed for multiple substances and over extended periods of time in the US.) Therefore information on purity and weight is also important, and discussion about price extends to these other characteristics.

Sources of price information

The quality and usefulness of price data has been extensively debated in the United States (see Caulkins, 2001a, 2005; Manski et al., 2001). It is important to consider Australian data sources in light of this debate, in order to be able to judge the implications and limitations of existing sources of price information.

There are three major sources of Australian price information: 1) data collected by law enforcement agencies and reported by the Australian Crime Commission and one of its antecedents, the Australian Bureau of Criminal Intelligence (ABCI); 2) Illicit Drug Reporting System reports, which are coordinated by the National Drug and Alcohol Research Centre; and 3) one-off surveys or studies that collect illicit drug price information.

Australian Crime Commission (ACC)
The ACC produces the *Illicit Drug Data Report* (IDDR) for each financial year, and has done so for over 10 years. The IDDR includes information on the drug offences, prices paid and purity of a range of drugs, including heroin (and other opioids), cocaine, amphetamine-type stimulants, phenethylamines (e.g. ecstacy), cannabis, hallucinogens (e.g. LSD and mushrooms), steroids and other drugs. This information is obtained from the state and territory police services and also the Australian Federal Police.[5]

The IDDR contains price information from nearly all agencies for common weights (e.g. caps, grams, ounces), either as a point estimate or a range. Some agencies also provide price estimates for less common weights (e.g. half-grams, quarter-ounces, half-cattis). Information is not provided as to the number of cases that have led to each estimate, nor whether they are based on actual purchases, undercover information, asking arrestees, or some other source.

For heroin purity, the ACC report median, minimum and maximum purity, and the number of cases in each category. For each state or territory, both state police and AFP purity analyses are reported, with the purity of seizures weighing less than or equal to two grams reported separately to the purity of seizures weighing more than two grams. Individual agencies make their own decisions about when forensic analyses will be conducted, and few jurisdictions analyse all drugs they seize in the course of their operations. The ACC data therefore reflect seizures analysed at a forensic laboratory rather than all drug seizures of a particular type.[6]

5 The agencies are: New South Wales Police, Victoria Police, Queensland Police Service, Western Australia Police Service, South Australia Police, Tasmania Police, Northern Territory Police, Fire and Emergency Services and the Australian Federal Police (for both ACT Policing and Australian interdiction activities).

6 For the 2003-04 report, key differences between jurisdictions included:

- The Western Australian Forensic Science Laboratory did not analyse seizures less than two grams;

It is important to note that the time period to which purity analyses are allocated differs amongst the jurisdictions. Figures for Victoria, Queensland and the Australian Capital Territory are recorded in the quarter in which police seized the drugs. Figures for the other jurisdictions are recorded in the quarter they are received by the laboratory. With the lag between seizure and analysis most likely to be several months, this limits the applications for which those data can be used.

The Illicit Drug Reporting System (IDRS)
The IDRS monitors market conditions and patterns of use of the main illicit drugs, as well as acting as an early warning system for emerging trends in illicit drug markets. It uses a quantitative survey of injecting drug users, a qualitative survey of key experts who work in the field of illicit drugs and extant indicator data sources such as Australian Customs Service data, seizure purity data and arrest data.

The IDRS commenced in NSW in 1996, and was extended to all other Australians jurisdictions by 2000. Since then, there have been approximately 100 to 150 injecting drug users (IDU) interviewed annually in each jurisdiction (a total of 900 to 1,000 respondents annually). The IDU sample is a convenience sample of people who have injected an illicit drug within the past six months and have resided in the same city for the past year. Respondents are asked about drug prices, drug use patterns, drug availability, health and criminality, and the form of these questions has been consistent from year to year.

One-off surveys or studies
There have been several Australian studies of heroin markets that have recorded price information. The most significant study is Weatherburn and Lind (1995), in which price data were collected in the Sydney suburb of Cabramatta over a two-year period, from February 1993 to January 1995. Purity analyses were done on heroin obtained both through "buys" by undercover police officers and "busts" during heroin arrests. Price information was obtained from the same sources.

This study provides insights into the comparability of price information gathered from drug buyers and police officers. Importantly, no difference was found between the prices paid by undercover police officers and other heroin buyers, which provides some confidence in the appropriateness of utilising both drug user and police information for understanding heroin prices.

Price

Heroin is an expensive product in Australia. Retail quantities commonly cost in the order of $2,000 per pure gram of heroin. As Caulkins and Reuter (1998) have pointed out, illicit drugs are extraordinarily expensive per unit weight, with heroin and cocaine much more expensive than gold.

- In NSW and ACT, purity was only tested in cases where the quantity seized was larger than the trafficable level (in NSW this was three grams for heroin);
- The New South Wales Analytical Laboratory only tested a limited number of samples per case;
- The Northern Territory Forensic Laboratory was unable to provide purity data;
- In some jurisdictions, the sample analysed only if the arrestees associated with it pleads "not guilty" to their charges.

The price of heroin is also highly variable. A stark example of this variation is provided by Weatherburn and Lind (1995), who found that the price paid (nominal price) per gram ranged from $118 to $11,667 and the price per pure gram ranged from $206 to $26,144.

Some of the variation in the price per pure gram would result from it being difficult for buyers and sellers to judge heroin purity. Caulkins (1994) notes that, as drugs are "experience" goods, purity can only be observed after the purchase (and, even then, imperfectly observed). Extremely low or high purities are unlikely to reflect buyers' expectations; it is better to use average purities of a number of samples taken at the same time in similar locations, rather than assuming that the purity of an individual sample represents the price paid by its owner.

Therefore, a more complete formula for the price per pure gram of heroin is:

Price per pure gram ($) = Nominal price ($) / [Expected purity (%) * Weight (g)]

Which, in practice, is:

Price per pure gram ($) = Nominal price ($) / [Average purity (%) * Weight (g)]

Geographical price variations

The Australian Crime Commission *Illicit Drug Data Report* provides annual state-level information about both the purity and nominal price of heroin. Despite the limitations associated with this information (outlined earlier in this section), it is sufficient for gaining some basic understanding of the heroin market.

Regional differences in illicit drug prices have previously been observed by Clements (2004). He used ACC information on marijuana prices and found there were regional markets for marijuana. Specifically, he found that marijuana prices were substantially more expensive in Sydney, followed by Melbourne and Canberra, and then the rest of Australia. He found that the regional differences in marijuana prices were of the same order of magnitude as housing prices, meaning the regions could be characterized as having: i) expensive marijuana and housing (NSW); ii) moderately priced marijuana and housing (Victoria and ACT); and iii) cheap marijuana and housing (the remaining states and territories).

Clements' (2004) analysis suggests local wages or living costs (as captured by housing price differentials) are important determinants of price. While this may also be the case for heroin, a different geographic relationship is equally possible for heroin. Marijuana is produced locally, while no heroin is grown in Australia. Therefore the location of importers and high level distributors may be more important than local living costs in the development of any geographic price differentials. And, as will be discussed later in this section, the price is increased substantially at the early stages of the distribution process. In such a circumstance, local wages may be less important than the Australian locations to where heroin is imported.

It is thought that most heroin enters Australia through Sydney (ACC, 2003; 2005). In 2000-01, 15 of 28 seizures made at Australian borders were in Sydney. By weight, these 15 seizures constituted 98.5% of all heroin seized (ACC, 2003). This could in fact lead to the heroin price being cheapest in Sydney, rather than the most expensive.

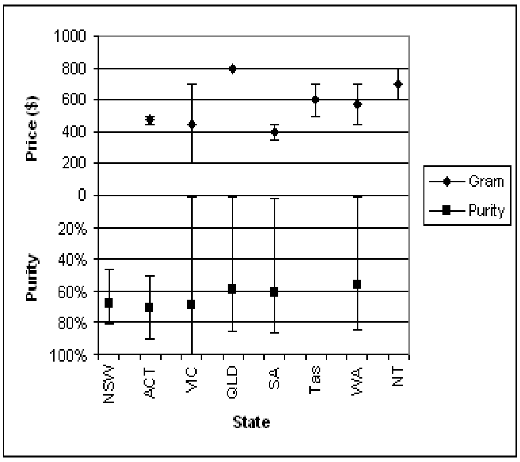
Therefore, there are three possibilities:

1. Heroin prices are cheapest where living costs (housing prices) are lowest (i.e. price in Sydney > price in Melbourne, Canberra > price elsewhere);
2. Heroin prices are cheapest closer to the major location for heroin importation (i.e. price in Sydney < price in Melbourne, Canberra < price elsewhere); or
3. There are no geographical differences in the price of heroin.

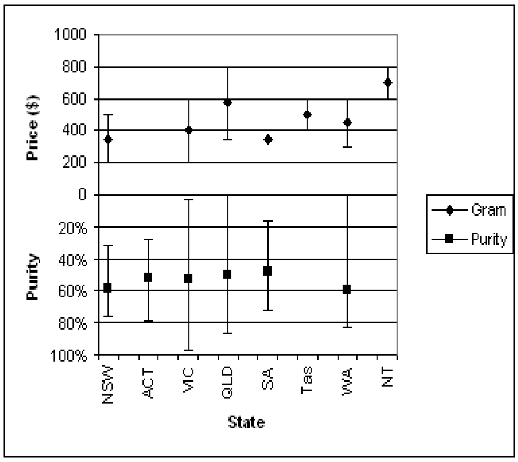
As discussed in previous section, the *Illicit Drug Data Reports* contain several inter-agency methodological differences that limit data comparability. As a result, nothing more than a general comparison is possible at this stage.

The prices for a gram of heroin and heroin purities that have been recorded by the ACC for six recent years are presented in Figure 4. Purity is inverted, so that it is easier to see whether purity follows the same pattern as price (price differentials being in the form of higher prices/lower purities or lower prices/higher purities). Australian locations are ordered by the proximity of the major city in the state/territory to Sydney. As Melbourne and Canberra are closest to Sydney, this ordering also divides the jurisdictions along the same lines that Clements (2004) does.

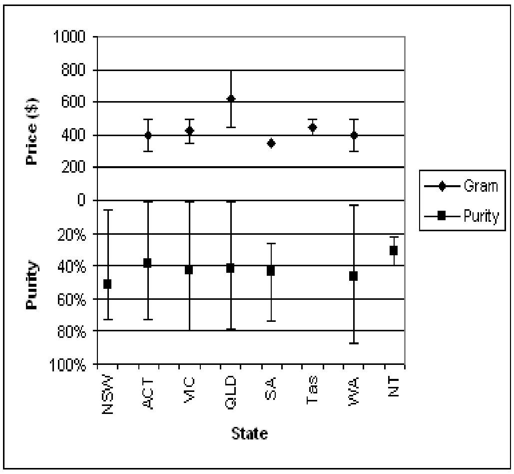
While it is not possible to be definitive about geographic price differentials, it seems that both the price increases and the purity decreases the further a location is from Sydney. It indicates that price increases related to the initial point of importation are more important than any local wage or cost of living effects.



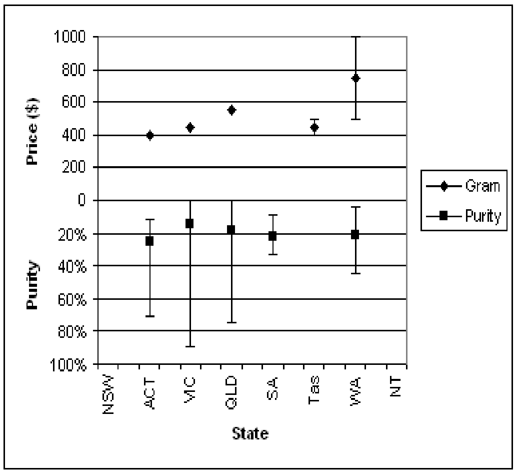
1998-99



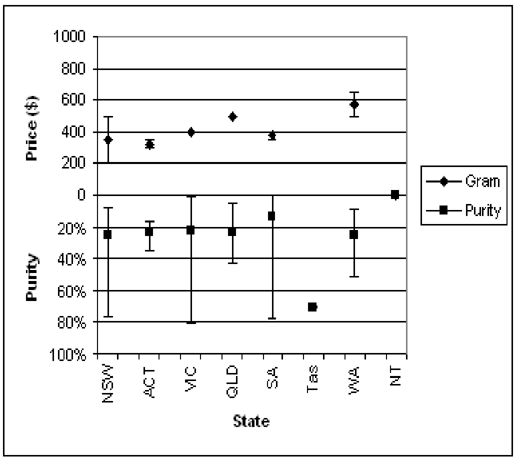
1999-2000



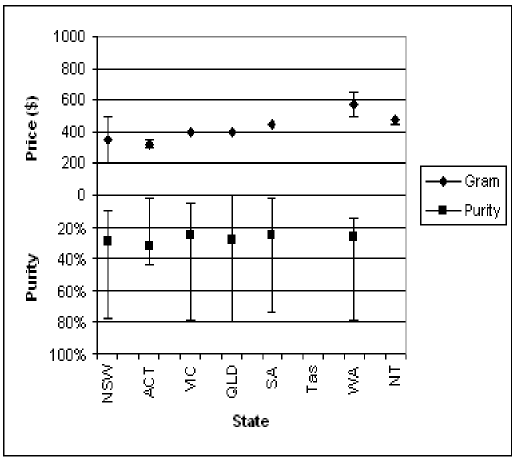
2000-01



2001-02



2002-2003



2003-04

Source: ABCI (2000, 2001, 2002); ACC (2003, 2004, 2005).

Figure 4: Heroin purity and (gram) price by jurisdiction, 1998-99 to 2003-04 (ACC)

Prices over time

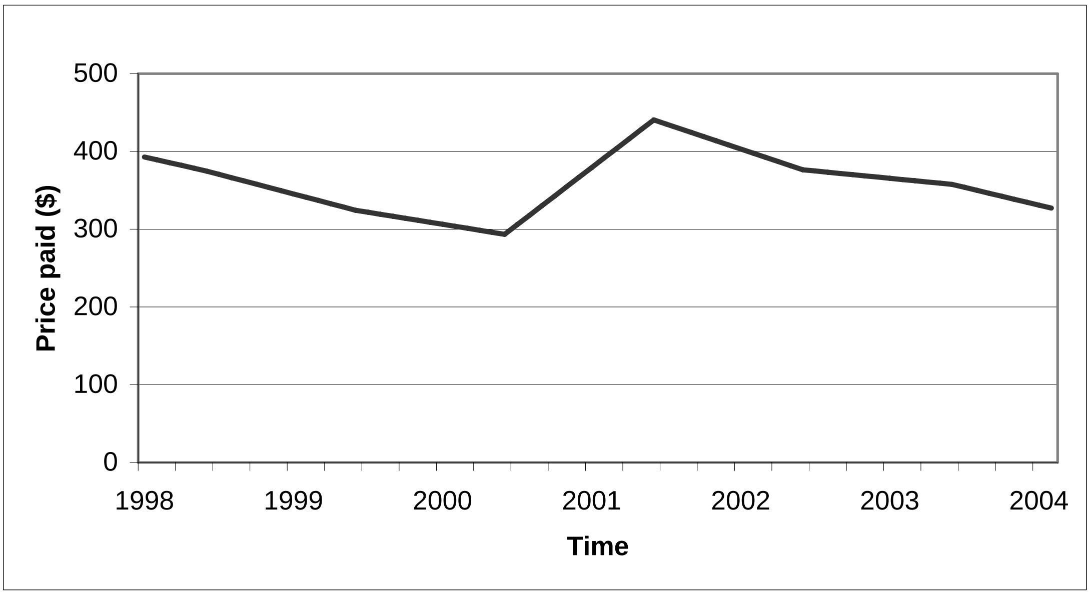
There is not sufficient precision within the Australian Crime Commission data to make judgments about the movements of prices over time in all but the most general terms. Heroin prices do seem to rise at the time of the heroin "shortage in early 2001, although there are a number of observations where price fell. More noticeably, the purity fell between 2000-01 and 2001-02, and has only slightly increased in subsequent periods. However, purities decreased later than would have been expected if it were contemporaneous to the heroin "shortage". The ACC-recorded purity movements may be due to lags in forensic analyses, which occur in the majority of jurisdictions and may last for several months. Clearly, there is not enough precision in the dataset to make clear judgements about heroin price movements over time.

To address this deficiency, a high-frequency heroin price series has been developed for Victoria. This series, in which price is estimated on a monthly basis, has several advantages over the ACC data. Time is based only on when police seized the heroin, rather than when the forensic analysis was conducted, and access to unit record data meant that assessments of the changes in purity across market layers could be made.

The price series constructed is for the price of a gram of heroin (a fuller explanation is provided in Appendix 1). There were two types of data used for the development of this price series: forensic analyses conducted by the Victoria Police Forensic Science Centre (VFSC) and survey responses of injecting drug users from the Illicit Drug Reporting System (IDRS). Heroin purity and weight information was taken from the VFSC data, while the prices paid were taken from the IDRS.

There are regular price observations for a "cap" and a "gram". As a "gram" relates back to a measurable and accepted quantity, it was selected as the base for the price series. The IDRS was thought to be a good source of price observations, as these were regular buyers who commonly purchased heroin at similar prices (in each survey, approximately one third of respondents provided the same price for a gram of heroin, with most other respondents giving prices that were also very similar). The use of the Victoria Police seizure data relies on the assumption that the police seizures are representative (or at least consistently biased over time). There is between 1,000 and 3,000 seizure records annually within this dataset.

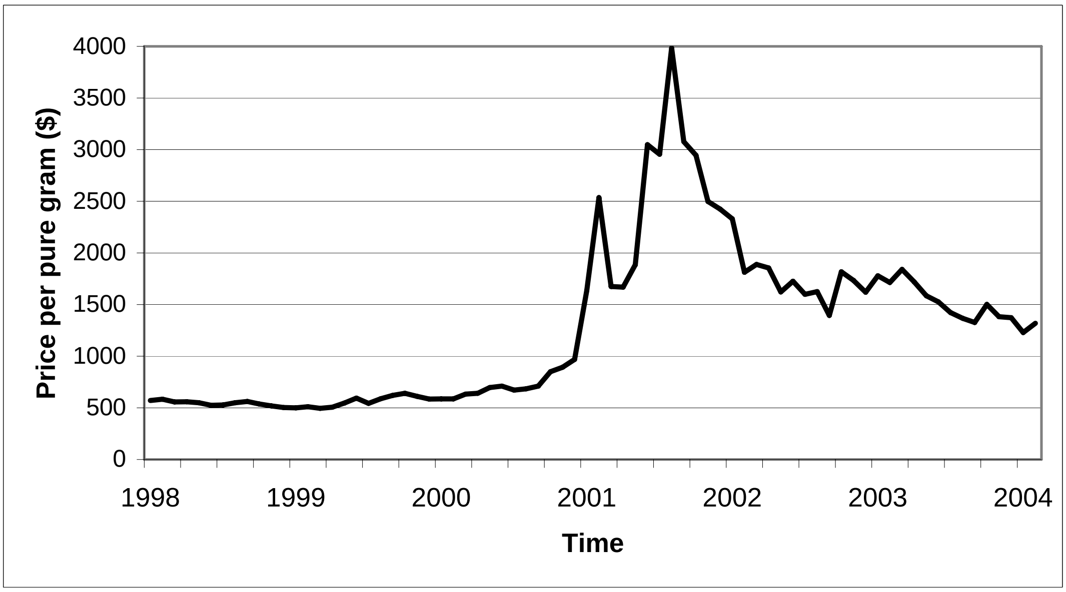
Before showing the price per pure gram, it is worth showing the movements in the nominal price. The average price of a gram interpolated from IDRS is shown in Figure 5. It is clear that there was a decrease in the price in the lead-up to the heroin "shortage" and then a significant increase of approximately 50% between 2000 and 2001.



Source: IDRS and author calculations (see Appendix 1).

Figure 5: Price paid, unadjusted for purity, Victoria, 1998 to Feb/2004

The price per pure gram of heroin in Victoria between the start of 1998 and the end of February 2004 is shown in Figure 6. Average monthly purity is used as a proxy for expected purity.



Source: IDRS, VFSC and author calculations (see Appendix 1).

Figure 6: Price per pure gram, Victoria, 1998 to Feb/2004

This high-frequency price series reveals a large and sharp increase in price in early 2001. This is largely due to reductions in purity, although, as shown on the previous diagram, the increasing nominal price also plays a role. The heroin price seemed stable at $500 per pure gram in late 1990s, and gradually rose to about $750 per pure gram before the drought's customarily presumed start date (end of 2000/ early 2001). The peak price was five times that prior price, and in 2001 was about triple the $750, on average. In 2002 and 2003 prices fell to roughly double their pre-drought levels (about $1,500 per pure gram), and continued to trend downwards in late 2003 and early 2004.

The causes of the heroin drought have been strongly debated (see Degenhardt, Day, Dietze, Pointer, Conroy, Collins & Hall, 2005, and commentaries). This price series does not, by itself, shed any light on that debate except to show that there was a large and sudden increase in the price of heroin at the same time that there was a decrease in availability. This adds further support to there being some responsiveness in demand to changes in price, although it also helps explain how there could have been such dramatic changes in measures related to consumption (e.g., fatal overdoses), even if impure heroin consumption did not change as significantly.

As is discussed further in the next section of this monograph, there is the potential for the high-frequency price series to be used in conjunction with other datasets to further understand market changes.

Price mark-ups/ quantity discounting

The Australian Crime Commission has information on the price paid for different quantities of heroin. Information from the 2001/02, 2002/03 and 2003/04 *Illicit Drug Data Reports* was used in conjunction with the price information from the IDRS reports over the same period and purity information from the Victoria Police Forensic Science Centre seizures dataset to develop estimates of the price per pure gram. These estimates are for prices in the most populous states (NSW, Victoria and Queensland) and for recent years (after the heroin "shortage"). The estimates are in Table 4, and a fuller description of the derivation of the figures is provided in Appendix 2. With uncertainty about the weight of a cap, its weight per pure gram is estimated using a cap weight of 0.05 grams and 0.1 grams.

Table 4: Heroin prices at different quantities

Size	Weight (grams)	Price	Purity	Price per pure gram	Ratio to previous price
Cap	0.05	$ 45	25% (retail)	$ 3,600	225% (cf. gram)
Cap	0.1	$ 45	25% (retail)	$ 1,800	113% (cf. gram)
Gram	1	$ 400	25% (retail)	$ 1,600	126%
Ounce	28	$ 9,000	25% (retail)	$ 1,270	161%
1/2 catti	350	$ 140,000	50% (mid-level)	$ 790	138%
Catti	700	$ 200,000	50% (mid-level)	$ 571	288%
Kilogram	1,000	$ 138,934	70% (import)	$ 198	

Source: ACC (2003, 2004, 2005)

These differences in the price per pure gram represent price mark ups or, equivalently, quantity discounts. As heroin passes through the distribution chain from production to retail selling, the price per pure gram increases to compensate those involved at each step. These are called price mark ups. As it is likely that most quantities in Table 4 are transacted by people at different stages of the distribution process, these price differentials are most likely due to mark-ups.

However, from the consumer's perspective, these same price differences – particularly the difference between a cap and a gram – can be seen as quantity discounts. When someone "buys in bulk" they tend to get the good at a cheaper price. In Australia, Clements (2004) has observed quantity discounting for marijuana while Weatherburn et al. (2001) and Breen et al. (2004) also have evidence of it happening for heroin.

Without detailed background on the stages in the market where these observations were taken (which are not given by the ACC), there is a limited amount that can be said about price observations at different weights. However, to the extent that they do represent different stages in the market, it should be noted that the mark-ups are generally greater at the higher end of the heroin distribution chain than at the lower end. This is different to the mark-ups that have been observed for illicit drugs in the United States, and this characteristic will be considered further in the next section.

Expenditure on heroin

The total amount of money spent on heroin is another market variable that can aid our understanding of what is happening in the heroin market, particularly as it equates to the total amount of money being received by suppliers of heroin. In most legitimate industries, it is easier to measure firms' revenues in order to understand how much buyers are spending but, like the development of the consumption-based estimate, with heroin it is easier to focus on the consumers.

Multiplying price by the weight is seemingly the most straightforward way of estimating the value of expenditure. However, not only is there a large range of plausible ranges for the quantity consumed, it is difficult to estimate an average price paid, both because cap weights are uncertain and because the average price depends on the mix of quantities purchased (e.g. the number of caps purchased relative to the number of grams). Instead, it is easier to apply direct estimates of users' expenditure to the earlier figures for the number of heroin users in Australia.

Dietze et al. (2003) and Weatherburn et al. (2001) asked regular heroin users about their spending on heroin, and both find figures in the region of $600 per week (with large variations in the amounts reported by individuals). During July 2000 and March 2001, Dietze et al. (2003) asked participants in their study for information on how much they spent on heroin yesterday and in the past week. The mean responses were that $99 was spent yesterday and $615 was spent over the past week. During mid-1998 and 2000, Mattick, Digiusto, Doran, O'Brien, Shanahan, Kimber, Henderson, Breen, Shearer, Gates, Shakeshaft, and NEPOD Trial Investigators (2001) reported that, prior to treatment, heroin users' average monthly spending was $2,600. Weatherburn et al. (2001) reported that heroin users in Cabramatta how much they spent $550 on heroin each week before Christmas 2000 (identified when the heroin shortage occurred), and $350 afterwards.

There is general agreement amongst these studies that pre-shortage spending was around $600 per week. However, it is not clear what the expenditure would have been in 2003, although Weatherburn et al.'s (2001) $350 per week estimate could be viewed as a minimum average spend, as it was taken during the period when the shortage was most acute. A weekly spend of $600 was used as the main estimate, together with a lower bound of $350 and an upper bound of $800 (a plausible upper bound on the average expenditure). There is no available information on the spending by non-regular users, so the earlier estimates of the proportion of heroin that is consumed by non-regular users are applied here to take account of their expenditure.

The variables and the resulting estimates are in Table 5. It is estimated that the total annual expenditure on heroin is $1,435 million, with a range between $896 million and $3,295 million (again assuming the uncertainties are independent, and finding a 95% confidence interval using a triangle distribution)

Table 5: Estimates of the expenditure on heroin in Australia, 2003

Variables	Low	Main	High
Regular users	33,827	41,401	80,847
Expenditure (per week)	$350	600	800
Expenditure (per year)	$18,200	$31,200	$41,600
Proportion of total consumption that is by regular users	95%	90%	85%
95% confidence interval from simulations (20,000 runs)			
Total expenditure on heroin ($)	$895,553,376	$ 1,435,226,462	$3,295,476,585

An alternative way of estimating heroin expenditure is by multiplying the estimate for the amount of pure heroin consumed by the price per pure gram at the retail level. If the 456 kilograms is multiplied by $3600 – when the price per pure gram if the cap weighs 0.05 of a gram – then annual expenditure is estimated to be $1,640 million. This suggests that users purchase most heroin in caps, although some is purchased in higher quantities.[7]

By themselves, these figures do not provide much insight into the Australian heroin market. However, combined with other information it gives us an understanding of the scale of the market, and the potential impact of government interventions such as fines and asset seizures.

The current state of market measurement

The current state of market measurement is limited but promising. Our understanding of price is more advanced than may first be apparent, and we are able to observe heroin prices across space, time and market levels, albeit imperfectly. In collaboration with the coordinators of drug surveys and law enforcement agencies, there is the potential to improve Australian heroin price data.

Our understanding of heroin quantities and spending is less precise, and is likely to remain so. There is insufficient knowledge of the number of heroin users at any one point in time to use this information to understand market changes in all but the most general of terms or in the most extreme of circumstances (such as the heroin shortage).

Reasonably accurate price information and broad quantity information can be combined with other information to provide some surprisingly useful insights into Australia's heroin market. In the remainder of the monograph, two of the most promising approaches are employed to improve current understanding: 1) relating risks to prices to understand heroin distribution; and 2) analysing the relationship between heroin prices and overdoses.

7 This calculation is not affected by what caps weigh. If the price per pure gram when a cap is presumed to weigh 0.1 of a gram is used, an expenditure estimate of $840 million results. However, to be consistent the main consumption estimate would have to use 0.1 of a gram (instead of 0.05), in which case that main consumption estimate would double and the expenditure estimate would be $1640 million – exactly the same as it is for when caps weigh 0.05 of a gram.

UNDERSTANDING THE AUSTRALIAN HEROIN DISTRIBUTION NETWORK

Most of the published market analysis in Australia has been done in the absence of a comprehensive economic framework, such as analysis of the recent heroin shortage (Caulkins, 2005). Information about the underlying supply and demand relationships has been rare; instead, most Australian heroin markets research has not moved beyond description.

As outlined at the start of the previous section, heroin is imported into Australia. There is no systematic observation of the movement of heroin from import to when it is sold to users, but there are some things we can be reasonably confident about. First, it seems there are a few independent groups involved in supplying heroin from producers to users. There is little evidence of vertical integration between source countries and the Australian borders, and likewise little evidence of an integrated supply structure once inside Australia (Australasian Centre for Policing Research, 2003).

Second, there are a number of levels in the heroin market. Makkai and McGregor (2003) provided 2002 *Drug Use Monitoring in Australia* respondents (i.e. arrestees) with a diagram of the heroin market with six levels:

- Level 1: Importer/manufacturer
- Level 2: Major distributor (in bulk)
- Level 3: Link between distributor and dealer
- Level 4: Dealer of large quantities to regular clients
- Level 5: Sells small quantities to regular and irregular users
- Level 6: Mainly uses drugs, may sell occasionally.

All of the arrestees thought the diagram of the heroin market was an accurate representation. (Although, given that only 3% reported selling heroin, they may have been responding to its plausibility more than its accuracy.) That there are many people involved at different stages has long been recognised in the US (e.g. Preble & Casey, 1969), so it is likely to be a similar case in Australia.

Law enforcement agencies provide some information on the heroin market. However, the information is not normally structured in such a way that allows the development of a proper analytical framework; it is hard to ascertain the representativeness of the information; and it is rarely available as a primary source (i.e. it is normally cited by secondary sources). Moreover, enforcement agencies do not have the arms-length interest that researchers ideally possess; as a result, suppliers have direct interests in misinforming them.

Even at the retail end, the market structures are not well understood. There has been some detailed ethnographic work of Sydney's heroin street markets, such as Maher (1996), but it is by no means certain that street markets are the primary source of heroin for users. As discussed previously, there are no representative surveys of heroin buyers.

As a consequence, there is insufficient information about the Australian heroin market to conduct a comprehensive analysis of its underlying structures. However, there is enough information to gain some understanding of how the revenues are distributed amongst the different stages of the supply chain. There is also enough information to apply the "risk and prices" framework, developed by Reuter and Kleiman (1986), to gain some insights why revenues may be distributed in this way and what the potential is for law enforcement activities to influence the actions of suppliers.

Revenues ("value added") at the various market levels

It is possible to estimate what revenues may accrue to each level of the heroin market in Australia, if particular weights are assigned to different stages of the supply process and some judgements are made about at what stage the Australian Federal Police and state and territory police seize heroin.

Levels 2 to 6 in Makkai and McGregor's (2003) schema are used to develop the model of the Australian heroin market. The supply chain is considered to be:

- Importers (Level 1) import heroin in kilogram and sell them in kilograms;
- Major bulk distributors (Level 2) buy heroin in kilograms and sell them in cattis (700g) lots;
- The people who are the link between distributors and dealers (Level 3) buy heroin in cattis and sell them in half-cattis;
- Dealer of large quantities to regular clients (Level 4) buy heroin in half-cattis and sell them in ounces;
- Dealers who sell small quantities to regular and irregular users (Level 5) buy heroin in ounces and sell half of their heroin in grams and half of their heroin in caps.

Revenues to those at Level 6 are not modelled, as it is too hard to make even the most basic assumptions about those using heroin and then selling it occasionally.

It is assumed that state and territory police seize their heroin equally from those at Levels 1, 2 and 3. It is assumed that two-thirds of the Australian Federal Police's seizures are from the importers (where their interdiction activities would be concentrated), with a sixth of their seizures being heroin taken from each of Levels 4 and 5.

The price per pure gram for each weight is taken from Table 4 in the previous section. A source-country price is required to estimate importer's revenues. A price of $7.60 per pure gram is used, which is the price for a kilogram of heroin in Burma in US dollars as reported by the UNODC (2005), converted into Australian dollars (RBA, 2005).

The value added is the difference between what that supply level sells the heroin for and what they paid for it. The estimated distribution of the revenues is provided in Table 6, where the most important column is the one that gives the value added as a percentage of the total revenue. Half of all value added accrues to the lowest level; only 1% accrues within the source country, and between 5% and 20% accrues to each of the levels in between.

The situation in the US is noticeably different. Even more of the revenues are gained at the lower levels of the market. Caulkins and Reuter (1998) estimate that 67% of the revenues for heroin and cocaine go to levels that could be considered to be a subset of Level 5. They also note that the ounce price of cocaine is one-third to one-half the gram price whereas, for heroin, ACC figures commonly have the ounce price of heroin at 20 times the gram price (ACC, 2003, 2004, 2005).

Table 6: Estimated revenues at different levels of the distribution network

	Price	Bought	Revenues	Cost	Value added	% of Revenue
Level 5: 1/2 caps and 1/2 grams	$2,600	469,529	1,220,775,639	605,155,526	615,620,113	50%
Level 4: ounces	$1,270	476,500	605,155,526	401,986,969	203,168,557	17%
Level 3: 1/2 cattis	$ 790	508,844	401,986,969	309,018,413	92,968,556	8%
Level 2: cattis	$ 571	541,188	309,018,413	132,771,576	176,246,837	14%
Level 1: kilograms (in-country)	$ 198	670,564	132,771,576	5,109,838	127,661,737	10%
Cost in Asia		670,564	5,109,838			1%
				Total	1,215,665,801	100%

Why these differences exist is explored by considering how the relative risks faced by different agents are factored into prices.

The "risk and prices" model

Reuter and Kleiman's (1986) "risk and prices" framework was developed to help understand how illicit drug markets operate and respond to law enforcement activity. The central idea is that people involved in the production and distribution of illicit drugs want a monetary return that reflects the risks of violence and being apprehended by law enforcement authorities, as well as the time and materials that they need to commit to their part of the process. Or, as Caulkins and MacCoun (2005) outline:

Economic return from dealing = Revenue from selling drugs - Cost of obtaining the drugs sold - Conventional business costs - Non-monetary costs

The risks of enforcement affect the non-monetary costs, which has been found to be the largest cost component of the process for expensive illicit drugs in the US (Caulkins & MacCoun, 2005). These risks are reflected in the price mark-ups in each step of the supply chain and ultimately in the price paid for drugs. The model reflects that prices should be driven by the intensity of enforcement, rather than its total magnitude. In other words, what is important is not the number of people imprisoned but the number of people imprisoned per kilogram sold (or some other measure pertaining to market size).

There are doubts about how well the risk and prices model describes the relationship between law enforcement, drug prices and drug suppliers' behaviour. In most applications of the "risks and prices" framework, actors are assumed to be risk-neutral – they value equally losses and gains of the same size and likelihood – when in practice people are commonly observed to be more concerned about losses than gains (risk-averse) (Caulkins & MacCoun, 2005). Since the1980s, the risk of being imprisoned for drug trafficking in the United States has risen while the cocaine and heroin prices have fallen (Reuter, 2001). These do not necessarily invalidate the model, but they highlight the limits of its application.

Despite these concerns, it is worthwhile assessing the potential to apply it in Australia. It is an analytical framework solidly grounded in core economic theory and, as such, is a useful starting point for developing an understanding of the market structure.

Heroin supply cost components

Reuter and Kleiman (1986) suggest that, at each stage of distribution, price is made up of: i) the cost of the drug itself (including the costs of any drug lost or seized); ii) compensation for labour (i.e. wages); iii) cost of capital; iv) operational expenses; and v) proprietors' return to capital. There are two main reasons for paying wages: for the time they spend and for the risks they face. Each will be considered in separate sections. The various stages of supply can be discussed in general terms, by considering the proportions of value added at each stage of supply.

Cost of the heroin itself

Table 6 provides a good insight into the costs of acquiring heroin at each stage of the process. A large component of the costs is purchasing the amount required for the sale to the next level or to the consumer. However, additional heroin has to be bought to cover any losses in the form of seizures by the police. It is worth explicitly considering how the cost of heroin needs to be adjusted for the proportion of heroin that is seized by authorities.

There are two proportions that can be considered: the proportion of heroin seized by the state and territory police and the proportion seized by the Australian Federal Police (there is no specific information at what level they seize the heroin).

The proportion of heroin seized by state and territory police (S/T) is:

S/T seizure rate = S/T qty seized / [Qty consumed + S/T qty seized]

As discussed when the quantity imported was estimated, Australia's state and territory police have seized an average of 21 kilograms of pure heroin in recent years. Therefore, using the best estimate for the amount of pure heroin annually consumed in Australia, the seizure rate is:

S/T seizure rate = 20,914 / [455,586 + 20,914] = 4.4%

The Australian Federal Police seize heroin at higher market levels, so the proportion of heroin they seize must take account of the amount that is later seized by state and territory police services as well as the amounts consumed. Therefore, the AFP seizure rate is:

AFP seizure rate = AFP qty seized / [Qty consumed + S/T qty seized + AFP qty seized]

On average, 194 kilograms of pure heroin has been seized by the AFP in recent years. Therefore, again using the best estimate for the amount of pure heroin annually consumed in Australia and the state and territory seizure average, the seizure rate is:

AFP seizure rate = 194,063 / [455,586 + 20,914 + 194,063] = 28.9%

Even if the low or high consumption estimates are used in these calculations, it seems that AFP seizures represent a large proportion of total amount imported into Australia, and the seizure rates are much higher than those of the state and territory police services. However, it should be noted that the difference between these rates would narrow on a "replacement cost" basis (as it costs more to purchase the same quantity of heroin at the retail end of the market).

By comparison the success of interdiction relative to local law enforcement in the United States is not as great in terms of the amount of cocaine and heroin seized (Caulkins & Reuter, 1998). The relative price differences between Austraila and the US may, in part, be due to the high seizure rate by the Australian Federal Police.

Compensation for time spent supplying drugs

The compensation paid for the actual time spent supplying heroin can be informed, at the retail level, by a "back of the envelope" calculation. Reuter and Kleiman (1986) applied a ratio taken by Moore (1973, cited in Reuter & Kleiman, 1986) of there being one dealer for ten heroin users. If this figure is taken for Australia, the best estimate for what ten heroin users consume weekly is two grams of pure heroin (10 users * 16 injections per week * 0.05 gram/injection * 25% purity = 2 grams). If the ounce price (approximately $1300 per gram) is taken as their average purchase price and the midpoint between the gram and cap price ($2600 per gram) taken as their average selling price, then these dealers make $2600 per week.

This estimate is highly sensitive to the proportion of heroin that is sold in caps versus the proportion sold in grams (if 75% was sold in grams and only 25% in caps then weekly income would be $1300). Maher et al. (1998) recorded the mean income from drug dealing for heroin users in Cabramatta was $901, although the median income was $258. Unless a lot of respondents were dealing occasionally or operating as user-dealers, the average weekly income of a dealer may be lower than two and a half thousand dollars.

In any case, the opportunity cost of the time taken to sell this heroin can be estimated. To do so, we require information on the time spent dealing and the alternative employment prospects faced by dealers. Alternative prospects may be imperfectly valued on the basis of the legislated minimum wage ($13.50 per hour; ACTU, 2005), although there are a number of factors – such as tax and welfare considerations – that may affect the opportunity cost even of dealers whose next best option is to work in a minimum wage job. For this reason, more direct surveying of the kind done by Reuter et al. (1990) in the future would be helpful.

Reuter, MacCoun and Murphy (1990) found Washington DC drug dealers spent an average 66 hours per month dealing. However, although dealing does not involve 40 hours of work per week, it may be that the jobs of dealers are full time in the sense that people who perform these tasks are unlikely to be simultaneously employed in the legitimate sector (Levitt & Venkatesh, 1998, 16). If 16 to 40 hours per week are taken as the bounds of the time required, then applying the minimum wage yields figures of between $216 to $540 compensation for time each week. Although unlikely to constitute the majority of the price mark-up, it is a significant proportion.

Assessing compensation for labour is not possible at the higher ends of the market, as there is not even sufficient information to make back of the envelope calculations.

Compensation for the risks of incarceration and violence

What about the compensation for the risks of incarceration and violence? Systemic violence seems to be low in the Australian heroin market. Reuter et al. (1990) used murder rates and gunshot-injuries as a measure of violence. However, in Australia there are only 1.3 murders per 100,000 (cf. 5.7 murders per 100,000 in the United States). Most Australian murders are of women (63%) and in residential settings (65%), whereas women are murder victims in 22% of cases in the US (ABS, 2005; FBI, 2005). Based on ABS (2004) arrest data, drug dealing is an activity predominantly done by males, so the murder rate due to dealing in Australia is likely to be small in absolute terms, and only a fraction of the rate in the United States.

That the risk of death can be only a trivial component of the price can be shown by another back of the envelope calculation. Suppose half of the 95 males murdered in Australia were all involved in the heroin trade. Even if the risk compensation was $2 million – a willingness to pay figure used for homicide by Mayhew (2003) – the total amount is $95 million, out of total revenues for heroin of $1200 to $1400 million (depending on whether these risks also apply to user-dealers).

There is little information that can be used to estimate the risks of violence. Reuter et al. (1990) estimated that the compensation for the risk of injury was about one-fifth the compensation for death. Even if the risks of violence are proportionally greater, they are still likely to comprise a relatively minor component of the overall costs.

On the other hand, incarceration costs are likely to be a larger than the violence costs. In 2003-04, there were 1,299 provider arrests (ACC, 2005). There is no information about whether they are importers or dealers, or at some stage in between. If the ratio of one dealer for every ten heroin users is applied to the estimate of 80,000 regular users, then 8,000 retail dealers are estimated to be in operation. So, if the majority of arrests are for dealing, then approximately 10% of dealers may be arrested.

How long do they receive? Court data indicates that 57% of those in Higher Courts defending an illicit drugs offence and 9% of those in Magistrates Courts defending an illicit drugs offence received custodial orders (ABS, 2005). In a recent census of Australian prisoners, 363 prisoners had been sentenced to an average 131 months for importing or exporting illicit drugs and 1,188 prisoners had been sentenced to an average 64 months for dealing or trafficking in illicit drugs (ABS, 2004). Taking the latter average sentence length and an estimate that 50% of heroin dealers received custodial orders (as most would appear in Higher Courts), then the expected prison length is 32 months per arrested dealer and 3.2 months for all dealers.

If they were compensated $50,000 per expected year of incarceration (similar to the estimate used by Reuter et al. (1990)), then the average heroin dealer requires an additional $256 per week ($50,000 * 3.2/12 years / 52 weeks). The amount is most likely to be smaller than the compensation for time, but the incarceration costs are also important.

The "risks and prices" theory is conventionally interpreted with its emphasis on compensation for the non-monetary risks of enforcement, injury and death, as they have been found to be the major cost components in the United States. However, these figures do not explain much of the total retail revenues of heroin in Australia.

Operational expenses and proprietors' return to capital (i.e. profit)

There is little Australian information on these last two cost components of the model. In studies looking at these for heroin and cocaine supply in the United States, they have been found to account for a negligible component of the retail price (Caulkins, Johnson, Taylor, & Taylor, 1999; Caulkins & MacCoun, 2003).

Nevertheless, a couple of aspects should be noted. Operational expenses for the distribution of heroin are likely to be unequally distributed through levels of the supply chain. High-level domestic dealers have expenses in the forms of vehicle maintenance and rent for drug storage. In Australia, the lack of land borders may mean the movement of heroin requires greater operational expenses at higher market levels than in other countries.

Profit is also a relevant cost component. It can be expected that larger operators will earn a normal profit, although they may be able to earn high rates of return in growing markets if there are significant barriers to entry (Reuter & Kleiman, 1986). Entry barriers, created by asymmetric information on the risks associated with law enforcement, allow incumbent drug dealers to continue to stockpile profits. Again, for Australia, the particular difficulties in importing heroin to a country without land borders may also bestow some market power once routes have been established.

Applying the "risk and prices" model

There are significant gaps and uncertainties in this framework. Even so, some understanding of the roles of different costs in the street price of heroin is gained through this exercise. There are three insights. The first is that, unlike similar studies in the United States such as Caulkins and Reuter (1998), the cost components do not seem to add up to an amount that is close to the revenues of the illicit drug at hand. While this is no doubt partially an information issue, even generous back of the envelope calculations would not easily make revenues fit with costs. The risk and prices model implicitly assumes a competitive market – suppliers do not have sufficient market power to charge more than their marginal costs. This "gap" in the Australian costing may point to the Australian situation being somewhat different, where some suppliers (most likely at higher levels) are able to exert greater influence over the price and thus the profits they earn. In any case, it's a puzzle, and one that will be important to unpack in order to determine the effectiveness of interdiction and local policing.

The second insight is that the price of an illicit drug like heroin is not necessarily strongly determined by the risks of enforcement and violence. The US experience leads to an emphasis on compensation for non-monetary risks, but Australian suppliers face lower risks. Quite possibly, given the different industrial relations systems, they also face better alternative employment options, which further increases the importance of compensation for time spent dealing rather than the risks associated with the dealing.

The third insight flows directly from the first two. The important differences between Australia and the US mean governments most likely face different possibilities for increasing the price through law enforcement. In Australia, a relatively large component of the overall heroin price is due to the revenues going to higher market levels. It may be that, to have the greatest impact on the price, Australia should enforce very long prison sentences for importers and high-level dealers, while increasing the risks to low-level dealers may have relatively little impact on the price. These policy conclusions are the opposite of what has been proposed for the US.

THE RELATIONSHIP BETWEEN HEROIN PRICES AND OVERDOSES

In addition to using economic concepts and simple calculations to understand Australia's heroin market, we can also increase our understanding by moving beyond traditional market measurement and looking directly at the statistical relationships between heroin prices and the harmful consequences generated by the supply and use of heroin. Except when policy makers are concerned about the use of heroin as the breach of drug laws, it is the harmful effects that will be of most concern.

If relationships can be found between policies and price, and in turn between price and harms, then this method of analysis may offer a useful approach to determining what policies are most appropriate given what harms policy makers are seeking to minimise.

As detailed above, we have now developed a high-frequency purity-adjusted price series for Victoria. Data on ambulance attendances at heroin overdoses are available for the period for which we have developed the price series from a database developed in 1997 (Dietze et al., 2000). While there is some debate about the definition of heroin overdose, because of various additional risks that commonly feature in the risk environment in which heroin use takes place (e.g. concomitant use of other CNS depressant drugs, see (Darke & Zador, 1996), the price per pure gram consumed provides an indirect measure of both the amount consumed and purity.

The Victorian heroin price series should be available on an ongoing basis, and the development of similar datasets in other jurisdictions should also be feasible. Therefore, in an effort to demonstrate the usefulness of the development of heroin price series, we have analysed this price series together with heroin overdose data from Melbourne to provide a simple illustration of the strong relationship between price and one of the harmful consequences associated with heroin use.

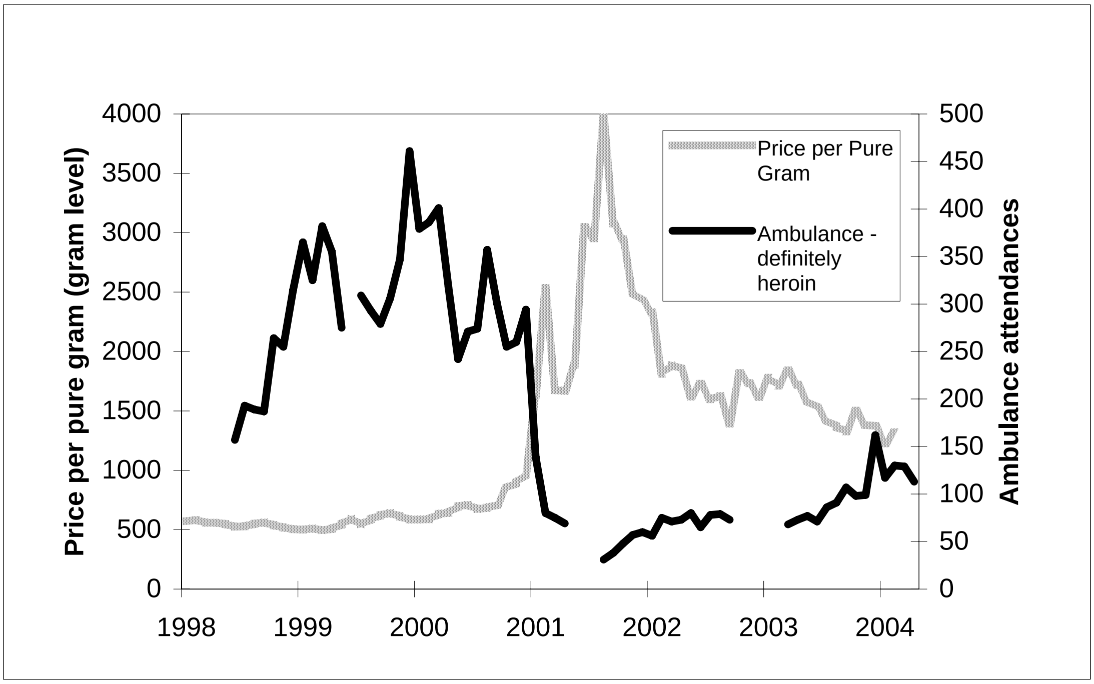
Smithson, Mcfadden, Mwesigye and Casey (2004) found that the purity of heroin seizures made by the Australian Federal Police in the ACT was a modest predictor of a variety of health and social outcomes. However, the methods we have used are essentially a replication of Caulkins (2001b), in which he estimated the correlation between the numbers of emergency department (ED) mentions and numbers of mentions one might expect if prices were the only thing that affected ED mentions. Correlation does not amount to causation, but, for the purposes of giving an intuitive demonstration the utility of using price, it is an effective approach.

Data used

The overdose data we have used were obtained from a database of non-fatal heroin overdoses attended by ambulances in Melbourne (Dietze et al., 2000). This database is a compilation of paper-based records completed by paramedics of the Melbourne Metropolitan Ambulance Service at the scene of attendance that are entered onto a computerized database by trained coders. These data have previously been used to analyse trends over time and place (Dietze et al., 2003), case characteristics such as age and sex (Dietze et al., 2000) as well as patient outcomes (Dietze et al., 2002).).

In this report we have plotted ambulance attendance data for "definite" non-fatal heroin overdoses (i.e. those involving a positive response to the administration of naloxone, where other opioids are excluded, see Dietze et al. 2000) alongside the Victorian price series detailed in

Appendix 1, for the period June 1998 to February 2004 (gaps in overdose data are due to industrial action by ambulance officers). Before even conducting the statistical analysis, it seems reasonably clear that there is a strong inverse relationship between price and overdoses for some periods. The relationship seems weakest during 1998 and 1999. That could have been a period where underlying market characteristics were changing in "unusual" ways, an argument that has been made by Dietze and Fitzgerald (2002).



Source: Turning Point ambulance reports; VFSC, IDRS and author calculations (see Appendix 1).

Figure 7: Heroin prices and overdoses (definitely heroin), Victoria, 1998 to 2004

Methods and analysis

The price and overdose data is used to develop a third set of data: the number of overdoses that would be expected if they were determined only by prices through a constant price elasticity relationship. Mathematically, that means the number of overdoses is proportional to price raised to a constant. It is what one would expect if: 1) there was a constant price elasticity of demand and 2) overdose deaths were proportional to consumption. The exponent's value (-1.12) was chosen to minimize the sum of the squared difference between the actual and the expected number of overdoses from mid-1999 onward. Its value can be interpreted as the elasticity of ambulance calls with respect to price, meaning it is the percentage change in ambulance calls that was associated with a 1% increase in price. In other words, every 10% increase in the purity-adjusted price of heroin was associated with an 11.2% decrease in the number of ambulance calls.

In Figure 8, the expected number of overdoses is plotted together with the actual number of overdoses due to heroin. Again, the strong relationship between the two is quite apparent. From mid-1999 on, the correlation between the actual number of ambulance calls and what would be predicted based on price alone is 93%, which means that 87% of the variation in overdoses in Melbourne from mid-1999 through early 2004 can be explained by price changes alone. As observed by Caulkins (2001b), considering the imperfections in the data and the number of factors that are omitted, the strength of this relationship is striking.

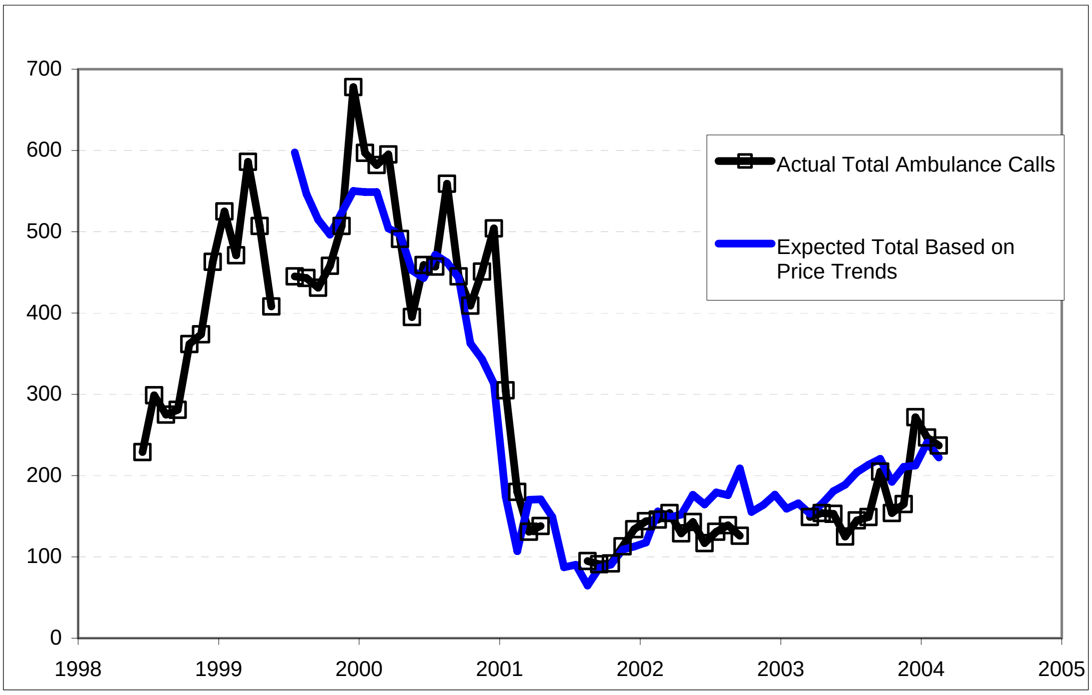


Figure 8: Actual Monthly Ambulance Calls to What Would Be Predicted Based on Price Trends from a Constant Elasticity Model (eta = -1.12)

The potential for the further use of high-frequency price data

The previous analysis suggests that we may be able to use price data to overcome some of the other informational limitations associated with analysing the heroin market in Australia. While Victoria Police may analyse more of their seizures than most other jurisdictions, it could be expected that there would be sufficient numbers of seizures in most states and territories to construct high-frequency price series.

The other elements that are necessary are datasets that record policies (e.g. seizures, treatment numbers) and market outcomes (e.g. property crime, drug-attributable health conditions). As Degenhardt and Dietze (2005) have discussed, there are many different datasets constructed in Australia, so it does seem that there is potential to apply this approach in a number of ways in Australia. Several studies have already tried to analyse the relationships between price or purity and drug seizures (e.g. Weatherburn & Lind, 1995; Smithson, McFadden, & Mwesigye, 2005) and treatment (Weatherburn & Lind, 2001). However, the lack of readily available price data has limited the research possibilities, and there are many more analyses that could be done if that issue is addressed.

CONCLUSION

This exploration of what is understood and what may be understood about heroin markets in Australia has been wide-ranging. There are a range of insights that can be drawn out of it and used as the basis upon which to develop further information and future research.

Key insights

First, and perhaps surprisingly, there is a great deal of information that can be of assistance in understanding the Australian heroin market. It has been underutilised and, given the ongoing efforts in data collection, should be put to better use. As an example, the work undertaken by the Victoria Police Forensic Science Centre in analysing all of their seizures rather than just those associated with large seizures or court cases provides tremendous opportunities to understand the heroin market in Victoria in great detail, and also to assess whether the more restrictive rules upon which forensic analysis is decided in other jurisdictions bias the results (it appears they do not). Similarly, the consistency with which the Illicit Drug Reporting System has been conducted across most jurisdictions for many years means that, together with other information, researchers are well placed for moving beyond general descriptions of the Australian heroin market. It is not until all of these information sources are considered together that the possibilities become apparent.

Second, a comprehensive economic framework provides us with a good idea of what information we should seek, which provides a good motivation to draw together disparate data. In addition, as we know what relationships between variables we expect to see, there is an ability to at least understand when some apparent connections may be spurious.

There are also substantive insights about the heroin market. An important one is that amount of heroin consumed in Australia may be substantially less in Australia than is commonly considered. This reduced amount may be a recent phenomenon; there may have been a consistent overestimation; or the current prevalence and related estimates may be wrong. Whichever is the case, these results require a re-think about how to associate the harms related to heroin use with the amount that is consumed and a further examination of the number of people thought to be using.

A second insight is the degree to which the price of a pure gram of heroin has changed in the past few years. The Victorian price series starkly shows that a decrease in the availability of heroin in late 2000 and early 2001 was matched by a large increase in the heroin price. While this is as economists would expect, the sharpness of the movement demonstrates that price of heroin is responsive to market changes.

Another insight is the importance of upper levels of heroin supply, in terms of the relatively high proportion of the total revenues that seem to accrue to those levels. The particular geography of Australia and a relatively high interdiction rate may partially explain this, although more research needs to be done in this area.

A fourth and final key substantive insight is the strong relationship between heroin prices and heroin-related overdoses. The causes of overdoses are undoubtedly complicated, but in price we have a reasonably accurate measure that is strongly related to how often overdoses occur (or, more accurately, require an ambulance). Policies that are found to increase the heroin price – and much more work needs to be done to establish those relationships – will decrease the number of overdoses.

Future research

There is any number of areas where future research efforts would be fruitful. However, there are several where new knowledge would substantially improve our understanding of the heroin market, and inform policy decisions.

The development of high-frequency heroin price series in as many jurisdictions as possible is a high priority. There is now a methodology for how this can be done using Australian data and, with the cooperation of law enforcement agencies and those conducting the IDRS, developing these would be a high-return activity.

It would also be enormously useful to properly understand the amount of impure heroin in a cap. This seemingly minor part of the overall picture has a big impact on how we understand the quantity of heroin consumed and the prices paid at the retail end. It seems to be something that even injecting drug users do not understand well. Cap weight and – given it is not absolutely certain that the two match up – the amount of heroin injected should be known with more certainty.

In order to prevent this becoming a "wish list" of sorts, we focus on only one other area where further research is a high priority. This is the activities of and decisions made by heroin dealers and other suppliers. It is an area with many individual activities, but the limitations to our understanding are so great that researchers who could shed light on any participants in the supply process would be doing an enormous favour to improving our overall understanding of the market. This is perhaps one area where the lack of legal protection afforded to research into illicit activities has had a particularly acute impact. Exercises like Reuter et al. (1990), which involved surveying drug dealers, have proved enormously useful yet it is unlikely they could currently be conducted in Australia.

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APPENDIX 1: CONSTRUCTING THE HEROIN PRICE SERIES FOR VICTORIA

Technical details about the construction of the price series are provided in this section. It includes information about the data sources; the information they contain; what data cleaning and data selection decisions were made; and why these decisions were made.

There were two types of data used for the development of the price series: forensic analyses conducted by the Victoria Police Forensic Science Centre (VFSC) and survey responses of injecting drug users from the Illicit Drug Reporting System (IDRS). Heroin purity and weight information was taken from the VFSC data, while the prices paid were taken from the IDRS.

The price series constructed is for the price of a gram of heroin. There are regular price observations for a "cap" and a "gram". As a "gram" relates back to a measurable and accepted quantity, it was selected as the base for the price series.

Victoria Police Forensic Centre (VFSC) data

The VFSC analyses all drug samples obtained by Victoria Police. They have analysed and recorded all drug seizures since 1997, and are the only Australian state or territory police agency to have adopted such a broad approach to forensic analysis (most jurisdictions analyse a subset of all illicit drugs seized).

No formal codebook exists for the database. The data that were available were determined by visiting the VFSC and being taken through the data entry process. A description of the process was written up and sent to VFSC, who returned an edited version of our original document. This process was adopted to ensure we had an accurate understanding of the VFSC data. Relevant fields were then identified and requested from the VFSC. At the same time, an application was also made to the Victoria Police Research Coordinating Committee, who approved the use of VFSC data to develop price information.

In order for other researchers to be able to replicate the starting sample of data, it is important to document how the data were requested (ONDCP, 2004b). A formal request was sent to VFSC on 17 June 2005 for unit record data on drugs classified as heroin (the label in the database was "diacetylmorphine (Opiates)") that have been analysed by the VFSC with offence dates between 1st January 1998 to the 31st December 2004. The VFSC provided an excel file containing 14,269 records on the 29 June 2005, with extraction from the database occurring less than a week earlier.

Each record had two identifiers: *Case number* and *Item number*. VFSC assigns a case number that is used throughout the analysis. Then for each case number, there is an item number and sometimes, a number of sub-items within the item. For example, three plastic bags may be seized and presented to Forensics. They will be allocated a common case number, and each plastic bag will be identified as a separate item (i.e. 1, 2, 3, etc.). Upon opening a bag, the analyst may discover that it contains several drugs. Each of these may be allocated a separate sub-item number (i, ii, iii, etc.). Each item/sub-item appears as a separate record.

The case number is a broad identifier: it can relate to a number of seizures (and regularly turns up at different dates in the sample). Furthermore, sub-items do not seem to comprise a large proportion of the sample: there are few instances where there are more than three or four sub-items from the same case number with the same offence date. The sub-items that did come from the same case and have the same offence date often had different purities. Therefore, each sub-item was treated as a separate record, and it was not expected that this would unduly affect the construction of the price series.

Data Fields

Main information

For each seizure analysed, the following information was included:

1. Offence Date – date that the seizure was made.
2. Purity – given in percentage terms (to one decimal place). Analysts estimate the purity analysis error rate to be up to 10% of the purity value, and could have been as large as 20% over the period being considered here.
3. Mass – measured in grams (to two decimal places).
4. Number of Packets – the number of separate quantities within the item/ sub-item (e.g. when eight foils are in a jar, then "8" is recorded).
5. Form – type of the drug, such as whether it was in powder, compressed or tablet form.
6. Colour – colour of the drug.

Geographic and police operational identifiers

There were also data fields that provided information on where the heroin had been seized, who it had been seized by and for what purpose:

7. Division – there are five geographically separate Victoria Police Divisions. Where there was no Division number, we assumed the seizure was obtained by a central unit.
8. District – Victoria Police District is a narrower – but still quite broad – identifier of who seized the drugs. There were approximately 75 such Districts, and District was included in nearly all records (~98%).
9. Station – Police Station is again a more specific measure of operational responsibility for the seizure. Only 0.6% of records do not contain information on police station. Some specialised "stations" change over time, presumably due to changes to Victoria Police's operational structure.
10. Postcode – The postcode of where the seizure had been located has been included as a data field since 2001 or early 2002 (it is not possible to be exact, as there is no field which provides the date on which the analysis occurred). Approximately 90% of records in 2002, 2003 and 2004 include Postcode information.
11. Status – this identifies which of two VFSC teams did the forensic analysis: "CDI" or "Other". "Other" is for court-related analysis; "CDI" is for non court-related analysis.
12. Local Government Area – this is the local government area where the police station that seized the heroin was located. This was a constructed variable, designed to match up with the geographic identifiers used in the heroin overdose data recorded by the Melbourne Metropolitan Ambulance Service.

    Five particular LGAs with high overdose numbers were labelled. The first step involved working out the location of each station with respect to its LGA. Then the available information on the postcodes where seizures actually occurred was used to ensure that the majority of seizures were made within the LGA in which they were located. Records from special squads were not included, as it was difficult to source the location of the seizure or areas deemed rural by LGA authorities. In total there were 9061 seizures (of the cleaned data) that could be allocated to a LGA.

Victoria Police held more information on seizure characteristics (such as a description of the paraphernalia found with the drugs), but there was no basis upon which to think that these omitted characteristics were relevant to the analysis.

Data Cleaning

There were a number of restrictions made to the sample, to ensure that a comparable and consistent set of data were available for analysis. The factors considered and actions taken by the ONDCP (2004) in developing the latest United States illicit drug price series were considered in the data cleaning decisions taken here.

There were originally 14,269 records. This was adjusted on the following basis:

1. *The five observations for which the purity was greater than 100% were adjusted to 100%.*

   There were five records that had a Purity greater than 100% (the highest purity recorded was 102.4%). These were well within the expected error rates (actual purity is expected to be within +/-10% of *Purity*). As such, they seem to be due to acceptable analytic variation rather than data entry errors, and were adjusted to 100%.

2. *All records where Form (the form of the drug) was not "Powder (compressed)" were removed.*

   Some forms of heroin are easier to cut (dilute) than other forms. "Powder (compressed)" was the predominant form of heroin that was seized in Victoria, with 92% of all records being of that form. Removing other drug forms eliminated variations in the form of the seizures being the cause of purity variation, without substantially reducing the sample size.

   After this adjustment, there were 13,121 records.

3. *Records with an Offence Date after 29th February 2004 were removed.*

   There is a lag between the Offence Date and when a seizure is analysed, due to delays in lodgement with the VFSC and then a period before it is analysed. Lodgement occurs approximately three months after an offence, although it can be up to two years. Analysis relevant to court activity – coded "CDI" in the *Status* field – occurs approximately six months after lodgement, while analysis of other seizures – coded "Other" in the *Status* field – lags lodgement by about ten or 11 months. The proportion of seizures that are analysed by "CDI" provides a way of determining when the longest lag, for "Other" forensic analysis, starts to affect seizure numbers.

   The proportion of seizures that is court related is relatively steady (15% to 30%) until March 2004. It is 30% in February 2004, but then rises to 49% in March 2004 and 68% in April 2004. The records analysed by the CDI team may not be representative of all seizures, so records with Offence Dates after February 2004 were removed. Lags may have some effect in February 2004 and earlier, but they are expected to be minor.

   After this adjustment, there were 12,871 records.

4. *Records with a Weight above 28 grams were removed.*

   It could be expected that Purity would be greater when Weight is higher. As large seizures occur infrequently – and too rarely to analyse independently – removing them means purity variation over time is not influenced by the weight characteristics of seizures over time. The purity of seizures above 200 grams was greater than the average purity of all seizures in the same month. However, below that weight there did not seem to be purity dilution. This is not so surprising when the form of the drug is "rock" (i.e. Powder (compressed)), which is much harder to dilute than powder.

   A conservative approach was taken to ensuring that weight variations did not affect average purity: records with a weight greater than 28 grams (approximately one ounce) were removed.

   After this adjustment, there were 12,713 records.

5. *The local government area where the police station was located was identified.*

   Metropolitan Ambulance data suggest that there are particular LGA's that have a higher number of overdoses than other areas. These areas were coded separately to see if there were differences in the number of seizures that occurred. The first step involved working out the location of each station with respect to its LGA. As there was a small amount of postcode data available on the actual location of the seizure, this was used to check if the majority of the seizure actually occurred within the stations current LGA. This did not include data from special squads in which it was difficult to source the location of the seizure or areas deemed rural by LGA authorities.

   From this, it was determined that there were 9061 seizures that could be allocated to a LGA.

Data cleaning removed just under 11% of the original number of records. There were a number of steps taken by ONDCP (2004b) that we did not take, largely due to different record keeping and administrative issues. ONDCP did remove seizures that weighed less than 0.1 gram on the basis that the purity analysis error rates were greater at low weights. However, the VFSC did not believe this was the case with their testing, so no omissions were made on the basis of small seizure weight.

Illicit Drug Reporting System data

The IDRS monitors market conditions and patterns of use of the main illicit drugs via a quantitative survey of injecting drug users and a qualitative survey of experts in fields related to illicit drugs. The IDRS commenced as a trial in NSW in 1996. It was conducted in NSW, Victoria and South Australia from 1997, and extended to the remaining jurisdictions in 2000.

Every year, approximately 950 injecting drug users (IDU) are interviewed nationally for the IDRS, with approximately 150 from Victoria. Interviews are normally conducted during June and July. To be eligible, IDU need to have been injecting monthly during the six months preceding the interview, and to have been resident for at least 12 months in the capital city in which they were interviewed. Convenience sampling is employed, with participants recruited from advertisements in street press, newspapers, treatment agencies, needle and syringe programs and peer referral (Breen et al., 2004).

There are two issues with these data: the use of convenience sampling, and single annual price information. While more frequent price observations taken from a sample judged to be representative of heroin purchasers would be desirable, the IDRS data are probably sufficient to capture most of the variability in the nominal price.

Heroin prices tend to be in round figures, so that – at the gram level – it can be paid for in $20 or $50 notes. This makes sense, given the illicit nature of these transactions. It means that the nominal heroin prices change infrequently and noticeably. Most large changes will be identified through annual observation, and "filling in" values in between these observations by interpolation of the values provides a reasonable measure of the movement of prices over time.

The round figures for heroin prices also means market information is better than would otherwise be expected. Regular heroin users, which nearly everyone in the IDRS sample is, most likely know the "going rate" for a gram of heroin. The VFSC data suggest the form of the drug in Victoria is quite constant and that it is not diluted at intermediate or retail levels of the market. The consistency of the responses suggests there is not any significant market segmentation among regular injecting drug users in Victoria. Furthermore, as is estimated here and by Degenhardt et al. (2004), regular heroin users consume approximately 85% of all Australian heroin, so the prices paid by regular users should be representative of the average prices in the overall market.

In the United States, ONDCP (2004b) and others use price information from police buys and arrests contained within the System to Retrieve Information from Drug Evidence (STRIDE). The Victorian Police Major Drug Investigation Division (MDID) was visited, in order to understand whether similar information was held for Victorian heroin prices. The MDID occasionally collect similar information, but it has not been systematically collected or recorded, and is relatively infrequent (20 to 30 heroin price observations per year for all quantity levels). Despite its imperfections, the IDRS provides the best available information on nominal prices for heroin in Victoria and, as a survey of regular buyers of heroin, is in some respects superior to police price data sources.

Unit record Victorian IDRS data from 1998 to 2004 were extracted under the Turning Point Alcohol and Drug Centre ethics agreement. There were a total of 1,257 records, with between 128 (in 2004) and 250 (in 1998) respondents in any year.

Data Fields

There were two responses from which price information was drawn:

1. Heroin Cost – how much it costs for a gram of heroin; and
2. Heroin Price Last Paid – the price last paid for a gram of heroin.

The second question was not included in the 1997 and 1998 IDRS questionnaires. There were 153 respondents who provided information on both, and the answers matched on 102 occasions. On that basis, it seemed reasonable to use both the responses to gain as many single representative responses as possible.

Data Cleaning

Several steps were taken to remove nonsensical or potentially erroneous data.

1. *Respondents with large differences between the values they provided for Heroin Cost and Heroin Price Last Paid were removed.*

   Of the 51 respondents who provided information on Heroin Cost and Heroin Price Last Paid, on 36 occasions the responses were within $50 of each other. These responses seemed reasonable, as the differences represented less than 20% in price. The other 15 responses, where the two responses differed by between $55 and $750, were removed from the sample.

2. *Heroin Price Last Paid was used to "fill in" Heroin Cost values.*

   The two responses were combined to create a single set of price observations. While Price Last Paid would have been the preferable field if it had been included in all years of the IDRS, its omission in 1997 and 1998 meant that Heroin Cost was used in the 36 occasions where they differed. There were another 28 responses that had Heroin Price Last Paid but not Heroin Cost. These responses were combined with the Heroin Cost information.

   After this adjustment, there were 598 observations.

3. *Outliers were removed.*

   Outliers were classified as prices less than $150 or greater than $700. They did not seem plausible prices for a gram of heroin, and may have been due to administrative or respondent error. There were 7 observations less than $150, and 4 observations greater than $700. For both the high and the low outliers, there were no more than two outliers from any survey year, further suggesting these observations were not representative of the sample.

   After this adjustment, there were 591 observations.

Price series construction

The three components – price paid, purity and weight – were brought together in a monthly series by constructing price per pure gram as:

Price per pure gram ($) = Nominal price ($) / [Average purity (%) * Weight (g)]

Where Nominal price = Average monthly price (from IDRS)
Average purity = Average monthly purity (from VFSC)
Weight = Average weight within 0.8 to 1.2 grams for whole series (from VFSC)

Time period was the only basis upon which observations were separated: there were no significant differences in the average purities or weights for seizures made in different locations for different purposes.

Average annual values for the price of a gram were used in the price series. As can be seen in Figure 9, the median and modal values were quite similar to the mean (and approximately one-third of the observations occurred at the mode). The annual means were converted into monthly values using interpolation (i.e. assuming a smooth transition from one annual observation to the next).

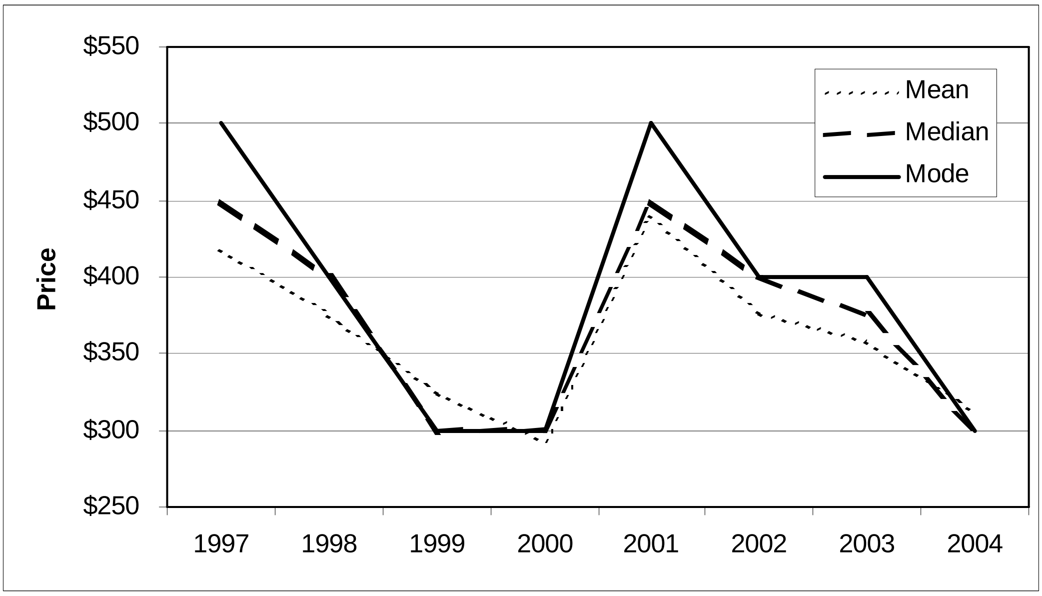

Figure 9: Mean, median and modal price for a gram of heroin (unadjusted for purity)

Purity was calculated on a monthly basis, which meant that the average values for all months were calculated using 50 or more observations. Average purity is plotted together with median purity in Figure 10 (there are no important differences between the two). As has previously been noted by Godkin, Caulkins and Dietze (2005) using similar data, purity declined fairly steadily from around 75% to 40% during 1999 and 2000, and then fell rapidly at the beginning of 2001. The movement in purity is generally in the opposite direction to the IDRS price movements, as would be expected, although the annual observations of nominal price make it hard to assess whether some differences between price and purity changes are real or a statistical artifact.

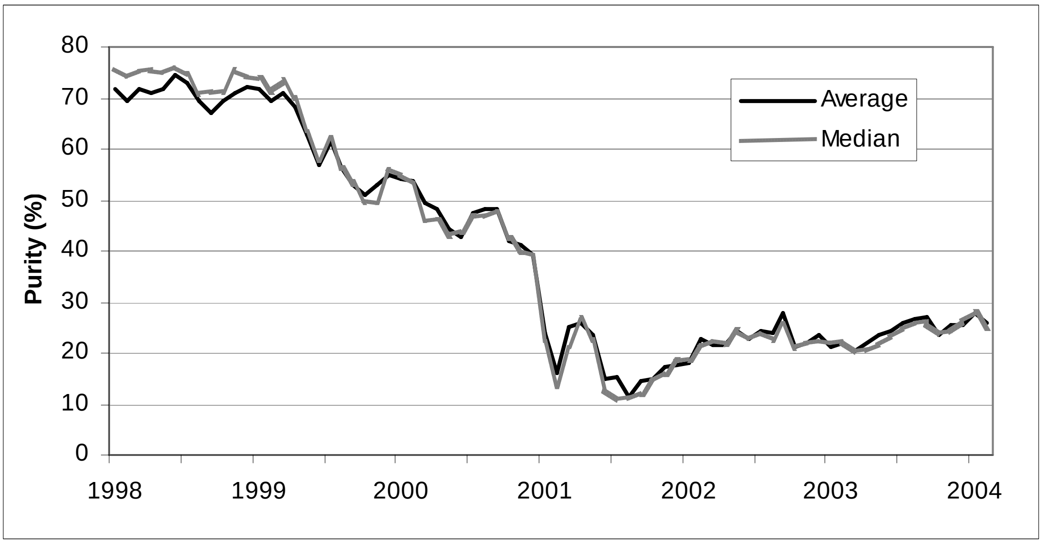

Figure 10: Mean and median purity for heroin

To determine values for the average weight of a "gram" of heroin, the quarterly average of seizures weighing between 0.8 and 1.2 grams were calculated. As can be seen in Figure 11, there was not a consistent pattern to the weight. As a result, the weight was made a constant 0.96 grams (the average weight of all seizures weighing between 0.8 and 1.2 grams).

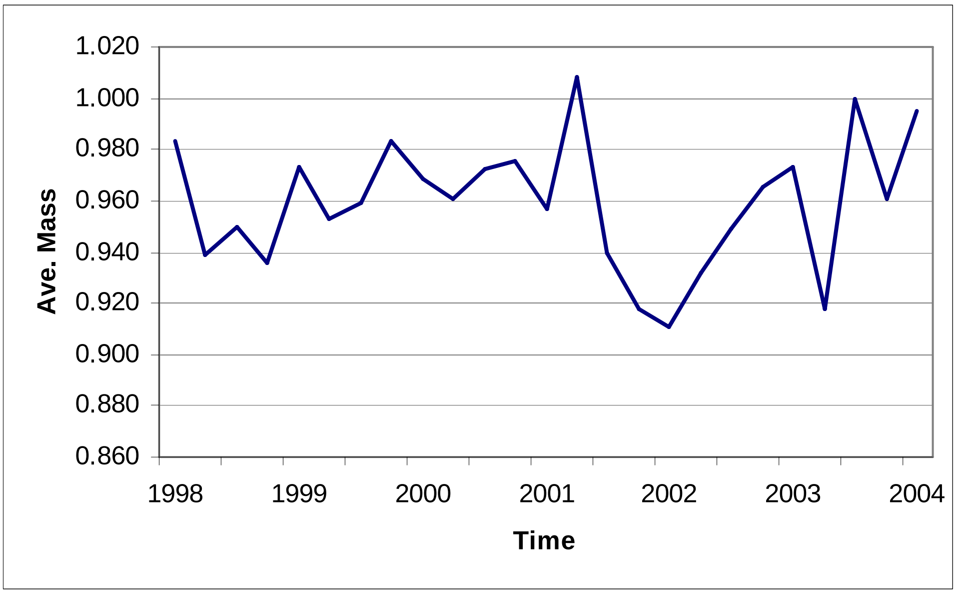

Figure 11: Average Mass of Seizures in 0.8 to 1.2 Gram Range (Quarterly)

APPENDIX 2: ESTIMATION OF PRICES AT DIFFERENT QUANTITIES (WEIGHTS)

Recent Australian Crime Commission reports (2003, 2004, 2005), the IDRS reports (Breen et al., 2003, 2004; Stafford, Degenhardt, Black, Bruno, Buckingham, Fetherston, Jenkinson, Kinner, Moon, & Weekley, 2005) and the VFSC dataset were used to develop estimates for the price per pure gram of heroin at different weights (the weights considered in the calculation were caps, grams, ounces, half-cattis, cattis and kilograms). These reports cover the period 2001/02 to 2004 and, as such, the prices reported here could be considered to be "post-shortage" estimates.

The form and values of ACC observations change quite significantly across jurisdictions and over time. Furthermore, there are many weights for which price is rarely reported, particularly for the larger weights. For these reasons, several sources of price information were used to ensure the estimates were, to some degree, representative.

While there are not large spatial differences in heroin prices, there are some (e.g. WA prices are generally higher than NSW, Queensland and Victoria), and there are more gaps in the price information of smaller jurisdictions. For that reason, price data were drawn from the most populous states (namely New South Wales, Victoria and Queensland).

Prices for the caps and grams were determined by combining 2001/02 to 2003/04 ACC data and 2002 to 2004 IDRS data (see Table 7). The main estimate is not strictly an average; rather, it is a value that is close to the prices consistently reported. This gave a price for a cap of $45 and $400 for a gram.

Table 7: Prices of caps and grams

Name	Weight (grams)	Post Drought Average	ACC data midpoint			IDRS data median		
			2001/02	2002/03	2003/04	2002	2003	2004
Cap	0.05	$ 45		$ 50	$ 50	$ 50	$ 50	$ 40
Cap	0.1	$ 45		$ 50	$ 50	$ 50	$ 50	$ 40
Gram	1.0	$400	$450	$400	$400	$409	$393	$350

Source: ACC (2003, 2004, 2005); Breen et al. (2003, 2004); Stafford et al. (2005).

The ACC was used on its own for ounces, half catti and cattis (as the IDRS did not report any information on these sizes) (see Table 8). It was estimated that an ounce cost $9,000, a half-catti (350 grams) was worth $140,000 and a full catti (700 grams) was worth $200,000. While there several observations provided for an ounce and half-catti, the estimate for price of the catti was based on two observations.

Table 8: Prices of ounces, half-cattis and cattis

Name	Weight (grams)	Post Drought Average	ACC data midpoint		
			2001/02	2002/03	2003/04
Ounce	28	$ 9,000	$ 7,500	$ 7,500	$ 11,250
Half-catti	350	$140,000			$140,000
			2001/02 (QLD)	2001/02 (NSW)	2002-04 (NSW)
Catti	700	$200,000	$260,000	$180,000	$180,000

Source: ACC (2003, 2004, 2005)

The cost of a kilogram was determined from 2002 information from the United Nations Office of Drugs and Crime (UNODC, 2005). The US$75,845 per kilogram was converted to Australian dollars using the average exchange rate for 2002 (RBA, 2005). These data are shown in Table 9.

Table 9: Price of kilograms

Name	Weight (grams)	Post Drought Average	UNODC US Price	RBA Exchange Rate
Kilogram	1000	$138,934	$75,845	$0.5444

These are all prices for impure amounts of heroin. They were converted to pure amounts on the basis of purity information from the VFSC seizure data and the ACC (2003, 2004, 2005). Observation of the data suggested there was "cutting" (heroin dilution) from import level to higher level weights in the VFSC dataset (more than 200 grams), and then again from those sizes down to smaller quantities. Three purity levels were assigned: "retail", "mid-level" and "import" purity.

The VFSC data and ACC information suggested a purity of retail heroin of about 25% for weights under 200grams, and a mid-level purity for seizures over 200grams of 50%. This was combined with the Australian Federal Police figures (the "more than two grams" category) in the ACC reports, in which purity was generally at about 70% for imported heroin. These purities were then assigned to the various weights as shown in Table 10.

Table 10: Purity assigned to heroin weights

Size	Weight (grams)	Price	Level	Purity
Cap	0.05	$ 45	Retail	25%
Cap	0.1	$ 45	Retail	25%
Gram	1.0	$ 400	Retail	25%
Ounce	28.0	$ 9000	Retail	25%
½ Catti	350.0	$ 140,000	Mid-Level	50%
Catti	700.0	$ 200,000	Mid-Level	50%
Kilogram	1000.0	$ 138,934	Import	70%

Source: ACC (2003, 2004, 2005) and VFSC data.

These estimates were combined to create estimates of the price per pure gram for different quantities. This is shown in Table 11 (which is the same as Table 4). With particular uncertainty around the weight of a cap, the price per pure gram for a cap was estimated for weights of 0.05 grams and 0.1 grams.

Table 11: Heroin prices at different quantities

Size	Weight (grams)	Price	Purity	Price per pure gram	Ratio to previous price
Cap	0.05	$ 45	25% (retail)	$ 3,600	225% (cf. gram)
Cap	0.1	$ 45	25% (retail)	$ 1,800	113% (cf. gram)
Gram	1	$ 400	25% (retail)	$ 1,600	126%
Ounce	28	$ 9,000	25% (retail)	$ 1,270	161%
1/2 catti	350	$ 140,000	50% (mid-level)	$ 790	138%
Catti	700	$ 200,000	50% (mid-level)	$ 571	288%
Kilogram	1,000	$ 138,934	70% (import)	$ 198	