

Heroin and Methamphetamine Seizures in Victoria, Australia: Purity Changes Associated with the Heroin “Drought”

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Abstract

The Australian heroin “drought” was a singular event deserving of the considerable scholarly attention it has engendered. The best way to understand market disruption is to examine both supply and demand side indicators, yet data on the former have been relatively neglected. Here we explore a rich data set on heroin and methamphetamine purity from 1998-2002 in Victoria that support monthly and even fortnightly time series. These series show that the drought was characterized by abrupt and substantial declines in heroin purity (from ~40% to as low as 10-15%), but those steep declines followed an extended period of substantial erosion in purity (from 70-75% in early 1999 to ~40% by the end of 2000). Purity rebounded from its post-drought lows but far from completely, stabilizing at ~20% for 2002. The heroin purity declines do not appear to stem from “cutting” at lower market levels. The declines did increase the purity variability per pure unit of heroin. There was no comparable evidence of contemporaneous effects in the methamphetamine purity series.

Keywords: Heroin drought, drug price and purity, drug policy

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1. Introduction

There was a significant disruption to heroin supply in Australia in late 2000 / early 2001, commonly referred to and characterised as a “drought” (Weatherburn et al., 2001, 2003). An alternative perspective is that rather than being a disruption to a normal heroin market the downturn was a result of the end of a heroin “glut” (Dietze et al., 2002). Regardless, the drought produced dramatic reductions in use-related indicators with effects extending beyond 2001 (Degenhardt et al., 2005a).

It is still not clear precisely what caused this disruption, but it appears to have stemmed from a combination of supply-side factors (Degenhardt et al., 2005b). Demand may drive long-term trends in drug-related phenomena, but sudden drops in aggregate demand from regular and dependent users would be unusual, and they are thought to have accounted for 85-95% of pre-drought heroin consumption in Australia (Hall et al., 2000).

Nevertheless, most research on this singularly important market event has focused on demand side indicators, notably changes in drug use and associated harms. Here we explore a novel and insightful supply-side indicator over a 5-year period surrounding the drought: the purity of essentially every individual law enforcement seizure in Victoria. These new data allow us to construct and examine time series predicated on forensic data that reflect monthly and bi-weekly changes in purity at both the wholesale and retail levels.

These series enrich understanding of the heroin drought and thereby illustrate the potential value of purity data for drug policy analysis more generally. For example, annual survey data show that the price per gram of heroin in Victoria (not adjusted for purity) increased from \$300 in 2000 to \$450 in 2001, before falling back to \$400 and \$380 in the two following years (Breen et al., 2002, 2003). It is hard to understand how such seemingly modest changes in price could have engendered the rather spectacular changes that have been observed in heroin-related overdose mentions. However, as we will see, fluctuations in the price per pure gram were much greater.

Over the 1998 – 2002 period heroin was the predominant illicit drug used in Victoria by injecting drug users interviewed in the Illicit Drug Reporting System (IDRS) However, methamphetamine was a clear second, with the proportion of respondents identifying methamphetamine as their drug of choice increasing from ~5% before to ~15% after the heroin drought. Cocaine and other illicit substances were all quoted at less than 6%. Hence, we also examine parallel series for methamphetamine to look for similar trends and/or spill-over effects in that related market in Victoria.

2. Methods

2.1 Data source

Since 1998 all seizures of heroin and methamphetamine by Victorian Police have been analyzed and collated by the Victorian Forensic Sciences Centre (VFSC). Following analysis, the seizures' characteristics are entered into a database managed by the VFSC. We obtained an extract comprising data collected from January 1st 1998 to August 24th 2003. Because of delays in analyzing samples and entering results into the database, there were relatively few observations from 2003, so we focus on the period between January 1998 and December 2002. Each observation in the extract records the type of drug, purity of the sample, number of packages within which the drugs were contained, total mass, and an assessment of the “form” of the seizure, e.g. powder (amorphous) or powder (compressed).

Table 1 breaks down the 12,281 heroin observations by form and year for 1998 - 2002. 97.9% of these heroin seizures were “compressed” or “amorphous” powder. There was a significant difference between the sample means according to the form of seizure (statistic? = $p < 0.05$) only in 1998 and 2002, and the means differed by less than 10%, so we combined data from both forms. The number of seizures declined from around 3,000 per year from 1998-2000 to about 1,000 per year in 2001 and 2002.

Table 1: Number of Heroin Seizures by form 1998 -- 2002

Form	Number of Seizures					Total
	1998	1999	2000	2001	2002	
Powder (compressed)	2,902	3,219	3,072	1,048	897	11,138
Powder (amorphous)	332	234	180	131	94	971
Powder (other)	6	9	23	8	4	104
Other Forms*	81	10	26	3	2	10
TOTAL	3,321	3,472	3,301	1,190	997	12,281

*Other forms include tablets, capsules, and beads.

We compare trends separately for “retail” and “wholesale” quantities. There are no standardized demarcations between retail and wholesale transaction weights. Analysts often assume individual doses are 0.03 – 0.12 grams (Moore et al., 2005). To avoid misclassifying retail or near retail transactions we round the retail wholesale boundary up to count as retail all observations of less than 1g.

Heroin can pass through several hands between import and retail sale, so there is not just one wholesale heroin market level. Following Caulkins et al. (2004), we group together observations of 1-10 grams and assume that they represent lower-level wholesale transactions (one step away from a street deal). Transactions of more than 10 grams were assumed to represent a higher-level wholesale market.

The single largest heroin observation is 6.6 kilograms, but the largest weight that occurs with any frequency is the “half-cati” or about 350 grams, or which there are 27 in the sample.

Table 2 breaks down the 5,509 methamphetamine observations by form and year. (The 134 observations for amphetamines were excluded from this analysis.) There was a significant difference between the sample means according to the drug form (t-statistic $p < 0.05$), so we restrict analysis to the amorphous powder form, the most common form of seizure.

Table 2: Methamphetamine Seizures by Type 1998 to 2002

Form	Number of Seizures					
	1998	1999	2000	2001	2002	Total
Powder (amorphous)	457	579	513	589	410	2,548
Powder (other)	35	122	357	573	363	1,450
Illicit Tablet	95	287	577	417	112	1,488
Other	1	0	7	9	7	24
Total	588	988	1,454	1,588	891	5,509

IDUs report typically buying methamphetamine as “points” (0.1g) or “half” (0.5g) weights, so as with the heroin data we distinguish between “retail” (0-1 gram), low-level wholesale (1-10 grams), and larger (10+ gram) observations. The single largest seizure was 4.7 kg, but the largest weight for which there are very many observations is around 300g.

2.2 Analysis strategy

Plotting a measure of the central tendency is often more informative than is plotting the purity of individual observations, and medians are preferred to averages since they are less sensitive to outliers. One method of smoothing was to create rolling medians, meaning, for any point in time, the median of the following 2, 4, 6 and 8 weeks’ data was taken. Taking medians over a broad range of dates reduces noise due to sampling variability, but also obscures short-term trends in the data. To determine the smallest sample size that was required, Bootstrap methods (Chernick, 1999) were used to identify the variation depending on sample size for observations from a particular year (1998). From this sample, 100 new samples of 10-250 observations were taken and the sample mean and sample median statistics were calculated from both the <1g and the 1-10g data sets for heroin and the <1g data set for methamphetamine. The results (Table 3) imply that it is possible to base medians on as few as 10 observations without introducing significant error from sample variation being large relative to true variation over time in average purity.

Table 3a: Sample means and medians heroin <1g 1998 ($\mu = 70.1\%$ $\sigma = 14.5\%$ median = 73.6%)

Sample Size	<1g				1-10g			
	Sample Mean		Sample Median		Sample Mean		Sample Median	
	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
10	70.32%	0.44%	73.23%	0.40%	70.12%	1.27%	70.41%	1.35%
20	69.37%	0.30%	73.00%	0.24%	69.68%	2.34%	70.00%	2.17%
50	69.9%	0.23%	73.46%	0.15%	70.03%	1.73%	70.28%	1.78%
100	69.98%	0.14%	73.51%	0.11%	70.10%	1.46%	69.73%	1.50%
250	70.15%	0.08%	73.52%	0.07%	69.90%	1.08%	69.89%	0.67%

Table 3b: Sample means and medians methamphetamine <1g 1998 ($\mu = 9.29\%$ $\sigma = 13.04\%$ median = 3.8%)

Sample Size	Sample Mean		Sample Median	
	Mean	Standard Error	Mean	Standard Error
5	9.15%	0.60%	5.14%	0.51%
10	9.27%	0.40%	4.71%	0.30%
20	9.67%	0.29%	4.15%	0.14%
50	9.06%	0.17%	3.81%	0.05%
100	9.12%	0.11%	3.78%	0.03%

To analyze the structure of long-term trends, two-week rolling medians were averaged over monthly periods and analyzed using ARIMA time series methods, with the heroin drought modeled as a change in level (a step term) or a change in slope (a slope term). Cross-correlation functions were used to identify the lag at which the step and slope terms influenced the purity series, and the time trend and specific step and slope terms were then identified in a linear model with serially dependent residuals. Serial dependence in residuals was identified using auto-correlation and partial auto-correlation functions, and was shown in all cases to be auto-regressive. All correlation functions were identified in SAS version 8.2 using PROC ARIMA, and because the serial dependence was only auto-regressive, all models were fit in SAS using PROC AUTOREG. Parameter estimates from the linear model were then used to plot the fitted trajectory of the purity series over time. For calculations of correlation functions all data series were differenced where necessary to make them stationary, and log-transformed to stabilize variance where necessary.

These methods enable the magnitude, timing and long-term consequences of the heroin drought to be modeled and depicted graphically with appropriate statistical adjustment for serial dependence. They are well described in the time series literature (Brockwell and Davis, 1991; Box and Tiao, 1975).

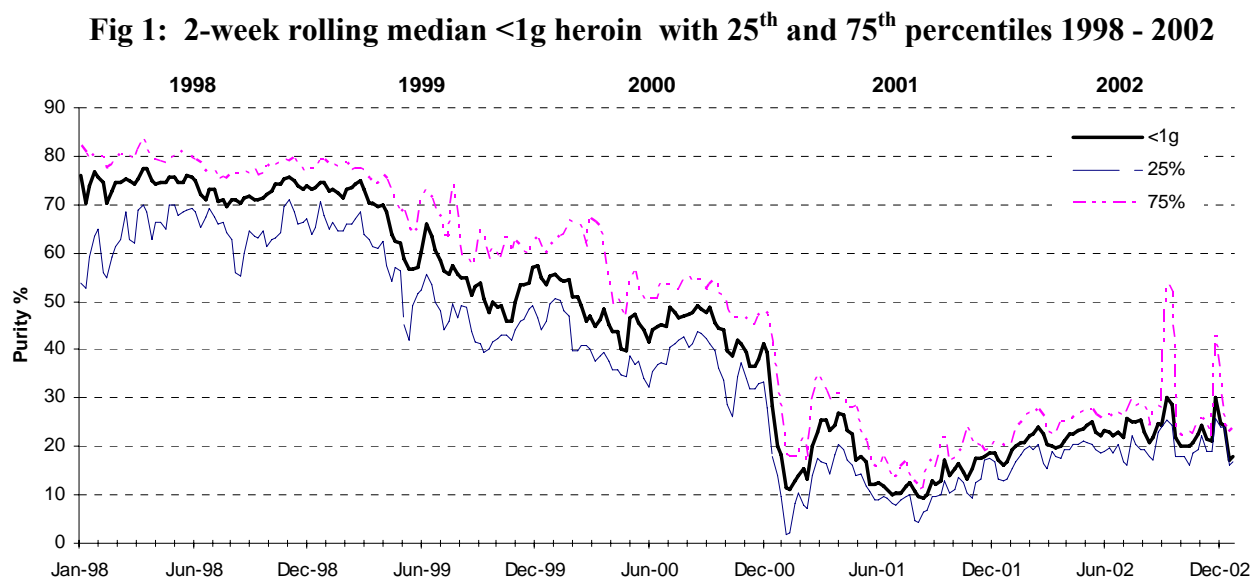
In other markets purity rises systematically with transaction size, so one must literally or effectively regress purity on transaction size and focus on how the intercept changes over time (Caulkins, 1994; Caulkins et al., 2004). We do not do that here because these data show no evidence of

any pre- or post-drought relationship between purity and transaction size over the range of weights for which there are abundant data (up to 1 – 2 ounces). There is also no evidence of higher purity at still larger transaction sizes, but smaller sample sizes preclude ruling out the possibility of cutting between the half-gram and ounce or multi-ounce levels. Hence these data support Coomber’s (1997) questioning of the traditional view that cutting occurs at most market levels. They do not support a conjecture that the drought was due to increased cutting between the low-level wholesale and retail market levels.

3. Results

3.1 Overall trends in heroin seizure purity

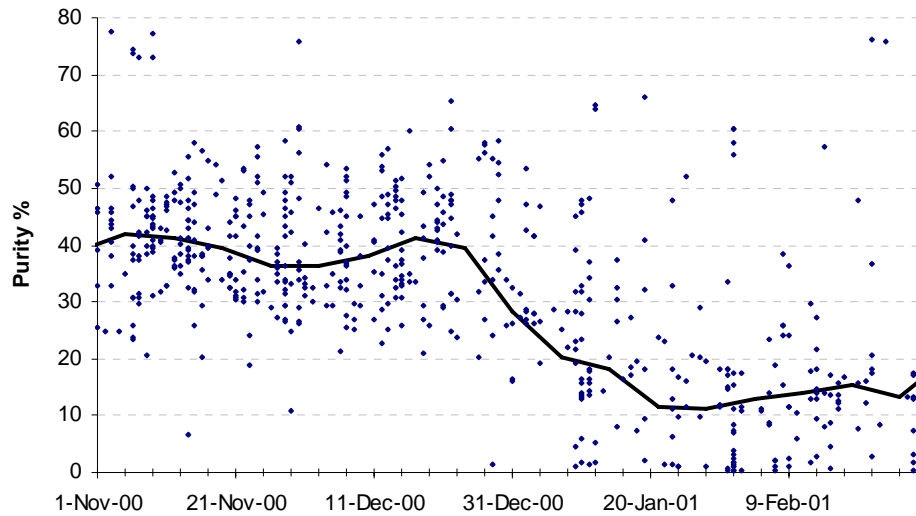
Figure 1 shows the 2-week rolling median, first, and third quartile of retail-level (<1 gram) heroin seizures’ purity over the period 1998-2002. It gives a level of detail not available in previous reporting of purity trends (e.g., Figure 1a in Degenhardt et al., 2005b). Purity was stable in 1998 at 70-75% then declined fairly steadily from ~75% to ~40% during 1999 and 2000. That finding was not expected since normally retail purity rises when supplies are plentiful and those years have sometimes been referred to as “glut” times (Dietze et al., 2002). Purity fell precipitously to 10-15% at the onset of the heroin “drought” in the beginning of 2001, then fluctuated during 2001 before stabilizing in 2002 at around 25%, or a bit more than half the pre-drought level. (The spike in the 75th percentile values at the end of 2002 is due to just 6 observations.)



Usually drug purity is so variable that plotting individual data points obscures rather than clarifies. However, the purity decline at the beginning of 2001 was so dramatic that it can be seen

readily even in the raw data, which are plotted in Figure 2, along with a 15-point simple moving average. In December of 2000 there were only a few outliers below 20% purity at the end of the month (specifically 3 of 162 observations, with one on the 28th and two on the 31st of December). By contrast, the majority of observations in January (50%) and February (80%) of 2001 were less than 20% pure.

Figure 2: Purity of Individual <1 gram Heroin Seizures, Nov. 1, 2000 – Feb. 28, 2001



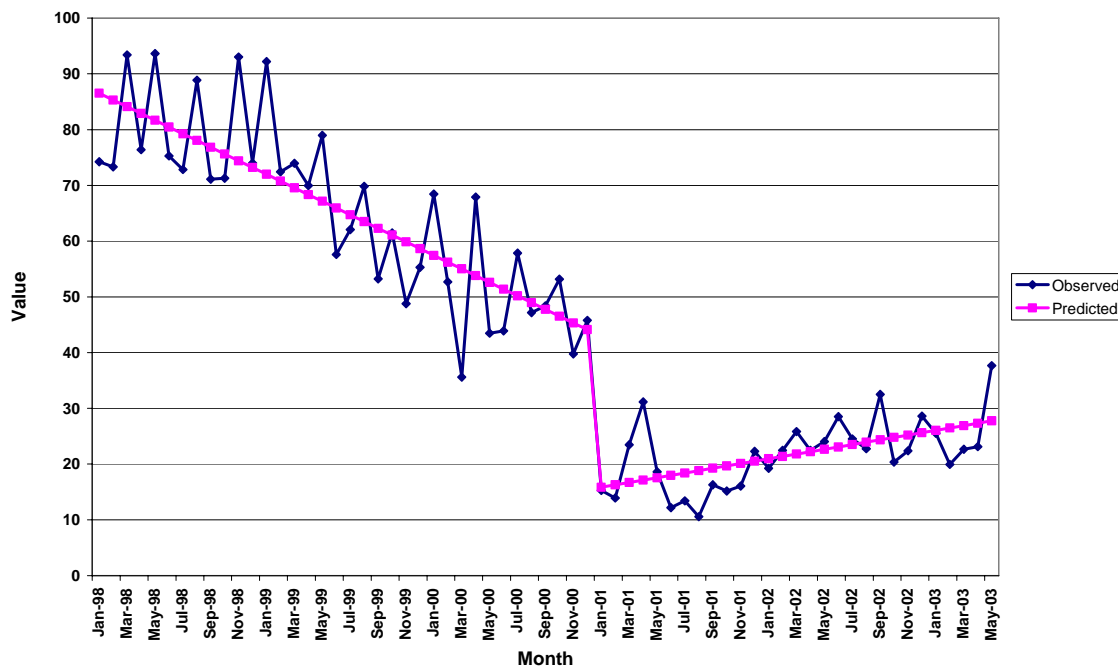
The linear time series model for the monthly purity data series confirms that there was both a “drought”, in the sense of an abrupt step change in purity, and a pre-existing long-run steady decline in purity. Furthermore, the post-drought purity fluctuations were around a generally increasing trend, indicating a recovery from the depths of the drought (Table 4). The step and change in slope occurred with no time lag from the point of onset of the shortage. The 3-month auto-regression term is probably an artifact of the calculation of rolling medians, but was adjusted for despite its synthetic nature.

Table 4: Linear model for monthly heroin seizure purity

Variable	Parameter estimate	Standard error	Wald statistic	P value
Intercept	87.742	3.276	26.78	<0.0001
Time	-1.212	0.152	-7.99	<0.0001
Step	-28.682	4.441	-6.46	<0.0001
Change in slope	1.637	0.266	6.16	<0.0001
AR(1)	0.262	0.125	2.10	0.04

Figure 3 plots the predicted values for this linear time series model, which explained 91% of the monthly variation in the purity data. Taking the estimated intercept as the baseline, before the drought heroin purity was decreasing by approximately 1.4% per month. At the onset of the drought, purity dropped to just over one-third of immediate pre-shortage levels, before slowly recovering at about 3% of heroin drought levels per month (a slower absolute rate than the pre-drought decline).

Figure 3: observed and predicted values for the heroin purity model



Figures

1 and 3 both show a brief spike in purity in March - May 2001 that interrupted the drought's drop in purity. This spike and, hence, the "double dip" character of the drought appear to be real, not just an artifact of chance variation. Pair-wise tests for the equality of the means of any of those three months with the month before (February) or any of the subsequent eight months (June – January, 2002) reject a null hypothesis of equal means at the 0.01 level. E.g., the p-value when comparing the mean of the 111 observations in February (average purity 16.3%) and the 96 observations in March (average purity 26.4%) is $p = 0.000006$.

3.2 Changes in Variability in Purity Post- vs. Pre-Drought

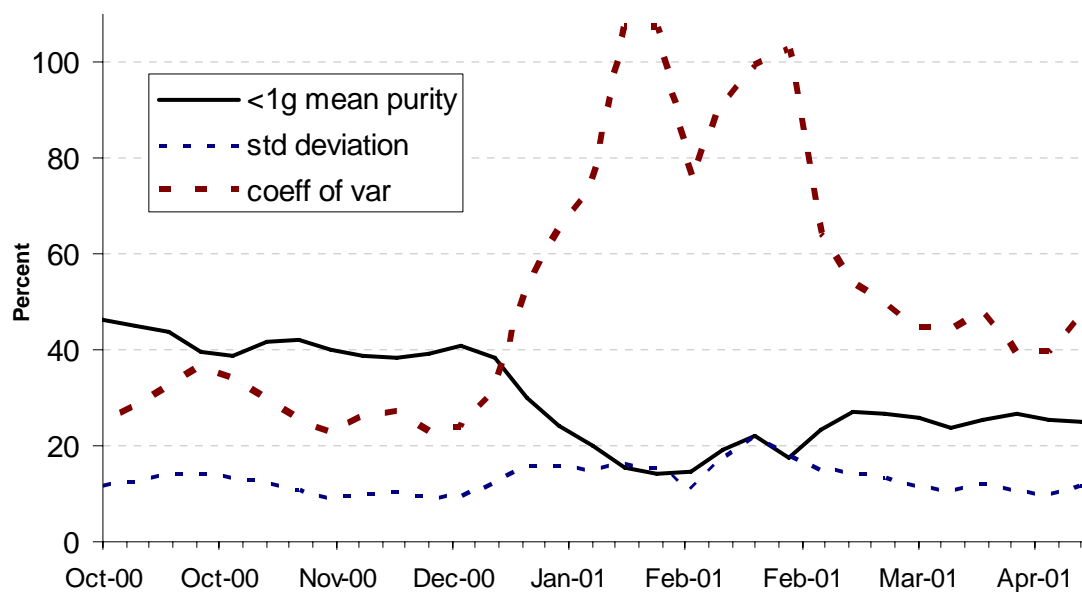
It is clear that heroin seizure purities were lower post-drought regardless of whether one attributes that to the drought in the narrow sense or separately to the longer-term downward trend in heroin purity. A

distinct question is what happened to the amount of variation in heroin purity, both in absolute terms and relative to its central tendency?

Overdose risk has traditionally been presumed to depend on average drug purity (e.g., Hall and Darke, 1997), but variability in purity may matter as well (Darke et al., 1999). According to this view, if every bag of heroin were 80% pure, that fact were widely known, and users had grown accustomed to 80% purity, there might be less risk of overdose than if purity were commonly 20% but suddenly and unexpectedly some 60% pure heroin was being injected.

Figure 4 plots not just the mean purity, but also the standard deviation, and the coefficient of variation from mid-2000 through the end of 2002. (The median, interquartile range, and interquartile range divided by the median purity show similar patterns.) When mean purity fell sharply, the coefficient of variation rose sharply. Overdoses fell very dramatically after the drought (Degenhardt et al., 2005c), so the health protecting effects of reduced purity and availability, and greatly increased purity-adjusted prices, apparently swamped any increased risk due to this greater variability (cf., Moore et al., 2005, Section 4).

Figure 4: Mean, Standard Deviation and Coefficient of Variation <1g Heroin Dec 2000 - 2002



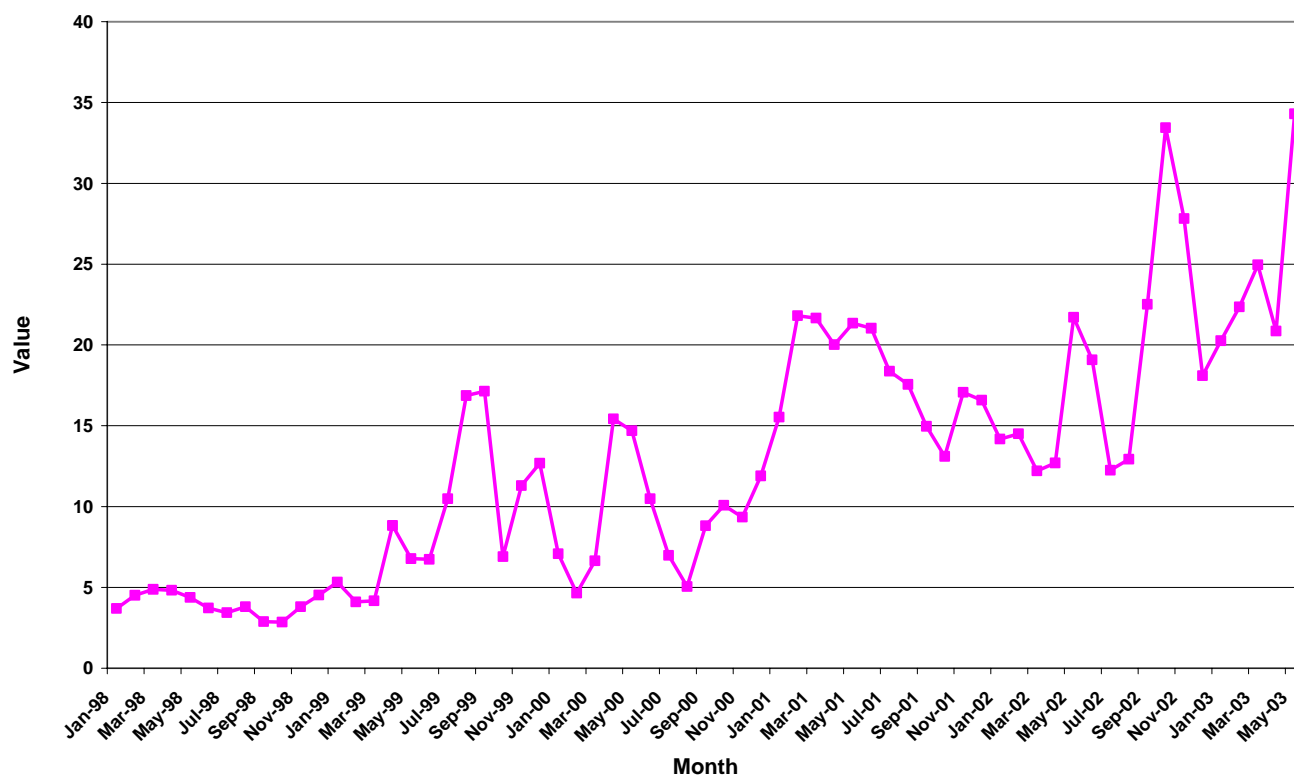
3.3 Methamphetamine seizures displayed no dramatic purity changes around the heroin drought.

There is evidence that the drought induced some heroin users to use more stimulants, including (meth)amphetamines (Baker et al., 2004; Degenhardt et al., 2005c). Before the drought there were many

more heroin users than stimulant users in Victoria. Hence, even a moderate proportion of heroin users switching to methamphetamine could generate a sizable shock to methamphetamine demand that might affect methamphetamine price and/or purity. By way of comparisons, US retail heroin prices spiked in 1989-1990, when there was a disruption in cocaine supply (Crane et al., 1997; Caulkins et al., 2004).

Figure 5 shows the monthly average of the two-week rolling medians of methamphetamine seizure purity. The linear time series analysis described above was replicated for methamphetamine purity, after log-transforming the series to stabilize the variance. That analysis showed purity increased steadily by approximately 1% per month over the entire period of the study, with 73% of the variability of the series explained by this simple linear model. There was no strong evidence of an effect of the heroin drought.

Figure 5: Monthly averaged 2-week rolling medians of methamphetamine purity seizures



4. Discussion

Analysis of forensic data allows for a detailed description of heroin and methamphetamine purity trends over the period 1998-2002 in Victoria. This analysis illustrates the severity of the heroin “drought” manifest through striking and rapid declines in heroin purity after the heroin shortage.

Combining these richer data on purity with IDRS-derived data on price per gram (unadjusted for purity) gives a revised sense of the increases in the price paid per pure gram at retail in Victoria (Fry and Miller, 2002; Breen et al. 2003, 2004). (See Table 5.) The IDRS reports suggested there had been only modest declines in purity between 2000 and 2001 with much sharper declines in 2002, implying that prices per pure gram continued to increase and at an increasing rate in 2002. Seizure-based purity estimates suggest a more traditional story of supply disruption: very sharp initial increases in the price per pure gram followed by a subsequent erosion in the price spike. Either purity series, however, suggests that the effective price of heroin more than quadrupled, whereas prices unadjusted for purity increased by at most 50%.

Table 5: Price, Purity and Price per Pure Gram 2000 - 2002

	2000	2001	2002	% Change 2000- 2001	% Change 2000-2002
IDRS Price per Gram	\$300	\$450	\$400	50%	33%
IDRS Purity	54%	46%	15%	-15%	-72%
IDRS Implied Price per pure Gram	\$556	\$978	2,667	76%	380%
Average retail seizure purity	46%	16%	23%	-65%	-51%
Implied Price per pure Gram	\$653	\$2,772	\$1,774	325%	172%

The analysis reveals two features not previously identified. First, there is evidence that the drought had a “double-dip” character, with the initial steep declines interrupted by a short-lived recovery in spring of 2001. Second, the precipitous decline coinciding with the traditional timing of the drought (end of 2000, beginning of 2001) followed nearly two years of steady and substantial declines in purity. Furthermore, the analysis shows that the drought does not seem to stem from changes in dilution or “cutting” practices at the lower market levels and does not seem to have spilled over in obvious ways to affect methamphetamine purity.

The pre-drought secular decline in purity suggests a somewhat more optimistic projection for the future of the heroin market. If purity had been entirely level up until the moment of some discrete supply-side shock in early 2001, then one would expect market conditions to eventually return to pre-drought levels. However, if the on-going secular decline would have continued anyhow, even without the event(s) that caused the drought, then there is no reason to think purity levels should rebound fully to pre-drought levels. Also, the magnitude of the consequences caused by the discrete shock could be smaller than one might otherwise have thought if some proportion of the considerable changes in heroin

use and related consequences should be attributed to the ongoing secular decline, not the discrete shock(s) to the system. Replicating the high-frequency purity series in other jurisdictions and correlating them with high-frequency measures of consequences, such as ambulance call-outs, might be informative in this regard (cf. Smithson et al., 2004).

A general implication of this research is that high-frequency time series (monthly or fortnightly as opposed merely quarterly or annual) are valuable, particularly when investigating transitory phenomena such as market disruptions. Annual data collections could miss two- or three-month long features such as the temporary rebounding of purity from March – May 2001. For example, IDRS supplements secondary data from sources such as the Australian Crime Commission with primary data collected from two groups. The first is a sample of injecting drug users taken in June through August. The second, taken between May and September, samples key informants who have regular contact with drug users through their work. Given the timing of those samples, questions about ‘current market conditions’ could miss temporary spikes in purity (or, worse, collect data entirely during such a spike and presume the spike-elevated levels characterize purity throughout the entire year).

Neither the present data nor any other drug-related data are perfect, and there are particular issues associated with using administrative data. On the one hand, they are relatively cheap since they do not require new primary data collection. On the other hand, they are not based on a probability sample (Manski et al., 2001). So triangulation with multiple sources is wise, and we claim only that seizure data are a useful complement to traditional data series. They by no means eclipse any existing data. However, drug policy analysis may be better off with all the traditional indicators plus seizure-based purity series than with just the traditional indicators alone.

Two final points bear mention. First, we worked here only with an extract of the forensics database. The original data base has many more fields, including geographic coding and detailed forensic information about adulterants, press marks, and variety of other information. Analyzing data in those other fields might yield still more insights. Second, purchase data (which are much like seizure data except that there is an associated price) can be extraordinarily useful (Caulkins and Reuter, 1998). Australia needs to augment seizure databases with price information when possible and making those databases available for research and analysis.

Acknowledgements:

This research was supported by the Colonial Foundation Trust through the Drug Policy Modeling Project and with Carnegie Mellon University internal funds, including funds provided to Carnegie Mellon through the Qatar Foundation.

References

- Baker, A., Lee, N.K., Claire, M., Lewin, T.J., Grant, T., Pohlman, S., Saunders, J.B., Kay-Lambkin, F., 2004. Drug use patterns and mental health of regular amphetamine users during a reported 'heroin drought'. *Addiction*. 99(7), 875-884.
- Box, G.E.P., Tiao G.C., 1975. Intervention Analysis with Applications to Economic and Environmental Problems. *JASA*, 70(1), 70-79.
- Brockwell, P.J., Davis, R.A., 1991. Time Series: Theory and Methods, 2nd Edition. Springer Series in Statistics, Springer-Verlag, New York.
- Breen, C., Degenhardt, L., Roxburgh, A., Bruno, R., Fetherston, J., Jenkinson, R., Kinner, S., Moon, C., Proudfoot, P., Ward, J., Weekley, J., 2004. AUSTRALIAN DRUG TRENDS 2003: Findings from the Illicit Drug Reporting System (IDRS). NDARC Monograph No. 51. NDARC, Sydney.
- Breen, C., Degenhardt, L., Roxburgh, A., Bruno, R., Duquemin, A., Fetherston, J., Fischer, J., Jenkinson, R., Kinner, S., Longo, M., Rushforth, C., 2003. AUSTRALIAN DRUG TRENDS 2002: Findings from the Illicit Drug Reporting System (IDRS). NDARC Monograph No. 50. NDARC, Sydney.
- Caulkins, J.P., 1994. Developing Price Series for Cocaine. MR-317-DPRC, RAND, Santa Monica.
- Caulkins, J.P., Reuter, P., 1998. What Price Data Tell Us About Drug Markets. *J Drug Issues*. 28, 593-612.
- Caulkins, J.P., Pacula, R.L., Arkes, J., Reuter, P., Paddock, S., Iguchi, M., Riley, J., 2004. The Price and Purity of Illicit Drugs: 1981 Through the Second Quarter of 2003. ONDCP, Washington, DC.
- Chernick, M.R., 1999. Bootstrap Methods: A Practitioner's Guide. Wiley, Chichester.
- Coomer R., 1997. The adulteration of drugs - what dealers do, what dealers think'. *Addict Res* 5: 297-306.
- Darke S., Hall W., Weatherburn D., Lind B., 1999. Fluctuations in heroin purity and the incidence of fatal heroin overdose. *Drug Alcohol Depend*, 54(2):155-161.
- Degenhardt, L., Conroy, E., Gilmour, S., Collins, L., 2005a. The Effect of a Reduction in Heroin Supply in Australia upon Drug Distribution and Acquisitive Crime. *Brit J Crim*, 45(1), 2-24.
- Degenhardt, L., Reuter, P., Collins, L., Hall, W., 2005b. Evaluating Explanations of the Australian Heroin Drought. *Addiction*, 100, 459-469.
- Degenhardt, L., Day, C., Dietze, P. Pointer, S., Conroy, E., Collins, L. & Hall, W., 2005. The consequences of the heroin shortage in three Australian States. *Addiction*. 100(7):908-20.
- Dietze, P. Fitzgerald, J., 2002. Interpreting changes in heroin supply in Melbourne: Droughts, gluts or cycles? *Drug Alcohol Rev*, 21, 295-303.
- Fry, C., Miller, P., 2002. Victorian Drug Trends 2001: Findings from the Illicit Drug Reporting System (IDRS), Technical report no. 129. National Drug and Alcohol Research Centre, Sydney.

Hall, W. Darke, S., 1997. Trends in Opiate Overdose Deaths in Australia 1979-1995, Technical Report No. 49. Commonwealth Department of Health and Family Services, Canberra, Australia.

Hall, W., Ross, J., Lynskey, M., Law, M. Degenhardt, L., 2000. How many dependent opioid users are there in Australia? NDARC Monograph No. 44. NDARC , Sydney.

Manski, C. F., Pepper, J. V. Petrie, C. V., 2001. *Informing America's Policy on Illegal Drugs: What We Don't Know Keeps Hurting Us*. National Academy Press, Washington, DC.

Moore, T.J., Caulkins, J.P., Ritter, A., Dietze, P., Monagle, S., Pruden, J. 2005. Heroin Markets in Australia: Current Understanding and Future Possibilities. DPMP Monograph #1. Turning Point Alcohol and Drug Centre, Fitzroy.

Smithson, M., McFadden, M., Mwesigye, S. Casey, A., 2004. The impact of illicit drug supply reduction on health and social outcomes: The heroin shortage in the Australian Capital Territory. *Addiction*, 98, 340-348.

Topp, L., Kaye, S., Bruno, R., Longo, M., Williams, P., O'Reilly, B., Fry, C., Rose, G., Darke, S., 2002. AUSTRALIAN DRUG TRENDS 2001: Findings from the Illicit Drug Reporting System (IDRS). NDARC Monograph No. 48. NDARC, Sydney.

Weatherburn, D. Jones, C., Freeman, K., Makkai, T., 2001. *The Australian Heroin Drought and Its Implications for Drug Policy*. New South Wales Bureau of Crime Statistics and Research, Sydney.

Weatherburn, D. Jones, C., Freeman, K., Makkai, T., 2003. Supply Control and Harm Reduction: Lessons from the Australian Heroin 'Drought'. *Addiction*, 98, 83-91.