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UNDER THE INFLUENCE OF THE MARKET: AN APPLIED STUDY OF ILLICITLY SELLING AND CONSUMING HEROIN.

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ABSTRACT

Illicit market activities are associated with considerable financial and psychological harms for drug users and third parties, and impose significant demands on public services. Since policy interventions interact with the market, evaluations of cost-effectiveness necessitate knowledge of how the market operates. There seems to be emerging consensus in the economic literature that economic factors, such as prices, can influence consumption patterns of addictive commodities. However, the descriptive validity of the notion of 'maintenance doses' for drugs such as heroin is questionable. This is important because 'maintenance doses' have provided the rationale for predictions about the shape of the demand curve, and particularly for changes in slope, or 'kinks'.

Data collected from over 500 heroin users contacted outside a needle exchange service in Oslo are analysed in this paper. Wide variations in levels of consumption, income and prices are reported. Using a switching regression model of heroin consumption with endogenous switching between dealing and non-dealing, the influences of economic factors on the decision to deal and the level of consumption are estimated. Drug users in employment are estimated to be almost half as likely to sell drugs and a 10% increase in non-dealing income is estimated to reduce the probability of dealing by 3%. Non-dealing users' consumption patterns are found to be price-elastic (elasticity = -1.23) and significantly influenced by the level of personal income (elasticity = 0.47). Influences on the extent of drug sales are also considered. Whilst appearing less responsive, dealers' market activities have predictable relationships with economic factors and market conditions. For example, a 10% increase in the proportion of active dealers arrested in the previous month is found to reduce the size of the dealing

population by over 3%. There is, however, some evidence that the remaining dealers are more active, such that attempts by enforcement agencies to reduce the size of the overall market are offset.

No evidence of kinks in the demand curve for heroin are identified for the range of prices quoted on the Oslo market over a 13-month period. Given the multitude of influences on both the costs and benefits of consumption and the observed heterogeneity of drug users and their patterns of behaviour, this may not be surprising. The high price-responsiveness of non-dealers heroin consumption and the importance of income levels in predicting behaviour emphasises the importance of policies which succeed in manipulating the economic conditions faced by illicit heroin users.

1. INTRODUCTION

The activities of drug-using individuals in illicit drug markets have a wide range of harmful implications for the individuals involved and for third-parties. Individuals who use drugs face relatively high risks of premature mortality and morbidity,[1] poor employment prospects and are often involved in criminal activity.[2,3,4] These problems also impose considerable costs on society in terms of both financial and psychological harm, and additional calls on public services. Furthermore, small-scale drug dealing, which is frequently practised by drug users,[5,6] may increase availability and decrease search costs, thereby possibly stimulating experimentation and encouraging continued drug use for other users. As a consequence of these problems, a similarly broad array of interventions have been developed by society. However, finding the optimal level and mix of policies requires knowledge of influences on market conditions and participants' behaviour. Since there are likely to be interactions between policy interventions and the nature of illicit drug markets, static evaluation of these interventions in isolation from market reactions may generate misleading conclusions on cost-effectiveness.

Despite the importance of the market activities of illicit drug users for the amount of harm caused to society and the cost-effectiveness of policy instruments, there have been few studies of market and personal economic influences on consumption and dealing behaviours. This dearth of research is primarily caused by a lack of reliable data.[7,8] In particular, there are only two published studies estimating the price- or income-responsiveness of illicit drug use,[9,10] although the potential importance of economic factors has been demonstrated elsewhere.[11,12]

It is commonly assumed that the consumption of addictive substances, such as heroin, is fixed or highly inelastic.[13] This leads to the conclusion that supply-side measures, such as increased enforcement activity, cannot be effective in reducing consumption, since increasing market prices will result only in greater income-generating activity by users who maintain their previous levels of consumption.[14,15] However, recent studies of the consumption behaviour and income-generating activities of opiate users highlight the flexibility of consumption patterns and their responsiveness to economic factors[11,12]. These findings coincide with increasing realisation in the economic literature that there are many reasons why consumption levels of illicit drugs may vary. White and Luksetich,[16] for example, list at least four options available to drug users rather than continued drug use in adverse circumstances: retirement from drug use altogether; switching to other substances; treatment-seeking; or decreased consumption through reduction of the frequency of consumption and increased tolerance of withdrawal effects.

This paper reports on analyses of data collected from injecting drug users in Oslo. The aim is to identify the extent to which economic factors influence the behaviour of users and user-dealers operating at the lower level of the market. The analysis focuses on the role of personal and market economic factors in influencing the market activities of individuals who use heroin.

In Section 2, a brief description of the illicit market in Oslo is given, and this is followed by a review of the economic literature on the demand for addictive substances in Section 3. The market activities of dealers, which include decisions about purchasing, consuming and selling, are analysed separately from those of non-dealers. The approach taken for modelling

consumption and selling activities is outlined in the fourth section. In Section 5, several issues relating to the data-set, including questionnaire content, representativeness of the sample, and the consumption measure chosen, are discussed. The consumption patterns of dealers and non-dealers are estimated using a switching regression model with endogenous switching between the two groups. Factors influencing the quantity of heroin sold by user-dealers are estimated allowing for self-selection into the dealing group, and tests for 'kinks' in the demand curve for heroin are based on a spline function approach. Explanations of the estimation techniques are outlined in Section 6. The regression results from the switching model of consumption, the self-selection model of sales, and the spline function analysis of the shape of the demand curve are presented in Sections 7, 8 and 9 respectively. The findings are discussed in the final section.

2. THE ILLICIT HEROIN MARKET IN OSLO.

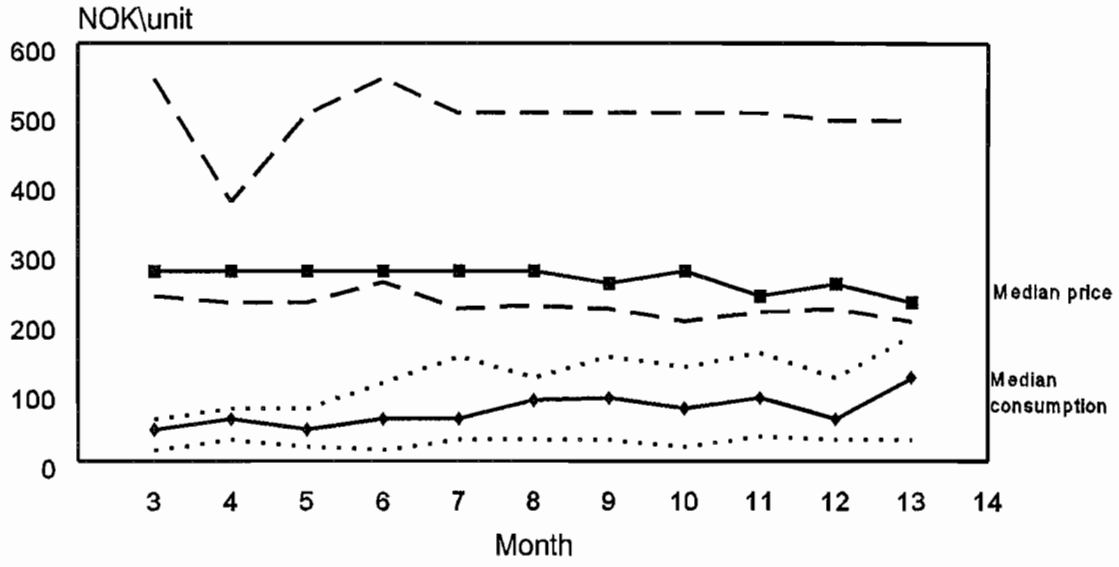
A common description of the supply-side of illicit drug markets is a pyramid with a few individuals or groups importing large quantities of drugs at the top of the hierarchy.[30] More people become involved in dealing further down the selling-chain. However, one pertinent characteristic of illicit drug supply is that, at lower levels of the market, those who demand drugs are often the same people who supply drugs to others. User-dealer networks evolve in which groups of individuals enter agreements whereby they take it in turns to buy large quantities of drugs and sell them on to the rest of the group.

The fieldwork for this study[36] and previous work[37] indicates that the majority of user-dealers in Oslo buy in grams and sell in units, but some non-dealers also buy in half-grams or grams. A gram of heroin is split in 10 - 12 units or 20 - 24 half-units, which is the smallest amount sold in the illicit market. The mark-up at each level is considerable; one unit costs about 450 NOK (£45) and a half gram (on average equal to 5.5 units) is available for 1250-1500 NOK (£125-150). Thus, the short-term financial incentives for becoming involved in dealing are clear; there are large cost-savings to be made even between unit and half-gram levels.

The potential for economic factors to affect consumption is indicated by the extent of inter-personal and inter-month variability of heroin consumption and prices. In Figure 1, monthly trends in the data collected on heroin prices and consumption are shown for the period August 1993 to June 1994. The first two months of the data-collection period are not presented because, due to changes in the questionnaire design, dealers (who generally report lower prices

and higher consumption) were excluded from the sample. The solid lines show the median price and consumption series, whilst the surrounding dotted lines describe the associated inter-quartile ranges. The median series appear to show a slight decrease in the average price of heroin and a slight increase in reported consumption over the period. However, the inter-quartile ranges demonstrate considerable inter-personal variability even at times of apparent market stability. Moreover, the consumption data show no tight clustering around particular quantities.

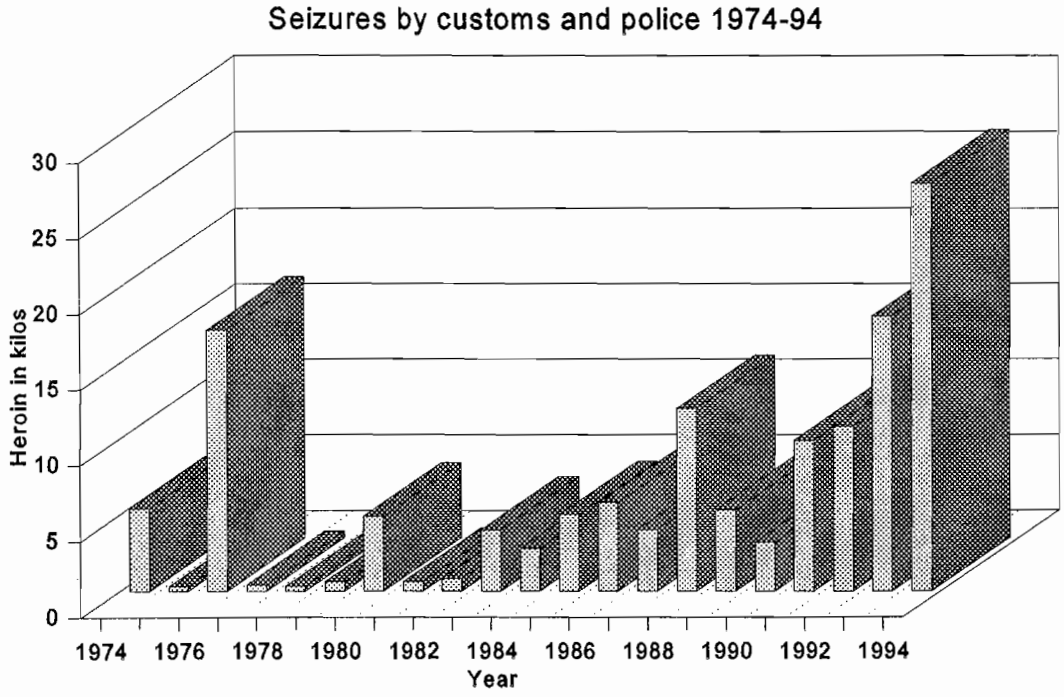
Figure 1. Heroin prices and consumption. August 1993 - June 1994



Over the interview period, the quantity of heroin seized was the highest ever (Figure 2). Nevertheless, street-level supply seems to have been stable throughout the interview period. Both interviewees and the police reported that heroin was easily accessible on the illicit market. Users reported few problems in obtaining desired types and quantities of drugs. Out of 750 primary heroin users, only 21 claimed that heroin had been more difficult to buy in the

current month compared to previous months. The drug squad in Oslo, which completed a specially designed questionnaire each month throughout the period with interviewing, reported no change in heroin supply for eleven of the thirteen months and increases in the remaining two months.

Figure 2. Heroin seizures in Norway.



3. ECONOMIC LITERATURE ON THE DEMAND FOR ADDICTIVE SUBSTANCES

Herrstein and Prelec[17] suggest four ways economic theory can deal with addictive behaviour:

1. Addiction as a disease
2. Addiction as rational self-medication
3. Addiction as the primrose path
4. Addiction as divided self

Characterising addiction either as a disease or as divided self gives little scope for economic analysis, since the former suggests no choice for individuals and the latter assumes a non-rational economic agent. The primrose path theory suggests how people slip into addiction since they have incomplete information on all the consequences at the point they start to consume. Addiction as rational self-medication implies that consumers are fully aware of all possible consequences and that the benefits from consumption exceed the negative effects.

Economic models of the consumption of addictive substances over time

In modelling addiction, and therefore estimating influences on the consumption of addictive substances, the time element is essential. Addiction is a state that emerges and decays over time, being influenced by a multitude of factors at several stages.

Some empirical analyses of addictive goods like tobacco have modelled the links between consumption in different periods. Consumers have traditionally been assumed to be myopic,

i.e. the effects of current consumption on future utility were ignored. Preferences were taken to be endogenous, since a measure of addiction in the utility function of the current period depended on past decisions.[18] This literature was mostly based on the work of Houthakker and Taylor,[19] and is reviewed elsewhere.[20,21]

The characterisation of addicted consumers as rational and fully-informed is fundamental to the Rational Addiction Theory developed by Becker and colleagues.[22,23] The consumption of addictive goods is proposed to be in accordance with consistent, temporal utility-maximisation. By not explaining addiction by changed preferences, this theory differs from others that attempt to explain the addiction phenomenon. One consequence of the theory is that addicted people may have highly price-elastic demand, and more price-elastic demand than non-addicted individuals. Prices in previous and subsequent periods will affect current consumption. Price changes will have larger impact in the long run than in the short run due to reinforcement. Looking at policy implications, Becker, Grossman and Murphy[24] suggest that relaxation of supply-side controls, through legalisation for example, will have undesirable effects on consumption since lower (presumably effective) prices will lead to increased use of addictive goods.

Economic models of contemporaneous effects on consumption of addictive substances

To analyse heroin consumption in line with the rational addiction approach requires information on past consumption or preferably panel data. It is often the case that data on consumption and economic conditions are available for the current period only. In these cases, it is not possible to estimate the influences on consumption patterns in a rational addiction

framework. Instead, the focus must be on the contemporaneous effects of economic factors on the consumption of addictive substances; features of addiction such as complementarity between consumption in different periods cannot be taken into account. In this limited context, there have been a number of theoretical papers suggesting different relationships between economic factors and demand, and various conclusions made about the appropriateness of demand- and supply-side policies.

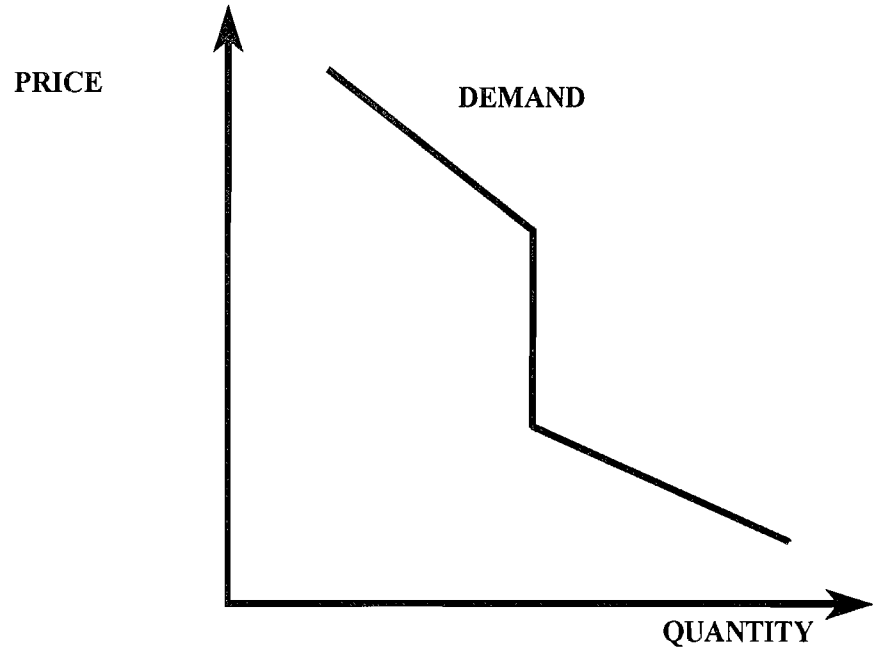
In the late-sixties and early-seventies, authors such as Rottenberg[14] and Koch and Grupp[15,25] argued that demand curves for addictive goods are perfectly inelastic, i.e. the same amount of drugs is consumed regardless of the price level faced. This was shown to imply that supply-side efforts to reduce the level of transactions in the illegal drug market would fail. Increased drug law enforcement that shifted the supply-curve upwards, would lead to higher prices, but nevertheless addicted individuals would continue to demand the same quantity. It was further argued that price increases could have an adverse effect on the non-using population, since the income requirements of drug users would increase, leading to increases in drug-related acquisitive crimes. This approach may coincide best with the primrose path theory of addiction: once addicted, individuals are unable or unwilling to reduce consumption in future periods, unless forced to by factors outside their control.

More recently, these theoretical predictions of perfectly inelastic demand have been challenged. The range of options available to illicit drug users faced with adverse circumstances was recognised, including switching consumption to substitute goods, entry into treatment, stopping drug use altogether or reduction of the amount consumed through

decreased frequency of injections and increased toleration of withdrawal effects.[17,26,27] Blair and Vogel[28] suggested that at low prices the demand for heroin would be relatively price-elastic. At higher prices, occasional users and experimenters were predicted to stop consuming and regular users were thought to reduce their consumption to a maintenance dosage. White and Luksetich[16] took an alternative view, and suggested reasons to suspect that the demand for heroin would be price-elastic at high prices because, facing higher income-generating requirements, regular users would approach treatment agencies or resort to crime so regularly that they were likely to be arrested by enforcement agents. Combining the work of White and Luksetich[16] and Blair and Vogel,[28] Wagstaff and Maynard[7] proposed that the two hypotheses referred to different segments of the curve and suggested that the demand curve for drugs may have perfectly inelastic and elastic segments. They suggested a kinked demand curve, which is elastic at low and high prices but inelastic in a middle range, see Figure 3.

Wagstaff and Maynard's[7] collation of the literature on the likely shape of the contemporaneous demand curve for heroin suggested an emerging consensus on recognising that heroin consumption patterns exhibit variability and decreasing pessimism as to the potential effectiveness of economic instruments. However, there has been no empirical investigation of the proposed shifts in slope and insufficient details provided to permit direct testing. In particular, Wagstaff and Maynard's demand curve has only a hypothetical scale and the arguments put forward to justify the shifts in slope do not directly translate into actual price values.

FIGURE 3. KINKED DEMAND CURVE FOR HEROIN (WAGSTAFF AND MAYNARD 1988)



Moreover, the appeal to maintenance doses of heroin consumption has no clear empirical basis and may not be intuitive. If a maintenance dose represents the amount of heroin needed to alleviate withdrawal pains, it would be expected that this quantity would have interpersonal variation depending on individual characteristics and interperiod variations depending on the recent drug-taking career. In addition, withdrawal costs will be just one influence on the individual's choice problem which must be traded against other influences, including economic factors. Roumasset and Hadreas[29] have made a similar criticism of the price-inelasticity hypothesis and, although proposing that there may be a minimum consumption level below which addicts will feel 'sick', suggest that the demand curve will be smooth, with price-elasticity close to unity below this minimum dose. The work of Becker and colleagues also

highlights the multitude of influences on heroin consumption which will include the price level.[24] Thus, there may be no 'maintenance dose' and good reasons for expecting no vertical segments in the demand curve for heroin at both the aggregate and individual levels.

4. A MODEL OF THE MARKET ACTIVITIES OF ILLICIT DRUG USERS.

The consumption patterns of dealers are known to be different from those of non-dealers.[30] Dealers have more ready access to the drugs they sell, have better knowledge of purity, face lower prices and may be able to buy on credit. Dealers also face different influences on their consumption patterns. In their dual role as suppliers and consumers, user-dealers must make decisions about purchasing, consuming and selling units of heroin based on both consumption benefits and profit-making possibilities. For dealers, each unit has a consumption and an income-generating value. Therefore, models of heroin consumption should differentiate between individuals according to their dealing status.

Heroin users and user-dealers are assumed to maximise utility subject to budget constraints. For each group, utility is assumed to be a function of heroin consumption, consumption of other drugs, consumption of other goods and leisure where, for simplicity, both leisure and consumption of other goods are assumed fixed:

$$U = g\ (\ C_H\ ,\ C_A\ ,\ C_O\ ,\ L\ ) \qquad \textbf{(1)}$$

in which: C_H, C_A and C_O are levels of consumption of heroin, other drugs and other goods respectively; and L is leisure time.

Effectively, total income from sources other than dealing activity is assumed to be exogenous. This characterisation conflicts with US studies of the role of heroin consumption in influencing the level of crime (one of the frequently cited sources of income used by drug-users) at the

aggregate level.[9,33] However, European, individual-level studies of income-generating activities and patterns of drug consumption have concluded that available resources influence the amount of drugs purchased and consumed:

> "The level of consumption of illegal drugs depends on the amount of money earned. In this sense junkies might be said to have a 'money' habit, or an 'activities' habit, rather than an 'unlimited' need for cocaine or heroin, or an unlimited willingness to do 'anything' to get it. There is little support in this study for the widespread notion that every junkie must steal to obtain his invariable daily dose of drugs" (Grapendaal, Leuw and Nelen,[34] p.158; see also Hoekstra and Swart[12]).

Each heroin user is assumed to make simultaneous decisions about whether or not to deal and their optimal level of heroin consumption in the current period. Among other factors, the decision to participate in dealing activity will be based upon profit possibilities, the perceived risk of detection and risk-attitude. Dealing status, D_H, is assumed to be determined by an underlying latent variable, D^*_H, such that:

$$D_H^* = f_1 (z, Y^{ND}, M, \pi, \phi, r, V, p) \qquad \textbf{(2)}$$

and:

$$D_H = 1 \quad if\ D_H^* > 0 \qquad \textbf{(3)}$$

$$D_H = 0 \quad if\ D_H^* \leq 0 \qquad (4)$$

in which; z is a set of personal characteristics, Y^{ND} is non-dealing income, M is an indicator of market size, π is net per unit profit, ϕ is an indicator of the availability of heroin at higher levels of the market, r is risk attitude, V is the cost to the individual of being arrested and p is the perceived risk of arrest by the police.

The optimal levels of heroin consumption for dealers and non-dealers are assumed to be determined by:

$$C_H^D = f_2^D(P_H, P_A, Y^{ND}, Q_H, \pi, Y^D, M, S, z) \qquad (5)$$

$$C_H^{ND} = f_2^{ND}(P_H, P_A, Y^{ND}, S, z, G) \qquad (6)$$

where: C_H^D and C_H^{ND} are heroin consumption levels of dealers and non-dealers respectively; P_H is the unit price of heroin; P_A is an index of prices for other drugs; Y^D is total financial profit made on drug sales; S is the season of the year; and G is a dummy variable indicating whether non-dealing individuals buy heroin in units or grams.

With cross-sectional data, there are problems in interpreting negative correlations between

prices and the consumption of heroin because of the price-discounts available on bulk-buys. In this study, this possibility is reduced by considering the consumption patterns of individuals at different levels of the market separately. Most dealers buy at the gram level and there are very few dealers buying at higher levels in this sample. Shift and slope dummy variables are entered into the non-dealers consumption equation to reflect any difference in consumption patterns and price-responsiveness of non-dealers who buy in grams. It is assumed that the market structure is such that price discounts for large purchases at given levels of the market are rare, i.e. purchases of multiple units are no cheaper per-unit than purchases of single units.

Finally, the optimal level of heroin sales by dealers, Q_H, is modelled as a function of various personal characteristics and economic factors:

$$Q_H = f_3(C_H^D,\ P_A,\ S,\ z,\ Y^{ND},\ \pi,\ M,\ p) \qquad (7)$$

5. DATA

The data used in this study were obtained in interviews which took place near a needle exchange service in the centre of Oslo. Respondents were approached after attending the service. Between 50 and 90 injecting drug-users were interviewed each month from June 1993 to July 1994. A total of 904 questionnaires were completed. Some individuals might have been interviewed more than once, providing an interview had not been carried out within the same month. Even if some users did answer the questionnaire twice during the thirteen-month period, it is thought that most refused to answer the same questions a third time. The interviews were anonymous and it was not possible to register the interviewees to look at changes over time. It was estimated that, during an interviewing session, approximately one-third of needle-exchange attendants answered the questionnaire.

Representativeness

Given the illegal nature of drug market participation, the representativeness of the data collected is difficult to ensure, but fundamentally important if statistical analysis is to be used to make generalisable conclusions. The representativeness of the sample has been discussed in more detail elsewhere.[36] In summary, there are five types of evidence for the representativeness of the individuals interviewed and their drug market activities:

(i) In 1994, the service handed out nearly 880,000 syringes and recorded 66,000 separate visits.[57] It has been estimated that there are between 4,000 and 5,000 drug injectors in Norway[38,39] and the needle exchange service is the only one of its kind in Norway. Since not

all of these will live in Oslo, it may be assumed that the service in Oslo attracts many of the district's users.

(ii) Concentration on the injecting population may lead to unrepresentative results for amphetamine users who most often choose other methods of transmission,[40] but is unlikely to cause bias for the primary heroin-using population. Therefore, subsequent analysis is confined to this group.

(iii) The sex and age characteristics of the sample fit well with other studies of this population.[41] Approximately 38 percent were female, and the mean age was 29.6 years (males mean age 30.6 years, females mean age 27.9 years).

(iv) People with an extensive injection habit will be likely to attend the service more often than infrequent users, and an over-representation of the former is probable. However, frequent reasons for refusal to participate in the interview were that withdrawal pains were bothering them or that sex-workers had customers waiting. Therefore, heavier users at the needle-exchange may have been more likely to refuse to participate and over-representation may not be a problem.

(v) If the sample of heroin users included in this sample is representative of this level of the market, and reported levels of dealing activity are reasonably accurate, the total quantity reported to be sold by dealers would equal the reported quantity purchased by users. Within this sample, the quantity reported to be sold by user-dealers is 94% of the quantity reported

to be bought by non-dealers.[36] The near-equivalence of these figures suggests that a representative picture of using and dealing activity at this level of the heroin market has been elicited.

Content of the questionnaire

Interviewees were asked detailed questions about their levels and sources of monthly income, levels of drug consumption, and the prices they had paid for different types and quantities of drugs.

Income: Respondents were asked how much money they had obtained from six possible income sources: work, state benefit, theft, sale of drugs, prostitution, and 'other' sources. The exercise was dealt with in two stages: individuals were initially asked to rank the six possible sources of income in terms of their contribution to total income; they were then asked to estimate the amount earned from each source. In cases for which monthly amounts are missing, income data are interpolated using figures provided by the rest of the sample.[36] Average monthly income was 50,580 NOK (£5,000) and, besides social benefit, dealing and prostitution were the most frequently reported income sources for men and women, respectively.

Consumption: Respondents were also asked about their drug consumption. Heroin and amphetamine users were asked how often they had injected during the previous day, how many days they had injected in the previous month and what quantity of drugs their last injection had contained. In addition, respondents were asked to estimate their average daily consumption

and expenditure.

Sales: Respondents were asked: which drug they normally sold; what quantity of this drug they had bought most recently and at what price; in what quantities they had 'sold-on'; how often each month they sold this quantity; and what proportion of the quantity bought they had consumed themselves.

Prices: Price data were obtained by asking people what they would have to pay for different types and quantities of drugs. Individuals were asked specifically about prices of units and half-grams of heroin, and generally about prices at higher levels. Dealers were asked how much they had paid for the last quantity of drugs they bought (at least partially) for dealing. Silverman and Spruill[9] suggested the market purity of drugs would be an important determinant of the price-responsiveness of heroin consumption. Other studies have noted the importance of presenting trends in market prices in quality-adjusted terms[7,42,46] to reflect the potentially important effects of purity changes on behaviour. These data, however, are difficult to obtain. At the aggregate level, the average purity of drug seizures by enforcement agents have been used as market purity indicators. However, the purity of drugs sold in the market-place is likely to exhibit the same level of inter-personal variation as prices and quantities consumed. Chatterton et al[47] demonstrated that it was possible to elicit purity-indicators from individuals in terms of deviation from the normal level. Nevertheless, elicitation of percentage purity estimates are not feasible. No purity data were collected in this study.

Excluded cases

In this type of study, there may be serious problems with missing or nonsensical responses to various questions. Whilst 904 subjects completed some parts of the questionnaire, the number of these interviews which provide sufficient data for this analysis is considerably smaller. The main reasons for exclusion from the sample are shown in Table 1.

Table 1: Frequencies of different types of missing values

Reasons for exclusion	Excluded	Number
Not primary heroin users (therefore no consumption data available)	154	750
No information on income sources	2	748
Dealers not asked about the extent of their activity	50	698
Dealers did not answer *any* questions on their activity	48	650
Dealers who dealt in drugs other than heroin	21	629
Dealers did not answer some questions on their activity	12	617
No answer to injections/day and/or injecting-days/month	42	575
No answer to quantity-per-injection	208	367

Non-primary heroin users were excluded because all these respondents reported significant use of amphetamines and therefore their responses to the injecting questions will relate to amphetamine consumption.

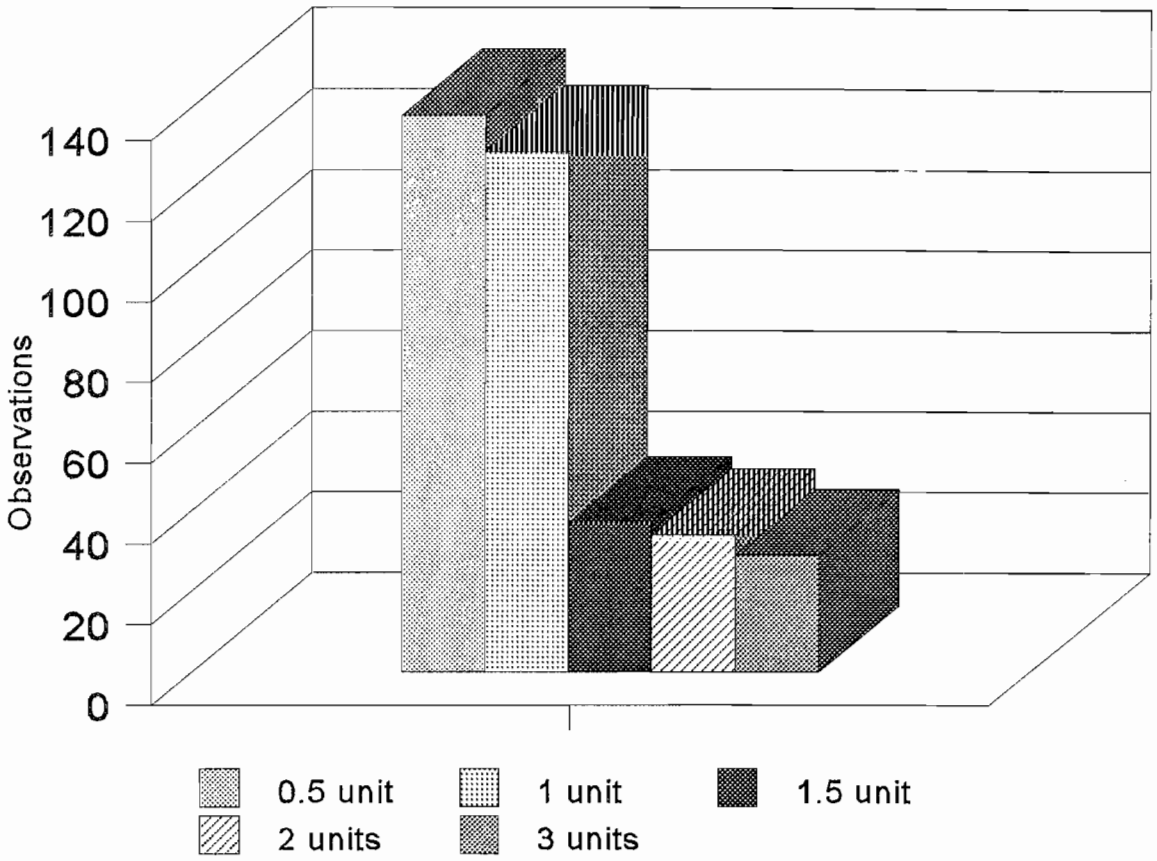
Many known heroin dealers are also excluded. The majority of excluded dealers did not answer or were not asked any questions on their dealing activity. It became clear during the fieldwork that respondents were experiencing difficulties with estimating monthly income from drug sales, and questions were appended to the questionnaire which asked for more details about drug-selling activities. This was done after the first two months of interviewing. Since the questions relating to dealing activity were not introduced until later into the study period, there is unlikely to be a systematic bias introduced by exclusion of these cases.

Dealers in drugs other than heroin are excluded because it is not known how larger quantities of drugs are divided into quantities sold at lower levels of the market. Therefore, it is not possible to estimate profit margins and quantities sold.

Consumption Data

There are a variety of estimates available from the questionnaire of the amount of heroin consumed by each individual. The most detailed measure is derived by multiplying the amount of heroin in each injection by the number of injections-per-day and the number of injecting-days per month. However, it became evident after several interviewing sessions that the amount of heroin in each injection varied substantially (see figure 4). Therefore, a question on the amount of heroin in each injection was added midway through the interview period. The wide variation in the amount-per-injection implies that simple multiplication of the number of injections per day and the number of drug using days per month is not a good indicator of monthly heroin consumption.

Figure 4. Units of heroin per injection.



Other possible measures, such as self-reported daily consumption or expenditure, were found to have little correlation with the more detailed measure. Since those who were not asked the amount-per-injection section represent the largest group of respondents who could potentially be lost from the sample (approximately 36% of the final group), missing values for the amount-per-injection question have been interpolated based on estimation of a regression equation using the personal characteristics of the respondents, and information on the number of injections per day and the number of injecting-days per month. The amount of heroin in each injection is a grouped numerical variable, and therefore the regression equation is estimated using Grouped Data Regression (see Appendix).

The predicted values for the amount of heroin in each injection, generated for those individuals with missing values using the grouped data regression, are combined with the two measures of injection-frequency to create an estimate of monthly heroin consumption for the 208 missing observations. For the remaining individuals, actual amounts-per-injection are used.

Independent variables used in regression analysis

The independent variables used in the regression models and the associated descriptive statisics are listed in Table 2.

The dummy variables THEFT and PROST are taken as proxies for attitudes to risk and existing knowledge of criminal contacts who may know from whom larger quantities can be obtained. The variable WORK is introduced to reflect the costs to the individual (in terms of status) of an arrest for a drugs offence, and to test MacCoun and Reuter's[48] hypothesis that drug selling is complementary to legitimate employment.

The variable LAGARRST is introduced to proxy the effect of changing risks of drug enforcement on drug-selling activity. The majority of arrests for drug offences are for supply-related charges. Many do not relate to heroin, but published figures are not available for arrests for heroin offences by month over this period. The number of arrests is divided by a market indicator (the number of visits to the needle exchange) to reflect adjusted risks faced by active dealers.[7,32,49] The variable is lagged by one month in line with the work of Silverman and Spruill.[9] An alternative variable representing the risks faced by dealers in the current month was found to be insignificant in the participation equation.

Table 2: Description and definition of variables

Variable	Mean	Std.Dev	Definition
DEALER	0.34	0.48	dummy; 1 = dealing actiity reported in last month.
CONSUMPTION	88.8	100.5	units of heroin consumed in last month.
SEX	0.61	0.49	dummy; 1 = male.
AGE	29.7	5.89	age in years.
THEFT	0.28	0.45	dummy; 1 = income from crime in last month.
WORK	0.13	0.34	dummy; 1 = income from work in last month.
PROST	0.24	0.43	dummy; 1 = income from prostitution in last month.
INCOME	32394	34827	total non-dealing income.
PHALFGRAM	1387.2	91.39	price for a half-gram of heroin.
SYRINGES	60589	8486	number of syringes handed out per month from exchange.
PROFIT	281.54	73.73	for dealers: per-unit profit for heroin; for non-dealers: difference between half-gram and unit price or zero if half-gram price is missing.
LAGARRST	0.0078	0.0037	arrests for drug offences divided by visits to the exchange, lagged by one month.
TIME2	0.23	0.42	dummy; 1 = September, October or November.
TIME3	0.22	0.42	dummy; 1 = December, January or February.
TIME4	0.33	0.47	dummy; 1 = March, April or May.
PRICE	337.91	158.65	per-unit price paid for heroin.
POTHER	1083.4	13.38	index of prices of other drugs.
GRAMUSER	0.45	0.50	dummy; 1 = non-dealing user who buys heroin in grams.
PGRAMUSER	102.29	116.99	cross-product of GRAMUSER and PRICE.
DEALMONEY	28435	37570	total financial profit from dealing.
DEALING	121.42	1059.5	number of units of heroin sold.
VISITS	4576.8	713.95	number of visits per month to the needle exchange.
MIDDLE	0.57	0.50	dummy; 1 = aged between 20 and 29 years.
OLD	0.22	0.42	dummy; 1 = aged 30 years or more.
HERDAILY	0.72	0.45	dummy; 1 = consumes heroin daily.
INJPERDAY	3.33	1.84	number of heroin injections per day.
INTERACT	2.79	2.29	cross-product of HERDAILY and INJPERDAY.

All continuous variables are logged in estimations.

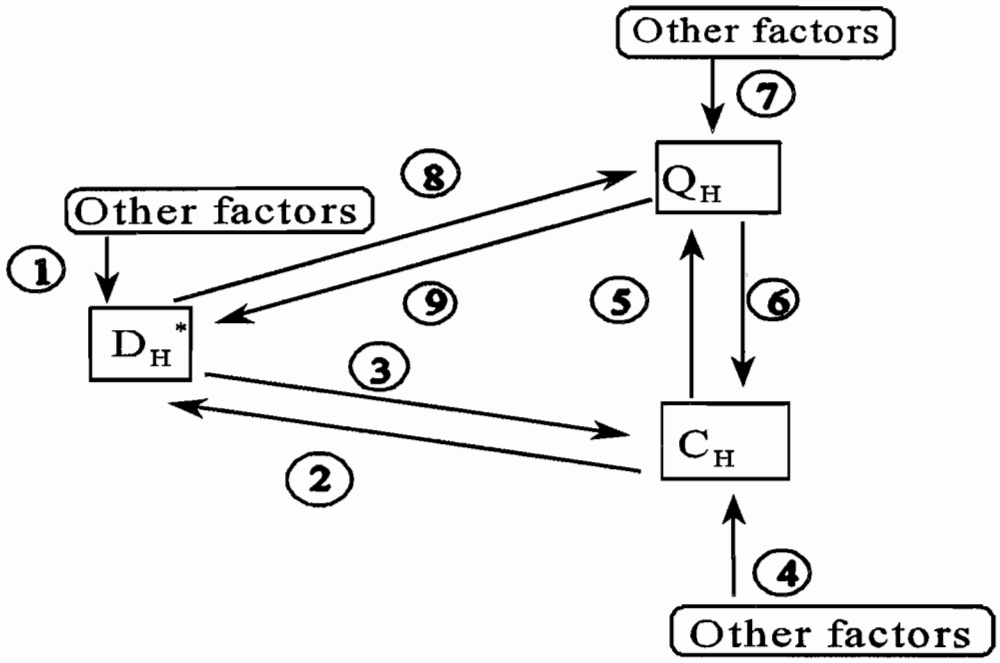
The potential per-unit profit which could be earned by non-dealers is assumed to be the difference between the equivalent per-unit price of half-grams and the unit price. This is the minimum amount of financial profit that a dealer would make and may best approximate to the potential profit for initiate dealers. Individuals who do not report a half-gram price are

assumed not to be aware of profits which can be made by dealers. This combined form for the profit variable was found to perform better when a RESET-type specification test was applied to the dealing-status equation.

6. ESTIMATION

The structure of the problem is illustrated in figure 5:

FIGURE 5. THE STRUCTURE OF THE PROBLEM



Initially, it is assumed that the propensity to deal, D_H^*, optimum sales quantity (Q_H), and optimal consumption quantity (C_H) are simultaneously determined. Thus, there are arrows both from C_H to Q_H and in the opposite direction. Furthermore, such a simultaneous decision would mean that neither C_H nor Q_H can be treated as pre-determined variables. The numbers in figure 5 refers to the equations in section 4 and the 'other factors' which are considered have been

detailed in the same section.

To test the simultaneity of C_H and Q_H, a simultaneous equation system for dealers' consumption and selling activity was estimated allowing for selectivity into the dealing group using LIMDEP. The quantity sold in the consumption equation, and the quantity consumed in the dealing activity equation, were tested for exogeneity using a Hausman test.[31] The null hypothesis that the number of units sold is exogenous in the consumption equation was not rejected at the 90% level. The exogeneity hypothesis for the number of units consumed in the dealing equation was rejected even at the 99% level. This may indicate that the level of dealing is determined by factors not including consumption. Thus, the model for dealing activity is estimated without a variable for consumption (which means that the arrow from C_H to Q_H in figure 5 will not be taken into account in the following estimations), whilst dealers' consumption in the switching regression model is estimated treating the number of units sold as an exogenous, independent variable. The latter finding is complementary to our assumptions of the exogeneity of other income sources.

After having established which variables may be treated as exogenous, estimation of the main results from this study were produced in three stages: (i) a switching regression model of consumption with endogenous switching on dealing status; (ii) a self-selection model of the amount of heroin sold by dealers; and (iii) spline function analysis of 'kinks' in the demand curve for heroin.

(i) Switching regression model of heroin consumption

Once the appropriate form of the dealers' consumption equation was identified, based on analysis of the simultaneous equation system, a regression model of consumption for the whole sample of dealers and non-dealers is estimated. To allow for self-selection of dealing status, the consumption equations for dealers and non-dealers are combined in a switching regression model with endogenous switching.

The observed consumption data C_i are assumed to be derived from a two-equation latent structure which considers both the consumption of dealers (C_H^D) and non-dealers (C_H^{ND}):

$$C_{Hi}^{D} = \beta_1 X_{1i} + u_{1i} \qquad \textbf{(8)}$$

$$C_{Hi}^{ND} = \beta_2 X_{2i} + u_{2i} \qquad \textbf{(9)}$$

in which: X_{1i} is a vector of independent variables which influence the consumption of dealers and X_{2i} is a vector containing the independent variables which influence the heroin consumption of non-dealers; β_{1i} and β_{2i} are vectors containing the corresponding coefficients; and u_{1i} and u_{2i} are random errors with zero mean and constant variances σ_{11} and σ_{22}.

Which of the latent variables from equations (8) and (9) that is observed (C_i) depends on auxiliary equations for a latent variable I_i^* and a binary variable I_i:

$$I_i^* = Z_i\gamma + \epsilon_i \qquad \textbf{(10)}$$

$$I_i = 1 \quad iff \quad I_i^* > 0 \qquad \textbf{(11)}$$

$$I_i = 0 \quad iff \quad I_i^* \leq 0 \qquad \textbf{(12)}$$

in which: Z_i is a vector of variables influencing the decision to deal; γ contains the corresponding coefficients; and ϵ_i are random errors with zero mean and unit variance. The observations for C_i are generated as follows:

$$C_i = C_H^D \quad iff \quad I_i = 1 \qquad \textbf{(13)}$$

$$C_i = C_{Hi}^{ND} \quad iff \quad I_i = 0 \qquad \textbf{(14)}$$

The participation equation (10) and the two consumption equations (8) and (9) were jointly estimated using LIMDEP. The error terms u_{1i}, u_{2i} and ϵ_i are assumed to be joint normally distributed with zero means and a variance matrix Σ:

$$\Sigma = \begin{bmatrix} \sigma_{11} & 0 & \sigma_{1\epsilon} \\ 0 & \sigma_{22} & \sigma_{2\epsilon} \\ \sigma_{1\epsilon} & \sigma_{2\epsilon} & 1 \end{bmatrix} \qquad \textbf{(15)}$$

The covariance between u_{1i} and u_{2i} is set equal to zero. Due to the strict separation in the model, only one regime is observed at the time. Therefore, the covariance would be inestimable even if it were assumed to be non-zero.[35] When the other covariances are different from zero, this provides evidence of non-random selection into one or both of the selection

regimes. The covariances provide information about the nature of selectivity into each group.

(ii) Self-selection model of the quantity of heroin sold by dealers

The number of units of heroin reported to be sold by heroin dealers in the last month is analysed using a self-selection model on dealing status. Joint-estimation of the participation and sales equations was undertaken using LIMDEP.

(iii) Spline function analysis of 'kinks' in the demand curve

As possible shapes of the demand curve have been of interest in this study, a spline function[35] was constructed to test for different forms of the relationship between heroin prices and consumption. A spline function is created to reflect possible changes in the elasticity of different segments of the demand curve depending on the level of price as proposed by Wagstaff and Maynard[7] (see figure 1). The literature offers no indication of the price levels at which the slopes may change, so changes in elasticity were tested for prices below the bottom quartile, the median price, or the upper quartile (assuming only one kink on the demand curve) and in both the bottom and upper quartiles (two-kinks hypothesis). The spline functions used were the following:

$$C_i = \alpha_0 + \alpha_1 P_i + \alpha_2 [\, D_1(P_i - P_1^*) \,] + \delta_i X_i + e_i$$

$$C_i = \alpha_0 + \alpha_1 P_i + \alpha_2 [\, D_2(P_i - P_2^*) \,] + \delta_i X_i + e_i$$

$$C_i = \alpha_0 + \alpha_1 P_i + \alpha_2[\, D_3(P_i - P_3^*)\,] + \delta_i X_i + e_i$$

$$C_i = \alpha_0 + \alpha_1 P_i + \alpha_2[\, D_1(P_i - P_1^*)\,] + \alpha_3[\, D_3(P_i - P_3^*)\,] + \delta_i X_i + e_i$$

in which: C_i is consumption for individual i; P_i is the unit price of heroin; P_1^*, P_2^* and P_3^* are the lower quartile, median and upper quartile values for the price of heroin; X_i are vectors of exogenous variables for consumption; e_i are error terms with zero mean and unit variance; and D_j (j=1,2,3) are dummy variables which take a value of one if $P_i \geq P_j^*$ and zero otherwise.

The spline functions were introduced into the switching regression model of heroin consumption, and separate estimations for dealers and non-dealers were obtained. Because no dealers paid prices in the upper quartile of the distribution of heroin prices, only median and lower-quartile 'kinks' were introduced into the dealers' consumption equation.

7. RESULTS OF SWITCHING REGRESSION MODEL OF CONSUMPTION

The coefficients from the switching regression model of heroin consumption with endogenous switching between dealing and non-dealing are shown in Table 3.

The estimated correlations between the error terms in the latent structure equations and the selection equation ($\rho_{1\epsilon}$ and $\rho_{2\epsilon}$) indicate that an assumption of exogenous switching between dealing and non-dealing is rejected.

The first column of coefficients relates to the probability that an individual reported being involved in dealing in the previous month. The variables introduced to reflect the risk-attitude of individuals and established contacts with criminal networks (THEFT and PROST) are not indicated to be significant predictors of participation in dealing, although the coefficients on both have positive signs. However, individuals who have income from legitimate employment are found to be significantly less likely to report dealing activity in the last month. Total income from non-dealing sources is estimated to have a negative impact on the probability of dealing, and increases in the financial rewards from selling each unit of heroin increases the likelihood of participation in selling. The market-price of half-grams of heroin is found to be negatively associated with dealing participation, which is interpreted as indicating the impact of increased availability of drugs at higher levels of the market in encouraging participation in dealing. Perceived risks of arrest (represented by LAGARRST) are found to have a negative impact on the probability of reporting selling activity in the last month.

Table 3: Results from switching regression model of heroin consumption

VARIABLE	PARTICIPATION	NON-DEALERS CONSUMPTION	DEALERS CONSUMPTION
Constant	**17.69**	49.15	8.41
	(2.98)	(1.19)	(0.22)
SEX	0.29	**-0.44**	-0.33
	(1.56)	(-3.25)	(-1.87)
AGE	-0.19	-	-
	(-0.71)		
THEFT	0.19	-	-
	(0.86)		
WORK	**-0.47**	-	-
	(-2.88)		
PROST	0.14	-	-
	(0.52)		
INCOME	**-0.25**	**0.45**	**0.14**
	(-2.92)	(7.20)	(5.05)
PHALFGRAM	**-1.57**	-	-
	(-4.53)		
SYRINGES	-0.48	-	**2.18**
	(-1.03)		(2.03)
PROFIT	**0.32**	-	**-0.16**
	(5.53)		(-1.92)
LAGARRST	**-0.39**	-	-
	(-2.28)		
TIME2	-	0.32	**0.53**
		(1.43)	(2.31)
TIME3	-	0.31	**0.81**
		(1.49)	(3.44)
TIME4	-	0.38	0.28
		(1.72)	(0.75)
PRICE	-	**-1.23**	-0.20
		(-7.32)	(-0.70)
POTHER	-	-6.26	-3.81
		(-1.09)	(-0.74)
GRAMUSER	-	-0.00	-
		(-0.50)	
PGRAMUSER	-	0.03	-
		(0.04)	
DEALMONEY	-	-	-0.15
			(-0.76)
DEALING	-	-	**0.19**
			(2.80)
$\rho_{1\epsilon}$	-	-	**-0.95**
			(-38.10)
$\rho_{2\epsilon}$	-	**0.62**	-
		(7.65)	

Figures in bold are significantly different from zero at 95% level.
Interpretations of the coefficients are contained in the results section.

The estimated effects of various factors on the consumption of heroin by non-dealers are shown in the second column of Table 3. Male injectors are estimated to consume significantly less than female injectors. The income-elasticity of demand for non-dealers is approximately equal to 0.47, implying that a 10% increase in non-dealing income leads to a 4.7% increase in the quantity consumed by users. The coefficients on the variables GRAMUSER and PGRAMUSER are not significantly different from zero, and the price-elasticity of heroin consumption by both gram-users and unit-users is estimated to be -1.23. This coefficient suggests that a 10% increase in price leads to a 12.3% decrease in consumption by non-dealers.

The third column of Table 3 shows the estimated regression equation for dealers' consumption. The heroin consumption of dealers is found to have an income elasticity of 0.23 for income from non-dealing sources. The effect of financial profits from dealing (DEALMONEY) on the amount of heroin consumed is found to be not significantly different from zero. Similarly, although the point estimate of the influence of the price pade by dealers for heroin is negative, the null hypothesis of no effect cannot be rejected. A 10% increase in the number of units sold by dealers is estimated to result in a 1.9% increase in consumption.

In the participation equation, the coefficients do not represent the estimated marginal impacts of the independent variables on the probability of dealing. This information is provided in Table 4, which shows the estimated probability of dealing associated with a variety of situations. In the base situation (which relates to males, reporting no income from theft, work or prostitution, and with all continuous variables taking mean values), the probability of being

involved in dealing is estimated to be 0.325. As the table shows, whilst the difference between the probabilities of dealing for males and females is not found to be significantly different from zero, the estimated coefficient indicates a considerably lower probability of dealing for females than males (0.230 compared to 0.325). The estimated impacts of the other binary variables, such as THEFT and PROST, are also considerable. The combined influence of being female and reporting income from prostitution is shown, since the vast majority of those reporting prostitution are female.

In contrast to the relatively large impacts of the dummy variables, 10% changes in the continuous variables are estimated to have little effect on the probability of dealing. A 10% increase in profit increases the probability of dealing by 0.011, whilst a similar increase in non-dealing income decreases this probability by 0.009. The estimated impact of increases in the success of enforcement activity on dealing participation is similarly of quite small magnitude, suggesting considerable improvements in intermediate output would be required to substantially influence the market activities of illicit heroin users.

Table 4. Estimated marginal impacts on the probability of dealing

SCENARIO	PROBABILITY
BASE[1]	0.325
Female	0.230
Income from theft in last month	0.397
Income from work in last month	**0.177**
Income from prostitution in last month	0.376
Female and income from prostitution in last month	0.274
10% increase in non-dealing income	**0.316**
10% increase in profit-per-unit	**0.336**
10% increase in proportion of dealers arrested last month	**0.314**

[1] In the base case the continuous variables take mean values and the dummy variables take most probable values. Therefore, the base case refers to males with no income reported from theft, work or prostitution in the last month.

8. RESULTS OF SELF-SELECTION MODEL OF DEALING

The regression results for dealers' dealing activity are shown in Table 5. The sample-selection equation used to correct for self-selection into the dealing group contains the same variables as the selection equation used in the switching regression model.

The results for the participation equation are broadly similar to those estimated in the switching regression model of consumption. In particular, the level of income, availability of heroin at the higher-level of the market, the risks of enforcement activity, and profitability remain significant predictors of dealing participation, with the influences estimated to be larger in all but the last case. Whilst the dummy variables indicating other sources of income take the same signs as in the consumption model, those raising income from theft are now estimated to be significantly more likely to be dealers, and the negative impact of employment on dealing participation is not significantly different from zero.

The results in the sales equation are rather disappointing with only one variable found to be significantly different from zero. At first, the positive, but significant, coefficient on the variable representing the level of enforcement activity (LAGARRST), may not appear intuitive. However, given the significant negative influence of enforcement risks on participation, it may be expected either that the remaining dealers will be those that are more heavily involved in selling activity, or alternatively that if enforcement reduces the number of sellers but does not reduce demand, that the remaining dealers wil respond by increasing the scale of their selling activity. This speculation may also explain the apparent disagreement of

the participation results in this study with the generally disappointing results of studies of the ability of enforcement activity to affect activity at the market level. It may be that enforcement does dissuade some individuals from engaging in selling activity, but that other dealers compensate by increasing the scale of their activity, leaving the total level of market sales unaffected.

Table 5. Results for self-selection model of heroin sales

VARIABLE	PARTICIPATION	SALES
Constant	**25.86**	9.73
	(3.73)	(1.47)
SEX	0.09	-0.11
	(0.50)	(-0.43)
AGE	-0.13	-
	(-0.39)	
THEFT	**0.70**	-
	(2.90)	
WORK	-0.37	-
	(-1.57)	
PROST	0.18	-
	(0.60)	
INCOME	**-0.48**	-0.08
	(-5.02)	(-1.49)
PHALFGRAM	**-1.85**	-
	(-4.04)	
SYRINGES	-0.84	-
	(-1.74)	
PROFIT	**0.30**	-0.17
	(3.92)	(-1.21)
LAGARRST	**-0.62**	**0.85**
	(-3.19)	(2.03)
VISITS	-	-0.42
		(-0.55)
IMR	-	-0.22
		(-0.53)

The results in the sales equation are rather disappointing with only one variable found to be significantly different from zero. At first, the positive, but significant, coefficient on the variable representing the level of enforcement activity (LAGARRST), may not appear intuitive. However, given the significant negative influence of enforcement risks on participation, it may be expected either that the remaining dealers will be those that are more heavily involved in selling activity, or alternatively that if enforcement reduces the number of sellers but does not reduce demand, that the remaining dealers wil respond by increasing the scale of their selling activity. This speculation may also explain the apparent disagreement of the participation results in this study with the generally disappointing results of studies of the ability of enforcement activity to affect activity at the market level. It may be that enforcement does dissuade some individuals from engaging in selling activity, but that other dealers compensate by increasing the scale of their activity, leaving the total level of market sales unaffected.

The signs of some of the non-significant coefficients have interesting interpretations. Higher levels of non-dealing income are estimated to have a negative impact on the extent of selling activity but this effect is not significant. Acceptance of this relationship would indicate that dealers are income-satisficers rather than income-maximisers, which is also an interpretation of the negative coefficient estimated for the profit variable, i.e. the more profitable that selling becomes per unit sold, the lower the level of sales required to reach a target level of income.

9. RESULTS OF SPLINE FUNCTION ANALYSIS

The results from the spline function analysis of changes in the slope of the demand curve are summarised in table 6.

Each column of the table contains the coefficients estimated on the price variables for both dealers and non-dealers in a switching regression model of consumption using five different price-response models. These models were described in section 6 and relate to the following predicted shapes of the demand curve:

(i) no kinks in the demand curve, which is represented by a log-linear relationship between heroin consumption and price;

(ii) significant difference between price-responsiveness above and below the median price;

(iii) significant difference between price-responsiveness above and below the upper quartile price;

(iv) significant difference between price-responsiveness above and below the lower quartile price;

(v) significant differences in price-responsiveness between the three sections of the curve relating to the regions below the lower quartile price, between the lower and upper quartile prices, and above the upper quartile price.

Table 6: Results from the spline function analysis

VARIABLE	MODEL (i)	(ii)	(iii)	(iv)	(v)
Non-dealers					
Overall price	**-1.23** (-7.32)	**-1.22** (-7.19)	**-1.22** (-7.19)	**-1.22** (-7.18)	**-1.23** (-7.23)
Lower price	-	-	-	-0.03 (-0.15)	0.10 (0.50)
Median price	-	-0.03 (-0.15)	-	-	-
Upper price	-	-	-0.03 (-0.16)	-	-0.02 (-0.11)
Dealers					
Overall price	-0.20 (-0.70)	-0.18 (-0.63)	-0.19 (-0.69)	-0.47 (-0.43)	-0.48 (-0.43)
Lower price	-	-	-	-0.35 (-0.28)	-0.36 (-0.28)
Median price	-	-3.43 (-0.17)	-	-	-
Upper price	-	-	n/a	-	n/a

Assuming the lower and upper quartiles are the appropriate places for the 'kinks', the Wagstaff and Maynard hypothesis (Figure 3) is a special case of model (v) in which price-responsiveness is greater in the upper and lower segments, and consumption is perfectly price-inelastic in the middle segment.

The results in table 6 offer good evidence that the hypothesis of kinks in the demand curve for heroin does not apply over the range of prices offered on the Oslo drug market over the study period. The high price elasticity estimate for non-dealers (-1.23) is robust to introduction of various other price variables. None of the variables introduced to detect possible slope changes are of considerable magnitude or statistically significant. At no point does the estimated price-responsiveness of non-dealers approach perfect price-inelasticity.

In the original model, the price coefficient estimated for dealers was not significantly different from zero, implying that an hypothesis of perfect price-inelasticity throughout the full range of prices could not be rejected. As would be expected the estimated price coefficient is not as stable as in the case of non-dealers; whilst none of the additional price variables which are introduced are significantly different from zero and none produce significantly different estimates of the overall price elasticity, there is a higher degree of variation across the different models.

10. DISCUSSION

Recent developments in the literature on the economics of addiction has concentrated on the way in which addiction develops over time and the relationship between consumption in different periods. These models however require details of individuals past consumption or preferably panel data. Panel data are difficult to obtain and therefore information usually only exists on current consumption and economic circumstances. A wide range of literature hypothesises about the contemporaneous influence of economic factors (particularly price) on consumption. However, a lack of available estimates of price and income elasticities of demand for illicit drugs has been lamented in several reviews of economic studies of the consumption of addictive substances.[7,55,56]

In this paper, price and income elasticities of the demand for heroin from the illicit market in Oslo have been estimated conditional on a number of assumptions about drug-users' behaviour. Based on recent surveys of variations in drug-users' consumption patterns,[12,34] total income from non-dealing sources is assumed to be exogenous when modelling influences on the amount of heroin consumed in the last month. Heroin consumption is modelled as dependent on dealing status, with dealers' consumption influenced by a wider range of economic factors. Dealers' consumption patterns additionally reflect profit-making possibilities and trends in market conditions. The results suggest that individuals do not choose whether or not to become dealers independently of their optimal level of consumption.

The estimated price-responsiveness of heroin consumption by non-dealers is substantially larger

than that of dealers (-1.23 compared to -0.20). The point-estimate for dealers is close to that estimated by Silverman and Spruill,[9] the only other estimate of the price-elasticity of demand for heroin in the literature. The higher price-elasticity for non-dealers in the heroin market may reflect the generally higher prices for heroin in the Oslo market compared to New York City (the setting for Silverman and Spruill's work). The differences in price-elasticity between dealers and non-dealers may also reflect greater price-responsiveness at lower levels of income, as has been found in studies of alcohol and tobacco consumption.[50,51,52] Alternatively, as heavier consumers, dealers may be expected to be more dependent and therefore less price-responsive. Evidence for this hypothesis has been found in one recent study of alcohol consumption,[52] but rejected in another.[53]

A recent review of the literature on the contemporaneous effect of economic factors on consumption suggests kinks in the demand curve.[7] However, no indications are offered as to where these slope changes are to be found in empirical studies and the theory is based on unrealistic assumptions about a maintenance dose of heroin. By estimating spline functions which allow for varying elasticity in different parts of the demand curve, some evidence on the probable shape of the demand curve for heroin is produced. The underlying logarithmic relationship between price paid and level of consumption is found to be robust to the introduction of various price variables. We find no evidence that the elasticity of demand for heroin varies in different segments of the curve, within the range of prices quoted on the illicit heroin market in Oslo over a one-year period.

The total level of income from non-dealing sources is found to have a significant impact on

the decision to deal and levels of consumption for both dealers and non-dealers. The results do not suggest that there is complementarity between legitimate employment and drug-selling, as has been proposed by MacCoun and Reuter.[48] Individuals who report income from legitimate employment are less likely to report dealing activity, perhaps because the personal costs of arrest are higher in terms of a more secure time-path of earnings foregone. Thus, job-creation programmes may be expected to deter drug users from becoming involved in dealing. Increases in non-dealing income, such as social benefits, are also estimated to reduce the probability of participation in dealing activity. However, increases in income have been estimated also to increase levels of heroin consumption, such that this approach would have undesired consequences on levels of consumption. Higher income-responsiveness in the non-dealing group may also reflect higher income-responsiveness at lower initial levels of income as has been found elsewhere in the case of alcohol.[52]

This study demonstrates the extent of variation in heroin users' consumption behaviour and the potential importance of market and personal economic factors on heroin users' activity in the illicit market. These findings suggest that policy and economic instruments may have an important role to play in influencing market participants' behaviour. However, manipulation of price and income levels is found to have both positive and negative effects. For example, price increases may reduce consumption levels significantly, but the associated increase in profit-making possibilities may encourage more users into dealing. Similarly, increases in the amount of income available to drug users may decrease participation in selling, but have an opposite, positive influence on the amount of heroin consumed by both users and user-dealers. Moreover, whilst these study results offer optimism as to the ability of enforcement agencies

to decrease the size of the dealing popultion, it may be that the remaining dealers are, or become, more active, such that the effect on the overall market is dampened.

APPENDIX

The results from the Grouped Data Regression are shown in Table 7. The results reveal some interesting relationships between different aspects of heroin users' consumption patterns. Males are estimated to use less heroin in each injection than females at the same level of injection-frequency, although the difference is not significant. Heroin users in the youngest age-group (20 years or less) are found to consume less than older users, which is compatible with increasing tolerance at later stages in a heroin-using career. However, heroin users in the oldest age-group (30 years or more) are estimated to use less heroin-per-injection than those in the middle age-group. Individuals may begin to retire from drug use by reducing the dose in each injection. Alternatively, lighter consumers may be less likely to stop using drugs altogether (see Yen and Jones[54] for a discussion of this hypothesis in relation to tobacco use), and may represent a higher proportion of users in the older age-group.

The coefficients estimated on the frequency-of-injection variables are broadly in line with expectations. Individuals who use heroin daily inject themselves with doses of heroin which contain almost half a unit more than non-daily injectors. Individuals who inject themselves more often per day also use more heroin in each injection. With each additional heroin injection the average dose of heroin *for each injection* increases by a quarter of a unit, such that an individual who injects themselves three times a day will use an additional half-unit of heroin in each injection over the consumption of someone who injects just once a day. The sign of the coefficient on the interaction term suggests a *capacity limit* for heroin users, whereby daily injectors do not increase the dose per injection with increasing injection-

frequency as much as non-daily injector.

Table 7: Grouped data regression results

Variable	Coefficient (t-ratio)
Constant	-0.350 (-1.75)
SEX	-0.044 (-0.59)
MIDDLE	**0.220** (2.14)
OLD	0.143 (1.18)
HERDAILY	**0.431** (2.38)
INJPERDAY	**0.240** (4.40)
INTERACT	**-0.171** (-2.97)
σ	**0.503** (11.11)

References

1 Robertson, J. R., Ronald, P. J. M., Raab, G. M., Ross, A. J. & Parpia, T. Deaths, HIV infection, abstinence, and other outcomes in a cohort of injecting drug users followed up for 10 years, *British Medical Journal* 1994; 309: 369-372.

2 Parker, H., Bakx, K. & Newcombe, R. *Living with heroin: the impact of a drug epidemic on an English community*. Milton Keynes: Open University Press, 1988.

3 Mott, J. Crime and heroin use. In Whynes, D. K. & Bean, P. T. (eds.) *Policing and Prescribing: The British System of Drug Control*. Basingstoke: Macmillan, 1991: 77-95.

4 Hammersley, R., Forsyth, A., Morrison, V. & Davies, J. B. "The relationship between crime and opioid use". *British Journal of Addiction* 1989; 84: 1029-1043.

5 Dorn, N., Baker, O. & Seddon, T. *Paying for heroin: estimating the financial cost of acquisitive crime committed by dependent heroin users in England and Wales*. London: The Institute for the Study of Drug Dependence, 1994.

6 Johnson, B. D., Goldstein, P. J., Preble, E., Schmeidler, J., Lipton, D. S. & Miller, T. *Taking Care of Business: The Economics of Crime by Heroin Abusers*. Lexington: Lexington Books, 1985.

7 Wagstaff, A. & Maynard, A. *Economic Aspects of the Illicit Drug Market and Drug Enforcement Policies in the United Kingdom*. Home Office Research Study 95. London: Home Office, 1988.

8 Sutton, M. & Maynard, A. Are drug policies based on fake statistics? *Addiction*, 1993; 88: 455-458.

9 Silverman, L. P. & Spruill, N. L. Urban crime and the price of heroin. *Journal of Urban Economics*, 1977; 4: 80-103.

10 Nisbet, C. & Vakil, F. Some estimates of price and expenditure elasticities of marijuana among UCLA students. *Review of Economics and Statistics*, 1972; 54: 473.

11 Grapendaal, M. Cutting their coat according to their cloth: Economic behaviour of Amsterdam opiate users. *The International Journal of Addictions*, 1992; 27(4): 487-501.

12 Hoekstra, J. C. & Stuart, P. S. Economic behaviour of heroin users and effects of policy measures. *Medicine and Law*, 1990; 9 (2): 831-840.

13 Stevenson, R. The economics of illicit drug policy. In: Whynes, D. K. & Bean, P. T. (eds) *Policing and Prescribing: The British System of Drug Control*. Basingstoke: Macmillan, 1991: 200-216.

14 Rottenberg, S. The clandestine distribution of heroin, its discovery and suppression. *Journal of Political Economy*, 1968; 76 (1): 78-90.

15 Koch, J. V. & Grupp, S. E. The economics of drug control policies. *The International Journal of the Addictions*, 1971; 6 (4): 571-584.

16 White, M. D. & Luksetich, W. A. Heroin: price elasticity and enforcement strategies. *Economic Inquiry*, 1983; 21: 557-564.

17 Herrstein, R. J. & Prelec, D. A. A theory of addiction. In: Loewenstein, G. & Elster, J. (eds.) *Choices over time*. New York: Russell Sage Foundation, 1992: 331-361.

18 Grossman, M. *The economic analysis of addictive behaviour*. Paper presented at the Workshop on Economic and Socioeconomic Issues in the Prevention of Alcohol-Related Problems, National Institute of Alcohol Abuse and Alcoholism in Bethesda, Maryland, 1992.

19 Houthakker, H. S. & Taylor, L. *Consumer demand in the United States: Analysis and Projections*. Second and enlarged edition. Cambridge, Massachusetts: Harvard University Press, 1970.

20 Deaton, A. & Muellbauer, J. *Economics and Consumer Behaviour*. Cambridge: Cambridge University Press, 1980.

21 Philips, L. *Applied Consumption Analysis*. Revised and Enlarged Edition. Amsterdam: North-Holland, 1983.

22 Stigler, G. J. & Becker, G. S. De Gustibus Non Est Disputandum. *American Economic review*, 1977; 67 (2): 76-90.

23 Becker, G. S. & Murphy, K. M. A theory of Rational Addiction. *Journal of Political Economy*, 1988; 96 (4).

24 Becker, G. S., Grossman, M. & Murphy, K. M. Rational addiction and the effect of price on consumption. In: Loewenstein, G. & Elster, J. (eds.) *Choice over time*. New York: Russell Sage Foundation, 1992.

25 Koch, J. V. & Grupp, S. E. Police and illicit drug markets: some economic considerations. *British Journal of Addiction*, 1973; 68: 351-362.

26 Holahan, J. The economics of control of the illegal supply of heroin. *Public Finance Quarterly*, 1973; 1 (4): 467-477.

27 Bernard, G. An economic analysis of the illicit drug market. *International Journal of Addictions*, 1973; 18 (5): 681-700.

28 Blair, R. D. & Vogel, R. J. Heroin addiction and urban crime. *Public Finance Quarterly*, 1983; 1 (4): 457-567.

29 Roumasset, J. & Hadreas, J. Addicts, fences, and the market for stolen goods. *Public Finance Quarterly*, 1977; 5 (2): 247-271.

30 Lewis, R., Hartnoll, R., Bryer, S., Daviaud, E. & Mitcheson, M. Scoring smack: the illicit heroin market in London. *British Journal of Addiction*, 1985; 80: 281-290.

31 Maddala, G. S. *Introduction to Econometrics*. New York: Macmillan, 1988.

32 Polich, J. M., Ellickson, P. L., Reuter, P. & Kalion, J. P. *Strategies for controlling adolescent drug use*. Santa Monica: RAND, 1984

33 Benson, B. L., Kim, I. J., Rasmussen, D. W. & Zuehlke, T. W. Is property crime caused by drug use or drug enforcement policy? *Applied Economics*, 1992; 24 (7): 679-692.

34 Grapendaal, M., Leuw, E. & Nelen, H. *A World of Opportunities: Lifestyle and Economic Behaviour of Heroin Addicts in Amsterdam*. New York: State University of New York Press, 1993.

35 Greene, W. H. *LIMDEP: User's Manual and Reference Guide*. Econometric Software Inc., 1991.

36 Brettville-Jensen, A. L. & Sutton, M. The income-generating behaviour of injecting drug-users in Oslo. *Addiction*, forthcoming, 1996.

37 Berg, J. E. & Andersen, S. Street sale of heroin - a profitable way of making a living? *Drug and Alcohol Dependence*, 1993; 32: 287-291.

38 Skog, O. -J. *Utviklingen av intravenøst narkotikamisbruk i Norge. Anslag for insidens of prevalens. (The development of injecting drug misuse in Norway. Estimations on prevalence and incidence)*, National institute for Alcohol and Drug research, Report 1/90, 1990.

39 Brettville-Jensen, A. L. *Narkotikadødsfall i Norge. En analyse av utviklingen fra 1976-1993 (Drug-attributed Deaths in Norway)*, National institute for Alcohol and Drug research, Report 4/94, 1994.

40 Skog, O. -J. Utviklingen av det norske narkotikaproblemet (Development of the Norwegian drug problem). In: Waal, H. & Middelthon, A. -L. (eds.) *Narkotikaforebygging mot år 2000*. Universitetsforlaget, 1992: 33-54.

41 Skretting, A., Ervik, R. & Øie, K. E. *AIDS-informasjonsbussen i Oslo. En intervju-undersøkelse av brukerne (The needle Exchange Service in Oslo. An user* survey), National institute for Alcohol and Drug research, Report 2/93, 1993.

42 Sutton, M. & Maynard, A. *What is the Size and Nature of the Drug Problem in the UK?* YARTIC Occasional Paper 3. York: Centre for Health Economics, 1992: 87.

43 Hartnoll, R. & Lewis, R. *The Illicit Heroin Market in Britain: Towards a Preliminary Estimate of National Demand.* Mimeo: Drug Indicator Project, University College Hospital, London, 1984.

44 Bean, P. & Wilkinson, C. *Drug Taking in Nottingham: the links with crime*. Research report to the Home Office Research and Planning Unit, 1987.

45 Fraser, A. & George, M. Changing trends in drug use: an initial follow-up of a local heroin-using community. *British Journal of Addiction*, 1988; 83: 1461-1466.

46 Caulkins, J. P. What is the average price of an illicit drug? *Addiction*, 1994; 89 (7): 815-819.

47 Chatterton, M., Gibson, G., Gilman, M., Godfrey, C., Sutton, M. & Wright, A. *Performance Indicators for Local Anti-Drug Strategies: a preliminary analysis*. Crime Detection and Prevention Series Paper 62. London: Home Office Police Research Group, 1995.

48 MacCoun, R. & Reuter, P. Are the wages of sin $30 an hour? Economic aspects of street-level drug dealing. *Crime and Delinquency*, 1992; 38 (4): 477-491.

49 Sutton, M. & Maynard, A. *Trends in the Cost-Effectiveness of Enforcement Activity in the Illicit Heroin Market, 1979-1991.* YARTIC Occasional Paper 4. York: Centre for Health Economics, 1994.

50 Fry, V. & Pashardes, P. *Changing patterns of smoking: are there economic* causes? IFS Report Series No. 30. London: Institute for Fiscal Studies, 1988.

51 Atkinson, A., Gomulka, J. & Stern, N. *Household expenditure on tobacco 1970-1980: Evidence from the family expenditure survey*. Economic and Social Science Research Council Programme; Taxation, Incentives and the Distribution of income, No. 57. London: London School of Economics, 1984.

52 Sutton, M. & Godfrey, C. A grouped data regression approach to estimating economic and social influences on individual drinking behaviour. *Health Economics*, 1995; 4 (3): 237-247.

53 Manning, W. G., Blumberg, L. & Moulton, L. H. The demand for alcohol: the differential response to price. *Journal of Health Economics*, 1995; 14: 123-148.

54 Yen, S. & Jones, A. Paper presented to The Third European Workshop on Econometrics and Health Economics, Antwerp, September 1994.

55 Godfrey, C. Economic influences on changes in population and personal substance behaviour. In: Edwards, G. & Lader, M. (eds.) *Addiction: process of change*. Society for the study of Addiction Monograph No. 3. Oxford: Oxford University Press, 1994.

56 Niskanen, W. A. Economists and Drug policy. *Carnegie-Rochester Conference Series on Public Policy*, 1992; 36: 223-248.

57 *Årsrapport for AIDS-infobussen (Annual report of the Needle Exchange Service)*. Oslo: Department for Preventive Medicine, Ullevål sykehus, 1995.