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The economic behaviour of poly-drug users in the Western Cape: an analysis of pathways, prices, location and gender

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MASTERS THESIS

For partial completion of Masters in Applied Economics

March 2017

ABSTRACT

The use of illicit substances in South Africa has implications for the health and well-being of both the user and society at large. Improved data on the markets for illicit psychostimulants are imperative for supporting policy efforts to manage their use and provide support structures for those affected. This thesis is one of the few detailed studies on the South African drug market using quantitative methods. It expands on what is known about illicit substance markets by addressing aspects of the following questions:

(1) What is known about the nature and scope of the methamphetamine, methaqualone and heroin markets?
(2) What is known about the characteristics of poly-substance consumers?
(3) What does the sequential pattern of substance initiation look like?
(4) Why do poly-substance consumers report different inter- and intra-regional drug prices?
(5) What issues need further research?

As a first step towards answering these questions, a dataset of 337 poly-substance users from the Western Cape was analysed. Survey participants were sampled using a respondent-driven sampling technique – an approach useful for sampling hidden populations and efficiently, adjusting for associated sampling bias. The study found that methamphetamine prices tend to fluctuate across a heterogeneous consumer base, with a significant discount paid by females who were observed, on average, to pay 25% less for this substance. Methaqualone has less variation across consumers but showed significant price dissimilarities between the two sites included in the analysis, with respondents from Greenpoint paying, on average, 18% higher prices. This indicates a lack of pricing information being shared between the two sites. Heroin showed variation across consumers, although the data on this substance were limited. Furthermore, the results show that substance markets operate differently across intra-city locations. The key rationale for this include high transit costs incurred by suppliers (as drugs cannot be transported openly), high search costs incurred by consumers and the prevalence of information asymmetries between regions. This study brings light and understanding to a traditionally hidden market and highly dangerous market; however, far more data on the South African and African drug market is needed.

Acknowledgements

Firstly, I would like to acknowledge that this paper would not have been made possible without God's grace and strength. Secondly, I would like to thank my husband for his love, tireless support, motivation and the meals that kept me going. I would also like to thank my parents for believing in me and supporting me, and my two brothers for inspiring and guiding me. I would also like to express gratitude to Corne van Walbeek and Simon Howell for supervising me through this process – thank you for the time and effort you both dedicated to providing thorough and insightful discussions, comments and feedback.

1. Introduction

The consumer price of illicit substances around the world – amidst increased efforts in regulating illicit substances and their precursor substances, and advancements in law enforcement methods – has been paradoxically declining in real terms since the 1990s (United Nations Office on Drugs and Crime [UNODC], 2015; Collins, 2014; Reuter, 2013). The reasons provided for this decline include increased competition, reduced quality of the substances and potential corruption (Reuter, 2013). Furthermore, the impact of globalisation and the internet distribution of illicit substances has had an effect on the drug market, levelling price differentials between countries through improved information and product flows between dealers and consumers (UNODC, 2015; The Economist, 2016).

Illicit substances harm the health and well-being of individual users as well as the communities where the use of such substances is widespread. They need to be understood in detail and carefully managed by policy-makers in order to mitigate the economic and societal costs incurred by their consumption and production. Historically, poor understanding of psychostimulant markets and the behaviour of consumers, and the absence of data, have resulted in ineffective policy and the aggravation of substance-induced societal and economic costs (Collins, 2014). The continuing dearth of literature on the subject is a result of the difficulties in obtaining data on hidden substance markets.

This research seeks to contribute to a better understanding of the nature and scope of drug usage markets and drug demand, which in turn can enable the creation of better-informed drug policies tailored to the local context, which will be more effective. The context of this particular research is the Western Cape, South Africa – the province with the highest number of treatment admissions and drug-related arrests in the country (South African Police Services, 2016; Peltzer et al., 2010). The most recent iteration of the South African National Drug Master Plan (NDMP), approved by Cabinet on 26 June 201, states that "comprehensive and up-to-date data on the nature, extent and consequences of the use of drugs other than alcohol in South Africa are not available" (p. 40). The paucity of data continues, with only a few studies having been released since the release of the latest NDMP.

To achieve a better understanding, this research aims to expand on the following five questions:

(1) What is known about the nature and scope of the methamphetamine, methaqualone and heroin markets?
(2) What is known about the characteristics of poly-substance consumers?
(3) What does the sequential pattern of substance initiation look like?
(4) Why do poly-substance consumers report different inter- and intra-regional drug prices? and,
(5) What issues need further research?

These questions are investigated using demand-side consumer data from three sites in the Western Cape. a novel sampling approach is implemented because of the difficulties of obtaining data from illicit substances users. The approach used leverages trust from social relationships to increase response rates. The demographic data from the sample is summarised and adjustments are made to estimate the demographic make-up of the broader poly-substance using population in the Western Cape. Heterogeneity among substance abusers is the basis for analysis of drug transactions by sub-group. This is performed by applying a series of bias-adjusted analyses with increasing complexity for each of methamphetamine, methaqualone and heroin.

2. Background

2.1. Illicit substance use in South Africa

Illicit psychostimulant substance use in South Africa has developed from the backdrop of a number of political and socioeconomic factors, such as apartheid's oppressive system, extreme inequality, and a poor social welfare structure, among others. The distress resulting from such factors is commonly mitigated and suppressed by psychostimulant substance use (Lakhdar, 2013). Since the first democratic election in 1994, South Africa has become increasingly connected to the global economy through open trade linkages and the removal of economic sanctions put in place during apartheid (Faulkner and Loewald, 2008). This has benefited the South African economy by opening up domestic markets to international trade and financial flows that have facilitated economic growth and development. However, negative unintended consequences have also ensued. One such consequence is that the market has also opened up to illegitimate and illegal transactions and trade (Peltzer et al., 2010).

Both as an advantageous location for trade, and as an emerging consumer market, South Africa has become an important interim destination for trafficking illegal substances from South America into Africa or South-East Asia (UNODC, 2015; Pithey and Parry, 2006). This channel for trade was historically concealed and far smaller, but as emerging economies become more open to trade, so too does the ease by which illegal substances are able to be distributed to or through their nations increase (UNODC, 2015). South Africa's opportune location in the international distribution of psychostimulant substances is boosted by structural factors such as a favourable location for ease of trade, porous border controls, an overburdened criminal justice system, existent trade linkages, a modern telecommunications and banking system, and socio-anthropological factors such as large diasporas, embedded criminal networks, and visible forms of inequality (Goga, 2014; Pithey and Parry, 2006). In the early 2000s in South Africa, a rapid expansion in the drug economy took place and with it came the rise of newer drugs such as methamphetamine (Pithey and Parry, 2006). It has been observed that South Africa has since developed into the leading market for illicit substances in the Southern African region (UNODC, 2005; UNODC, 2002).

It is likely that drug usage and availability have increased due to the additional pressures placed on society by modernisation and the disruption of traditional family structures (Peltzer et al., 2010). The breakdown of family relationship and deaths at a young age were stressors

found to be common reasons cited for initiating drug-use behaviour (Hobkirk et al., 2016). Unemployed populations and those employed in low-quality jobs tend to show a high prevalence of substance abuse (Hobkirk et al., 2016; Peltzer et al., 2010) and the relationship between unemployment and drug-use is self-reinforcing and, therefore, extremely difficult to break free from (Henkel, 2011). When unemployment becomes embedded as the de facto lifestyle of many people, illegal substances become both a potential economic resource and a psycho-social pivot point. Additionally, it appears that individuals are seeking treatment for drug abuse at an increasingly early age (Peltzer et al., 2010). Hobkirk et al. (2014) find that youth were particularly lured by the appeal of psychostimulant use because of the lack of opportunities for further education, employment and general boredom. This is a concerning finding in light of the self-reinforcing unemployment effect and the disquieting unemployment rate among the youth of South Africa of 67.3% (Statistics South Africa, 2016).

In addition to unemployment, there are a number of other social ills which are generally correlated with high levels of substance use and abuse. The state of drug abuse in South Africa appears to be worsening, with the associated negative implications of poor health, safety risks, environmental risks, low productivity and weak governance, as well as an increased burden placed on the State for law enforcement and medical health care (Howell, 2015; Peltzer, 2010; Watt, 2014).

Howell et al. (2015) observed that drug-related arrests in South Africa are on the rise and are estimated to have increased by 181.6 % between 2004 and 2014. Data from the South African Police Service indicate that the Western Cape recorded the most drug-related arrests in the country (33.2%) which, while not directly indicative of usage trends, provides a strong indication of the prevalence of drug use in the province (South African Policy Service, 2016). An exponential increase has also been observed since 1994 in the demand for drug-related treatment (Peltzer et al., 2010), as well as a shift in preferences for drug type. Most notable has been the rapid increase in methamphetamine as the primary drug of use since its initial appearance in South Africa in the early 2000s (Plüddemann et al., 2008).

2.2. Substance profiles

For the purpose of this research, the focus is narrowed to three substances: methamphetamine, methaqualone and heroin. These substances are associated with major health risks and their use remains highly stigmatised in South Africa. Drugs such as marijuana, which are only associated with minor health risks, are excluded because of the complexity surrounding quality and variety of species available. There are a multitude of marijuana strains available in South Africa, with a wide range of intended and unintended effects. This variation makes it difficult to include marijuana under one umbrella category to represent all varietals. Additionally, marijuana is seen to be more socially acceptable than other substances and is not policed in the same way (Howell, et al., 2015). However, while excluded from this research, it should be noted that there is widespread use and production of marijuana in South Africa. According to treatment centre data, it is estimated that marijuana is the most common primary substance used in South Africa (UNODC, 2014; Peltzer et al., 2010) and that the country is the third largest producer of the substance globally (Peltzer et al. , 2010).

2.2.1. Methamphetamine

Methamphetamine is an illicit psychostimulant substance that, when consumed, produces a feeling of increased energy and euphoria for users of the substance (Paneka, et al 2013). In impoverished settings it has been found to have a high addictive potential. Regular use can lead to severe health problems such as extreme weight loss, tooth decay, and cardiopulmonary complications, as well as an array of mental health problems (Watt, 2014). International studies have found that markets for methamphetamine tend to rely heavily on social relationships. Consumers typically buy from dealers whom they know within residential properties (Rodriguez et al., 2005). It has also been noted that women are more susceptible to the misuse of methamphetamine than men and tend to become reliant on the substance far quicker (Lopez, 2009).

Methamphetamine is also known as ‘tik’ in South Africa due to the ticking sound made when the crystals are heated. Literature suggests that, towards the end of 2005, methamphetamine had eclipsed the use of alcohol in terms of popularity in the Western Cape province, and it was also found that the many users were under the age of 20 (Morris and Parry, 2006). Subsequently, a rapid rise in the use of methamphetamine in the Western Cape has been observed (Hobkirk, et al., 2016; Pasche and Myers, 2012; Pludderman et al. 2008; Peltzer et al. 2010).

2.2.2. Methaqualone

Methaqualone, also known as ‘mandrax’, is a non-barbiturate sedative which was initially thought to be non-addictive and was sold with only basic prescription requirements for the relief from insomnia. However, around the 1970s, the use of the drug for non-medical purposes escalated and users started to report dependence to the substance (Tennant, 1973). The drug is usually taken in combination with another substance, such as alcohol or marijuana, to increase the resultant ‘high’ (Tennant, 1973).

Africa was reported to be the largest market for methaqualone in 2005, with the substance being both produced locally and imported (Odejude, 2006). Around that time, it was the second most popular drug in South Africa (Parry et al., 2004). The substance induces feelings of relief from tension, anxiety and stress in the consumer (UNODC, 2003). It is sold in tablets which are typically crushed and is also frequently smoked together with cannabis (Odejude, 2006; Parry et al., 2004). This combination gives a short-lived rush, including delusions and hallucinations, alongside a loss of bodily control, paraesthesias and the extended feeling of being intoxicated (Odejude, 2006; Tennant, 1973).

2.2.3. Heroin

Heroin, a type of opioid, is thought to be the cause of a larger number of fatalities than any other drug since overdosing is relatively easy (UNODC, 2010). The substance has a high potential for addiction and users experience a rush that comes with a feeling of absence of the mind (Fitzgerald et al. 1999). The substance is injected and is associated with diseases spread through the transmission of viruses through the blood stream; examples include HIV/AIDS and Hepatitis C (UNODC, 2010).

Heroin was not easily accessible in the South African market until after 1994 when the country became more open to international markets, and the its use has been increasing since then (van Heerden et al., 2009). Initially, the substance was very expensive, which precluded the low-income and youth customer segments from purchasing it, but the nominal price has remained flat since the 1990s, resulting in greater access as real prices declined (Peltzer et al., 2010). Data now show that the percentage of treatment admissions for heroin has been increasing from the early 2000s (UNODC, 2010).

2.3. The result of ineffective psychostimulant substance management

The cost to society of the ineffective management of psychostimulant substances as a result of health problems is exacerbated by the overburdened public health resources, which now sees disproportionate numbers of overdose patients and increased transmission of blood-borne viral infections. Examples include the human immunodeficiency virus (HIV) and hepatitis. There is a potential link between drug use and child maltreatment, although the extent of the causality is not fully defined (Barth et al., 2006). The increased burden of the foster-care, as well as medical care for mental health issues resulting from neglect, place further costs on the nation's health system.

Secondly, there is the issue of public safety costs resulting from increased rates of criminal activity associated with illicit substance use (Chandler et al., 2009). These costs may also include safety risks associated with drug usage, such as driving under the influence of drugs (INCJ, 2007).

There are also significant environmental risks associated with the manufacturing and disposal of psychostimulants (Pal et al., 2013; Zuccato and Castiglioni, 2009; INCJ, 2007). Chemical by-products from manufacturing, and chemicals in human waste, contaminate surface and ground water and put other humans and animals at risk. Contaminant levels, in fact, may provide information on the level of community consumption of illicit substances (Zuccato and Castiglioni, 2009; Bones, et al., 2007). Furthermore, the illegal cultivation of plant-based ingredients for drugs tends to result in deforestation and land degradation arising from poor farming techniques (Fjeldså et al., 2005). This is predominantly the case with rural cultivation. However, it is has been observed in some countries that urban cultivation of drugs is also degrading the neighbouring environment and results in a decreased quality of life, and therefore, of property values in neighbouring areas (INCJ, 2007).

The issue of decreased labour productivity is also of concern for economies where drug use is widespread (Shield et al., 2015). Loss of productivity arises as a result of an increase in the likelihood of illness and lowers employability. Individuals using drugs, and participating in the labour force, have been observed to have higher rates of absenteeism, lower productivity on the job and higher safety risks (Frone, 2008). In addition, there is a loss of productivity associated with incarceration. In the United States, the value of lost productivity due to drug use has been estimated at 0.9% of the country's gross domestic product (INCJ, 2007).

2.4. Policy and regulation

Previously, the idea of a 'drug-free world' was pursued, the result of which is that policy makers actively aimed at a complete eradication of the supply and distribution of illicit substances. Currently, restrictions and regulations on the inputs of production of illicit substances are thought to influence the price of these substances by constricting supply. Trade restrictions and regulations on inputs are used to burden suppliers bringing the products to the market. Enforcement is expected to influence negatively both the demand for and supply of these substances, since it makes production and trading increasingly difficult, and it may also discourage users from consuming the illicit substances for fear of prosecution (Caulkins, 2014). Even for the rational consumer, increasing price by restricting supply is expected to deter consumption to a degree; however, the goal of reducing consumption to zero through prohibition is unrealistic. Importantly, appropriate policy approaches are likely to have varying effectiveness across countries and illicit substance markets (Caulkins, 2014).

Collins (2014) explains how, according to theoretical economic dynamics, reducing supply has the potential to induce expansionary effects for the illicit substance industries. Since there is relative ease of entry and exit for merchants, reducing supply in the short term will increase prices temporarily, which incentivises new sellers to enter the market. Over time this will crowd-in in more suppliers, and eventually the market will return to the original equilibrium value. This effect is expected to be intensified for addictive substances since it is argued that users are likely to have relatively inelastic demand curves as they will typically continue to consume these goods, regardless of price increases, while reducing consumption of other goods.

While theoretically plausible, there is very little rigorous evidence available to support this. Prohibition has been, and continues to be, an effective mechanism for keeping wholesale and retail prices high which reduces the quantity of prohibited substances consumed. Nevertheless, the cost of prohibition is extremely high, and the benefits engendered do not always outweigh the costs (Caulkins, 2014).

Alternative policy options to prohibition are sometimes proposed and tested around the world. These include decriminalisation with taxation (Becker, Murphy and Grossman, 2004); harm reduction strategies, and demand reduction strategies (Cockayne and Walker, 2015). An evidence-based approach is proposed to ensure that policies are effective for a nation's local context (Cockayne and Walker, 2015).

2.4.1. South Africa's drug policy

South Africa's current drug policy is outlined in the National Drug Master Plan (NDMP) 2013 – 2017, and implementation of the policies therein is undertaken by the Central Drug Authority (CDA) in terms of the Prevention and Treatment of Drug Dependence Act (20 of 1992) and the Prevention of and Treatment for Substance Abuse Act (70 of 2008).

The previous National Drug Master Plan focused on the criminalisation and prohibition of all aspects of the value chain for illicit substances. This approach has subsequently fallen out of favour with many academics and policy-makers because of the aforementioned imbalance between the costs and resultant benefits (Cockayne and Walker, 2015; Caulkins, 2014). The current policy is in line with the shift towards the use of a threefold strategy of demand reduction, supply reduction and harm reduction.

Demand-reduction strategies refer to actions which reduce the need for illicit substance use by potential end-consumers. This can be done through one or more of the following: poverty alleviation, economic development, education, the provision of alternative substances to reduce drug dependence (Anderson and Kearney, 2000), and psychosocial development (Patel, 2006). Supply reduction targets the availability of illegal substances as well as their precursor chemicals for manufacture. In the case of illicit substances, this may take the form of drug seizures, border controls, crop destruction and manufacturing and distribution centre closures. The restricted supply is thought to increase the price and discourage use, although there is very little evidence on the effectiveness of this intervention (Strang et al., 2012). Harm reduction moderates the damage psychostimulant substances causes to users and communities. This may include reshaping drug markets towards less harmful practices, improving access to treatment, and the rehabilitation and re-integration of substance abusers into society (Caulkins and Reuter, 2010).

The revised NDMP applies these three strategies in its framework and is a vast improvement upon the more punitive approach applied prior to 2013. One significant improvement of the policy is that it has shifted the focus from national interventions to those at a local level, targeting communities which are identified as being highly vulnerable (Howell and Couzyn, 2015; Geyer and Lombard, 2014). The revised NDMP involves numerous stakeholders in the process of mitigating drug abuse and substance-related crimes. These stakeholders include: government departments, the private sector, and special interest groups. Furthermore, there is a clear indication of an intention to bolster the capacity to monitor and evaluate drug policy

interventions. Previously, the only outcome measured was the number of actions taken, but the efficacy of the intervention remained unknown. Four areas will be monitored under the new policy, including performance, organisational capacity, financial performance and community needs (NDMP, 2013; Howell and Couzyn, 2015).

While there are significant improvements from the previous NDMP, the structure of the document is fragmented, overly ambitious and lacks a clear implementation strategy to take the intended policies to the population. A critique of the NDMP framework by Howell and Couzyn (2015) concludes that the plan is full of "internal inconsistencies and impractical resolutions", making its policies difficult to apply. The root of the problem is that the plan appears to take a reformed view of drug control policies, in line with current global thinking, but there are no practical steps to move the system as a whole in this direction. In addition, the involvement of multiple entities in the implementation of the policy has the potential to allow for a loophole to be created, where government itself is absolved from being held to account in the event of failure (Howell and Couzyn, 2015). The authors show that drug policy reforms are likely to merely be lip-service and stakeholders involved in the implementation are likely to find the policies challenging to apply. The criminal justice system will, in all likelihood, continue play a central role in drug enforcement and policing in South Africa, as it did under the NDMP (2013-2017).

3. Applying economic principles to the market for illicit substances

Studies on illicit psychostimulant substance use and abuse encompass a variety of disciplines and analytical methods for the common goal of understanding the manner in which people use and produce these substances. These include disciplines such as ethnography, psychology, epidemiology, criminology, public health, and economics (Ritter, 2006). The variety in approaches has resulted in a diverse, yet unsystematic, knowledge base for understanding drug use behaviour, making policy and intervention design a complex endeavour. Ritter (2006) concludes by stating that "the area of illicit drug markets is ripe for inter- and trans-disciplinary endeavours" (pp. 461) and that such approaches may be able to "transcend disciplinary boundaries in search of new knowledge" (pp.461). The approach taken in this current study is primarily based on the discipline of economics, and the literature reviewed largely falls within this discipline. However, an active effort is made to broaden the

review to include multiple disciplines; therefore, elements of ethnography and criminology also feature prominently.

The following review of the relevant literature synthesises elements of the structure of the drug supply value chain, the economics of drug demand and supply, the sensitivity of consumer demand, and the importance of individual transactions, and concludes with a note on the complexity of studying drug markets.

3.1. The demand and supply of illicit substances

The economic approach to analysing the drug consumers and producers operates under the assumption that illegal markets behave, in many ways, similarly to legal markets for goods and services (Collins, 2014; Ritter, 2006; Caulkins, 2006). Theory of the firm (Levitt and Venkatesh, 2000) and demand-supply interactions have been observed to be able to capture some of the characteristics of the illicit psychostimulant market (Caulkins, 2006; Ritter, 2006; Moore et al., 2005). The discipline of economics is particularly convenient for studying markets of illicit goods, due to its rigorous taxonomy of market structures and associated theories. This provides an organised framework in which to coordinate a relatively chaotic body of work (Ritter, 2006). However, in many cases there are deviations from the elementary market conditions resulting in interesting but unexpected outcomes (Caulkins and Reuter, 2006).

One of the primary deviations from traditional markets is the idea of rational, self-interested agents with lexicographic preferences – also referred to as *homo economicus* – which is often assumed in theoretical models, but seldom observed in empirical data of illicit substances user behaviour (Bowles and Gintis, 1993). Departures from the theory of consumer optimisation occur in most markets for products and services, and may be heightened for consumer behaviour in the market for illicit substances (Beckert and Wehinger, 2013; Sandberg, 2012; Caulkins, 2006; Coomber, 2003). Furthermore, even suppliers of illicit substances have been observed to behave in a manner entirely unreflective of profit-maximising behaviour (Sandberg, 2012; Caulkins and MacCoun, 2003; Levitt and Venkatesh, 2000).

A further dissimilarity which distinguishes the economic analysis of illegal psychostimulant markets from the economic analysis of normal goods is the centrality of an unobserved quality to the product (Caulkins, 2006) which results in something similar to Akerlof's (1970) 'market for lemons' (Dwyer and Moore, 2010). The quality or purity of experiential goods,

such as drugs, is not observable by the consumer until they consume it and consumers cannot request a refund once consumed. Furthermore, poor quality is not uncommon owing to the practice of diluting, or cutting, drugs with cheaper substances (Lakhdar, 2013).

Nonetheless, economic theory remains useful for understanding the market for drugs, although inconsistencies ought to be considered. Firstly, the value chain from cultivation to production to distribution is similar to that of a traditional corporate firm. The structure of the 'firm' or the supply behaviour is relatively unknown, but has been clarified to some degree through studies such as that of Caulkins et al. (1999) and Levitt and Venkatesh (2000). These authors observed a hierarchical supply chain structure with some central leaders and 'traffickers' coordinating the supply chain, which culminates in street sale transactions performed by foot-soldiers, entrepreneurs or dealers. Dealers are more easily identified in this chain because they make their livelihood selling drugs in public places. Dealers typically sell in small quantities to end-consumers, obtaining their wares on either consignment terms, in exchange for a salary, or from suppliers in order to trade independently (Caulkins et al., 1999).

The framework of supply and demand in economics also provides a convenient framework for interpreting market outcomes, such as the drug price and consumer behaviour. Many authors have noted that the market price of psychostimulant substances is largely determined by similar market forces as the market price for licit goods (Reuter & Haaga, 1989; Ritter, 2006). Furthermore, this framework provides a theoretical backdrop to any attempt to determine causality between a drug policy and any subsequent shift in drug market outcomes (Reuter, 2010).

The fundamentals of the discipline of economics are formed upon the assumption of a capitalistic market in which prices are a function of the relationship between quantities demanded and supplied. When the quantity demanded is in excess of supply, price typically rises; conversely, when the quantity demanded is exceeded by supply, prices tend to drop. In essence, markets play catch-up towards equilibrium, where the quantity supplied is equivalent to the quantity demanded (Henderson, 1922). Shifting the market away from its equilibrium state requires a change, or 'shock', in one or more external factors which influence suppliers or consumers. In the medium term, once markets are given sufficient time to adjust, negative shocks to supply, such as an increase in input price, theoretically increase the equilibrium price for a normal good and decrease the quantity of that good that is supplied

to the market, provided all other factors remain the same. Negative shocks to demand, such as a shift in tastes and preferences away from a particular product, should theoretically reduce the equilibrium quantity demanded and, once markets have adjusted, increase the price (Henderson, 1922). These shocks and their subsequent impact on market equilibrium are relatively well understood, albeit that *ceteris paribus* does not hold in real life, in the market for normal goods. However, in the market for illicit goods, the appearance of shocks and the mechanism by which they affect price and consumption is relatively less understood and, therefore, various methods have been applied to the limited data available on illicit markets, in an attempt to map the mechanisms by which supply and demand of these goods can be altered.

3.2. Illicit substance elasticities

The extent of positive and negative shocks to the quantity demanded is commonly determined through a calculation of the elasticity of demand, which is a measure of how sensitive consumers are to changes in the price of a particular product. Inelastic demand implies that consumers do not significantly change the quantity of a particular product or service which they consume when that product or service changes price. Elastic demand implies that consumers are very sensitive to price changes and will significantly change the quantity of a particular product or service consumed when there are changes in the price of that product or service.

For highly stigmatised drugs such as methamphetamine and some opioids, the calculated demand elasticity is consistently negative across a number of studies, although the extent of the responsiveness - whether price elasticity of demand is elastic or inelastic - varies across studies (Olmstead et al., 2015; Saffer and Chaloupka 1999; Roddy and Greenwal, 2009; Ramful and Zhao 2009; Chalmers, Bradford and Jones, 2009; Bretteville-Jensen, 2006). The addictive property of these substances has been hypothesised to result in asymmetric elasticities being observed where the responsiveness to price is higher for declining prices than for increasing prices (Bretteville-Jensen, 2011).

In a study conducted in Australia, Marijuana - a socially ubiquitous substance - has been shown to be price inelastic at present prices for the overall consumer base, but significantly elastic for poly-substance drug users who also consume marijuana. The rationale for this is that ‘hard’ drug users experience an ease of substitution when using marijuana as one of the

multitude of drugs in their consumption portfolio, as they are likely to be more dependent on 'hard' drugs, which are typically more addictive (Ramful and Zhao, 2009).

The overall reduction in the quantity demanded for a particular illicit substance as prices increase is potentially due to a net reduction in consumption, but may also be a result of a substitutionary effect. Consumers potentially substitute their consumption of one substance with another (Chalmers, Bradford and Jones, 2009) or find more efficient means of consumption; for example, by obtaining psychoactive effects through injecting heroin as opposed to smoking it (Bretteville-Jensen, 2011).

Cross-price elasticity measures the responsiveness in quantity demanded of one product to a change in the relative price another product. Few studies have measured cross-price elasticity of the demand for various drugs and their results differ based on which two drugs are being compared. Whether poly-drug users consume a plurality of drugs in a substitutionary or complementary manner is unclear from available determinations of the cross-price elasticity of demand (Bretteville-Jensen, 2011; Chalmers Bradford and Jones, 2009; Saffer and Chaloupka, 1999).

The variation in elasticities between studies is likely to be a result of difficulties in obtaining sound, comparable data on drug use and production, as well as the differences prevalent in the demand behaviour across consumer groups (Caulkins 2006, Lahaie et al, 2014). This behaviour is influenced by a combination of inconsistent behaviour among drug suppliers (Coomber, 2003) and asymmetrical information between transacting agents (Dwyer and Moore, 2010).

In addition to the aforementioned elasticities, a further indicator that is of interest in studies of illicit substance consumption is the participation elasticity. This indicator is also frequently used in labour economics to determine a change in the participation rate of the labour force with respect to a shift in factors affecting wage rates (Eissa, Kleven, and Kreiner, 2008). The participation elasticities for illicit substances provide the change in initiation rates as a result of price shifts, decriminalisation, and penalty implementation or enforcement. The initiation of marijuana use and the use of 'hard' drugs has been observed to be negatively influenced by a shift in the price of heroin (Ramful and Zhao, 2009; Saffer and Chaloupka, 1999). Pacula et al. (2010) summarises the participation elasticity of marijuana use for a shift in price, decriminalisation, and penalties and their enforcement. Penalties and decriminalisation were observed to be less effective in influencing participation than price and police enforcement

(Pacula et al., 2010). Participation elasticities for addictive substance are limited in that it is not possible to separate the effect of an increase in first-time users from a reduction in 'quitters' (Bretteville-Jensen, 2011); however, studies using duration models that are able to account for the two factors have resulted in findings similar to studies using simple participation elasticities (van Ours and Williams, 2007; Melberg et al., 2010).

3.3. Initiation into the illicit substance economy

It is important to understand the determinants of psychostimulant substances in order to curb demand, and more specifically, youth psychostimulant use. Six major contextual factors influence the use of these substances, namely: drug availability, the norms around drug use, the availability of socio-economic opportunities (Hobkirk et al., 2016; Norman et al, 2010), educational environment, and individual and family factors (UNODC, 2015).

The availability of psychostimulant substances has been shown to influence the decision to begin consuming these substances (Hobkirk et al, 2016; Caulkins, 2014). This finding has been the foundation for many policies aimed at reducing the supply of psychostimulant substances so as to curb the use and, thereby, diminish associated harms to society (Moore, 1990; Reuter and Kleinman, 1986). These policies have recently fallen out of favour due to their high cost with limited effectiveness and even harm to society (Collins, 2014). Reasons for the limited effectiveness may include the other drivers of drug initiation, which perpetuate the use of drugs despite supply-side enforcement.

Qualitative studies, aimed at understanding the attitudes of drug users, note that a desire to 'fit in', or influence from friends, partners or even family, may also catalyse the process of drug initiation (Anderson, 2001; Hobkirk et al., 2016). Social norms and the acceptance of illicit behaviour make it more acceptable to initiate drug consumption behaviour. A number of studies also show that psychostimulant substance initiation for many users is for the purpose of mitigating trauma or distress (UNODC, 2015; Lakhdar, 2013; Norman et al, 2010).

The lack of socio-economic opportunities, such as employment, educational institutions and recreational facilities, are also major contributing factors to the use of illicit substances. A developmental approach to drug use prevention seeks to control drug consumption through a targeted improvement in the aforementioned areas. This approach is gaining popularity and there is an initial body of evaluation work indicating the potential for success using this approach (UNODC, 2015).

Initiation of drug use differs between individuals and has been noted to differ particularly along gender lines. Women tend to begin using illicit substances later than males (UNODC, 2015) and their drug careers are more likely to be initiated through their relationships with men (Anderson, 2001). Bretteville-Jensen (1999) disaggregates the elasticity of demand for drugs by gender and found that females also tend to have a higher price elasticity of demand than males. The differences are thought to occur because of the way women are viewed in society, as well as the dissimilarities in opportunities afforded to women in comparison to men (Anderson, 2001).

Kandel et al. (1992) theorised that there is an underlying pattern which describes how drugs are initiated. This pattern of initiation tracks a pathway through the various categories of drugs. The authors suggest that substance users begin with the use of licit substances (alcohol and cigarettes), then progress to marijuana – a more socially acceptable substance – then to illicit drugs other than marijuana and, finally, to medically-prescribed drugs. This was termed the 'gateway effect'. Individuals using 'hard' drugs are thought to have been introduced firstly to substances that are not as harmful as hard drugs and are more easily accessed. However, there is the potential for other factors such as gender, age of initiation, frequency of use and even hidden factors such as 'unobservable propensity towards substance abuse' to influence whether or not an individual initiates hard drug consumption (Kandel et al., 1992; Yamaguchi and Kandel, 1984). This theory has subsequently been contested.

Although socially acceptable substances such as tobacco and marijuana have been shown to be significant predictors for later use of more stigmatised substances, the causality of this effect remains unclear (Phillips, 2015; Fergusson, Boden and Horwood, 2006; Bullock et al., 1998). Separating causality from correlation in this context proves to be extremely difficult. Using a multivariate analysis approach, it has been shown, in some cases, that marijuana use is a significant predictor for the initiation of harder drugs (DeSimone, 1998; Pacula 1998; Kenkel, Mathios and Pacula, 2001). Multistage approaches to this problem that account for unobserved heterogeneity also find evidence in support of the gateway drug theory (Bretteville-Jensen et al., 2005). However, Degenhardt et al. (2010) show that the gateway hypothesis may not be wholly representative of true initiation patterns and it is in fact the availability of substance that is the main influencer on drug initiation by type.

3.4. The role of one-on-one transactions and social capital

It has been mentioned that individual factors have a significant role to play in the decision to initiate psychostimulant substance use (UNODC, 2015). The individual characteristics of drug consumers influence not only the decision to initiate, but also their negotiation and consumption behaviour (Lahaie et al., 2015). Furthermore, suppliers of illegal psychostimulants have the power to leverage price variations and information asymmetries to their advantage, and tend to do this on a customer-by-customer basis (Dwyer and Moore, 2010). This potentially makes the market more efficient, as buyers are paying amounts closer to what they are willing to pay; in other words the market nears first-degree price discrimination (Stole, 2007). Therefore, the ability to understand the heterogeneity observed amongst drug consumers will bring us a step closer to understanding the drug market as a whole.

Drug markets are unique in that sale transactions occur on a very personal basis with drug dealer and drug user interacting and negotiating deals in person. As Arlacchi (1998, pp.208) puts it, "illicit markets may be distinguished from licit markets by their failure to adopt impersonal forms or intentional communication and distribution of goods". Individual interactions are also important in determining a price for the drug being sold, as observed in numerous studies, where observed prices fluctuate according to an underlying factor of the social relation between buyer and seller (Ouellet and Morselli, 2014; Dwyer and Moore, 2010; Lopez et al., 2009; Bohnert et al., 2009; Coomber and Maher, 2006; Lee, 2004; Denton, 2001). Sellers have also been observed to deviate from profit-maximising behaviour to those whom they know are in less fortunate economic circumstances than themselves (McKenna, 2014; Dwyer and Moore, 2010). The ability to obtain more favourable terms of purchase is referred to as social capital throughout the remainder of this paper. Social capital is defined in a multitude of ways for different contexts. In the context of individual transaction between drug users and drug dealers, it can be defined as "a resource that actors derive from specific social structures and then use to pursue their interests; it is created by changes in the relationship among actors" (Baker 1990, p. 619).

Aside from social capital, it has been found that quantity purchased is a major influencer of the final price paid at the individual transaction level (Lahaie et al. 2015; Caulkins and Padman, 1993). Authors observe as much as a 2.3% reduction in price for every 10% increase in the transaction (Lahaie et al., 2015). While bulk discounts may be available for certain customers, the majority of consumers still tend to buy illicit substances in small quantities.

This is typically due to cash constraints (especially in the case of impoverished consumers) or because a dealer was not willing to sell a larger quantity due to the risk of carrying large quantities in the context of law enforcement (Chalmers and Bradford, 2013).

The illicit substance market is similar to Akerlof's (1970) 'market for lemons' which explains the dynamics within a market where sellers have more information about the product being sold – in Akerlof's case used cars – than the buyer. In essence Akerlof shows how in such a market, sellers of poorer quality "lemons" maximise profits by claiming to sell a high quality product. Buyers, with the inability to observe quality, will be willing to pay an amount less than the value of the high quality product because they will factor into the price the risk that the product being purchased is of low quality. The resulting market price favours sellers of low quality products drives out sellers of high quality goods. Similarly in illicit substance markets buyers have no way of knowing the exact quality until the product has been consumed. In legal markets information asymmetries can be overcome by regulations and institutions, but due to the illegitimacy of drugs, purchasers cannot be protected from unfair pricing. Price is, therefore, not a good indication of quality since it is in the best interest of dealers selling low purity drugs to take on the appearance of selling high purity drugs (Ouellet and Morselli, 2014; Caulkins and Padman, 1993).

Another price gradient typically occurs between geographic regions. Caulkins (2006) argues that this is largely due to the inability of information on illegal goods to travel easily between regions, as well as to transport costs. This is not entirely dissimilar to markets for legal goods. As with oil and gas markets, drug prices have also been found to correlate positively to the distance from the supply source (Lahaie et al. 2014). The exaggerated barriers to information flows observed in markets for illicit goods may also contribute to the distinctness of price across regions (Caulkins, 2006). Price differentials in legal markets exist between countries and cities (Hassink and Shettkat, 2003), although there is opportunity for arbitrage over smaller distances.

As previously mentioned, social relationships play a substantial role in the transactions between buyers and sellers of illicit goods. Dealers prefer to attract a customer base of good customers – those regularly purchasing and paying the asking price – and, therefore, offer different price schedules to these customers than to customers approaching a dealer intermittently (Dwyer and Moore, 2001). Repeat customers are, leading to a mutually beneficial outcome for both buyer and seller (Beckert, 2013).

Longstanding clients are favoured in order to overcome the problem of asymmetrical information present in the market for illicit substances (Lahaie et al., 2015; Ouellet and Morselli, 2014; Beckert and Wehinger, 2013; Chalmers and Bradford, 2013; Lakhdar, 2013; Dwyer and Moore, 2010; Coomber, 2003). Dealers prefer regular clients because of the reduced likelihood that these consumers are undercover law enforcement officials, violent or poor payers (Chalmers and Bradford, 2013; Dwyer and Moore, 2010; Coomber, 2003). It also allows dealers to sell their wares faster and with greater certainty, which allows for pre-planning. For this reason, sellers may incur an upfront loss (for example, providing free drug samples of a high quality) to customers to assure them of a high-quality product (Lakhdar, 2013). This behaviour is in line with Akerlof's (1970) proposed solution to the 'market for lemons', which would involve a costly signal to the market to expose the quality of a seller's product.

Consumers concerned with issues of quality and price would also rather return to drug dealers they can trust when purchasing illicit substances (Dwyer and Moore, 2010). In a market where quality is important, yet unobserved, consumers can use longstanding relationships to provide greater certainty as to the quality of product they will receive. Furthermore, search costs for drugs dealers are high because of the enforcement and quality risks (Caulkins, 2006) and, therefore, efficient consumers locate a preferred dealer (often with a series of backups for when they are unavailable) and repeatedly return to them for future purchases (Lahaie et al., 2015; Chalmers and Bradford, 2013; Beckert, 2013). Their loyalty is typically rewarded with a more stable quality, priority access, better prices, offers of credit, and bulk discounts (Lahaie et al., 2015; Chalmers and Bradford, 2013; McKetin et al., 2005; Coomber, 2003). The importance of reciprocity is exaggerated for markets where agents are economically and socially vulnerable (McKenna, 2014).

The transactional differentials occurring between groups are often a result of inefficiency mitigation discussed above. Certain observable characteristics have been identified by sellers as indicators of a likely 'good' customer exhibiting favourable behaviours such as on-time payments and peacefulness (Lakhdar, 2013). First, a consistent source of income is preferred because it increases the reliability of payment. This is especially important in drug markets located in impoverished areas. For example, sellers have been observed to compete for customers receiving regular social transfer payments (Anderson, 2005). These payments are often received by women. Furthermore, women are perceived to be less sporadic with their expenditures and sources of finance, and they are also less violent in trade negotiations.

These factors combined make women favoured customers in many drug markets, as dealers assume if a potential customer is female that this is a signal for good customer behaviour (i.e. they pay on time and are non-violent(Anderson, 2005).

3.4.1. Rationales for inconsistent prices

To recapitulate, in the economic literature on the market for illicit substances, five key explanations for the inconsistencies in illicit substance purchase prices arise. First, that drug dealers are thought to charge higher prices on a transaction if they believe that the customer is not aware of the going price for a particular substance. Effectively there is a degree of price discrimination taking place where dealers, because of the one-on-one transactions, are able to extract a greater surplus from clients according to their willingness-to-pay (Dwyer and Moore, 2010; Stole, 2007). Secondly, there is evidence that dealers do not always act as perfectly rational profit-maximising agents. They are, in fact, commonly influenced by social relationships with their customers. Thirdly, there may be non-monetary costs which consumers incorporate in their willingness-to-pay. These costs may differ between individuals (Caulkins, 2006). Fourthly, some consumers may be able to negotiate more effectively than others (Lahaie et al., 2015). Lastly, consumers often use bartering tactics to obtain drugs. Therefore, the price may not include the full value transferred in exchange for illicit substances (Dwyer and Moore, 2010).

3.5. Difficulties with drug-use data

Due to the illicit nature of psychostimulants, obtaining accurate information from consumers or producers is very difficult and the risk of bias within the data is high. Social desirability bias is inescapable in drug-use studies (Van de Mortel, 2008; McGilloway and Connelly, 2004), as well as the sampling bias resulting from uncovering hidden populations involved in illegal behaviour. While many purists may feel that this leaves studies with such data unworkable, others argue that there is a wealth of knowledge available in such studies, but that the data need to be approached carefully with bias-mitigation techniques, so as to avoid misinterpretation (Caulkins, 2006).

4. Empirical data

The empirical data upon which the findings of this research are based come from a multi-site, mixed-methods approach, which culminated in data sampling using RDS, to accessing hidden populations of poly-substance users in Cape Town. A detailed discussion of the data-

sampling process for the dataset used in the current research is outlined by Burnhams et al. (2016).

Around the world, such data would usually be collected from arrestees or drug-users who seek treatment, which would result in innately biased samples since there is likely to be a pool of users who are never reached. Data on drug usage and prices are most commonly extracted from 1) undercover agents and informants – such as the United States Drug Enforcement Administration's (DEA's) System to Retrieve Information from Drug Evidence (STRIDE), 2) self-reported data from individuals in treatment centres, and 3) data from arrests and drug seizures (Caulkins, 2006). Notable selection bias is associated with all three of these techniques as is typical when sampling individuals involved in illegal or stigmatised activities, as potential respondents fear prosecution or further stigmatisation. To overcome this, sampling techniques have been developed that leverage the trust found in social relationships to overcome the inhibitions which potential respondents may have. This technique is broadly called chain referral sampling, as respondents refer other individuals from their networks to increase the sample size in a chain-like formation. One such chain referral technique is respondent-driven sampling (RDS) which is used in this research and discussed in more detail in the following section.

4.1. Respondent-driven sampling

The data sampling process used in this research is a respondent-driven sampling (RDS) process developed by Heckathorn (1997). This sampling process uses the recruitment of a set of known individuals ("seeds") from a targeted population who are given incentives to recruit additional respondents from their social networks. The recruiting process repeats iteratively, with the recruited individuals then becoming the recruiters, until the desired sample size is reached (Shonlau and Liebau, 2012). The strength of the RDS approach is that it is able to mitigate the potential biases within the subsequent recruitment groups in a more efficient manner than other methods used in the research of hidden populations, such as snowball, key informant and targeted sampling (Heckathorn, 1997).

During the initial seeding stage, respondents are selected using information about existing networks of drug users. The seeds represent a non-random sample since they all carry some trait making them identifiable to fieldworkers – usually as individuals who were arrested or treated. As an example, for samples of HIV-positive individuals, the initial seed may potentially come from a hospital's historic records of individuals seeking treatment for HIV.

Therefore, the seeds all took active steps to find treatment for their illness and such an attitude may indicate someone with a greater desire to get well and who is more proactive about improving his or her situation. These respondents are also less likely to be secretive about belonging to the target population (Heckathorn, 1997).

The social network of a drug user is important as it is the means by which users are initially exposed to the drug market and the use of drugs is continually influenced by an individual's social network which continues to play an important role in accessing drugs (Ouellet and Morselli, 2014; Dwyer and Moore, 2010; Lopez et al., 2009; Coomber and Maher, 2006; Denton, 2001). A clear source of potential bias arises in that individuals with larger social networks have a greater likelihood of being included in the sample. For this reason, techniques are applied to mitigate the influence of network-size bias on the data sampling process (Shonlau and Liebau, 2012; Volz and Heckathorn, 2008; Heckathorn, 1997). A further source of bias arises from the tendency of respondents to recruit individuals who are similar to themselves. This is known as homophily bias.

Solutions for deriving population proportions which moderate the effect of homophily bias make use of *Markov chain theory* to estimate the stochastic process underlying the recruitment outcomes. To illustrate this, in the situation where a population has two key sub-populations, *m* and *n*, the likelihood of a recruiter in sub-population *m* recruiting individuals from either *m* or *n* can be estimated based on the number of times recruiters in group *n* recruit individuals from group *m* (S_{nm}). Together with the following assumptions, the proportion of each sup-population in the broader population may then be estimated.

There are five basic assumptions underlying the RDS analysis technique. The first assumption is that there is reciprocity, such that if individual *n* recruits individual *m*, that recruitment is just as likely to have occurred the other way around. The second assumption is that respondents are networked, as discussed above; this is likely to be the case as individuals use their network to source drugs.[1] The third assumption is that respondents are able to report accurately on the size of their network within the target population. Fourthly, the RDS process assumes that there is random recruitment and that recruitment is efficient. Lastly, for the use of *Markov chain theory*, it is assumed that the value of any category group among

[1] There is a third assumption of 'sampling with replacement'; however, researchers suggest that this assumption can be ignored since the sample is a very small fraction of the total population.

those recruited depends on the previous recruiter only (and not the recruiter's recruiter). This simplifies the theoretical model to a single-period transition matrix which is used to model the recruitment process.

In order to determine the number of links stemming from members of a category group, the number of respondents in that group (N_i) is multiplied by the average network size within that group (D_i). The transition matrix is then created by using the proportion of linkages in group *n* of the sample that connect to individuals in group *m* (this is denoted by S_{nm}) and multiplying this by $N_m D_m$. The assumption of reciprocity implies that the number of links going from group *m* to group *n* is the same as the number of links going from group *n* to group *m*.

(1) $$N_m D_m S_{mn} = N_n D_n S_{nm}$$

The above equation shows the total number of linkages between the two groups. Dividing both sides of (1) by the total number of individuals in the sample as a whole (N) gives:

(2) $$P_m D_m S_{mn} = P_n D_n S_{nm} \quad \text{where} \quad \sum_i^N P_i = 1$$

P_m and P_n are the population proportions of group *m* and *n* respectively. In the case of only two category groups, the two equations with two unknowns can be solved in a relatively straightforward manner. In the case where there are more than two group categories, the system of equations is over-determined. Parameters can be estimated using either least squares or the data smoothing method detailed by Heckathorn (2002). For the two category case, (2) can be solved to give *n*'s population proportion:

(3) $$P_n = \frac{D_m S_{mn}}{D_m S_{mn} + D_n S_{nm}}$$

Equation (3) provides the basis for an estimator for population proportions which is calculated using the linkages between groups (S) and average network size per group (D).

(4) $$\widehat{P}_n = \frac{\hat{D}_m \hat{S}_{mn}}{\hat{D}_m \hat{S}_{mn} + \hat{D}_n \hat{S}_{nm}}$$

Equation (4) is used to estimate the population proportions of demographic groups of poly-substance users in section 7. For more complex analysis of the price of illicit substances,

individual weights are given to each respondent to adjust for network-size bias. There is no basis for controlling for homophily bias in continuous data.

To calculate the individual weights the following formula is used:

(5) $$W_x = \frac{P_x}{C_x}$$

Heckathorn (2007) shows how the above equation can be separated into a component controlling for recruitment between groups and a component controlling for network size.

(6) $$W_x = \frac{\hat{P}_x}{C_x} = \frac{\hat{P}_x}{\hat{E}_x} \cdot \frac{\hat{E}_x}{C_x} = DC_x \cdot RC_x$$

With this separation, the degree component (that controlling for network size) can be formulated based on a mechanism whereby individuals with high network sizes are expected to be oversampled and those with small networks under sampled. To mitigate for any oversampling due to an individual's large network size, DC_x would need to be deflated. The opposite applies to undersampling. The degree component is thus inversely related to network size.

(7) $DC^i = K \cdot \frac{1}{D_i}$, where K is a positive constant

Substituting (7) into the original individual weight calculation (5) produces a multiplicity adjustment which can be used to mitigate the effect of network size. This weight is a function of an individual's network size (D_i) and a recruitment adjustment (where applicable).

(8) $$W_x = K \cdot \frac{1}{D_i} \cdot RC_x$$

Heckathorn (2007) shows how the estimation of population proportions is equivalent when formulated at an individual or group level. For continuous data, adjustments due to cross-ties between groups are typically nonsensical. Because of this, only the degree adjustment is used. The estimated proportions using these weights are sometimes referred to as Volz-Heckathorn or RDS II estimated proportions.

When using group level estimates (RDS I), Schonlau and Liebau (2012) recommend using bootstrap standard errors for use when calculating population proportions. For the analysis using the multiplicity adjustment, Sandwich (White) robust standard errors are used to control for heteroscedasticity. Unweighted regressions are shown in the appendices since the

decision to use weights is not straightforward and comes at the expense of precision (Ramirez-Valles et al., 2008).

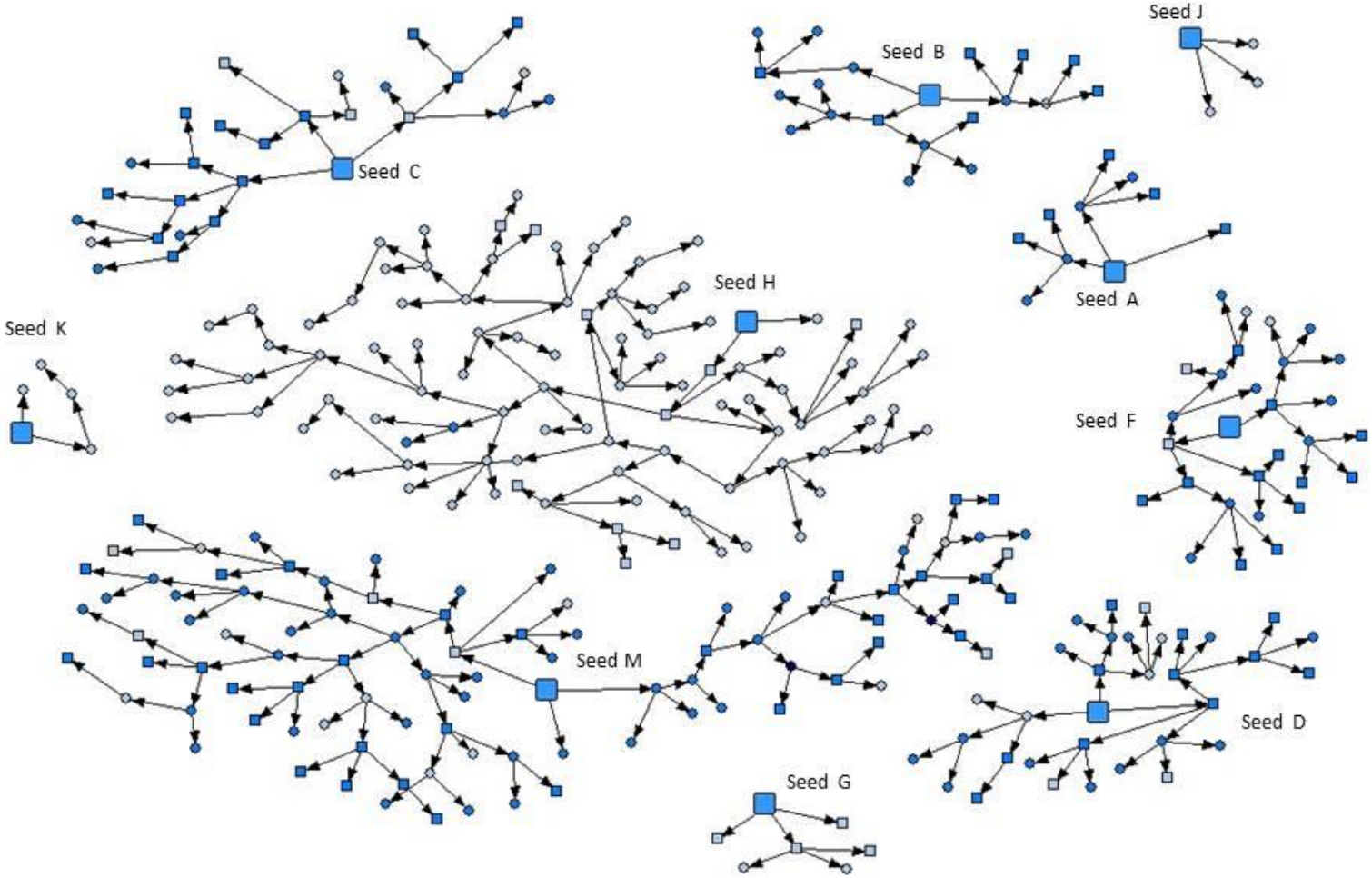
4.2. Data sampling process

As a precursor to the data sampling process, focus group discussions (FDGs) were conducted with known poly-substance users in order to determine the feasibility of the RDS approach for the local context of the target population. The FDG participants were selected from three regions in the Western Cape, namely Delft, Greenpoint and Khayelitsha. The participants had to have resided in one of these areas for a minimum of one year to be eligible for the survey sample. They were also required to be self-identified poly-drug users and have used one of the six identified drugs upon which the study was based, in the past seven days. Use of psychostimulant substances within the past seven days was confirmed through biological verification. This approach has been successfully used in two previous studies of hidden population groups in South Africa (Kimani et al., 2014; Rispel et al., 2011).

The second phase consisted of a field-worker assisted, computer-based survey with a larger sample group (n=337) that was recruited through a RDS process, using the FDG participants as the 12 initial seeds. The overall coupon response rate – the proportion of distributed coupons to redeemed coupons – for the RDS process was 42.5%. The recruitment process was successful in identifying respondents that could not have been accessed through the traditional channels of treatment centres and arrest-data. In the current dataset, there are 178 individuals – ie. (53 %) - that had not previously sought treatment or been arrested.

One limitation was that the incentive to participate and recruit was not large enough to encourage middle- to high-income respondents. Seeding respondents from these population groups was also difficult due to scepticism about anonymity, and a lack of interest (Burnhams et al., 2016).

The recruitment chains developed from the initial seed respondents are shown in figure 1. This diagram shows that there were two were highly productive seeds, while another two did not recruit any further respondents (not shown). In Greenpoint and Khayelitsha, recruitment was dominated by a single seed.



Gender	
Male	
Female	

Race	
Coloured	
Black African	
Indian	
White	

Seeds	Gender	Race
A	Male	Coloured
B	Male	Coloured
C	Female	Coloured
D	Female	Coloured
F	Female	Coloured
G	Female	Coloured
H	Male	Coloured
J	Male	Black African
K	Male	Black African
M	Female	Black African

Figure 1 Diagram of the recruitment network from the respondent-driven sample

Source: Burnhams et al. (2016)

4.3. Descriptive analysis

The three sites, from which respondents were sampled, were chosen because of their socio-economic and ethnic dissimilarities, providing a relatively representative sample of all the various social groupings in the Western Cape region. The recruitment dynamics between the three sites show that these sites are also socially distinct. As shown in table 1 below, respondents typically do not recruit from outside of their local regional context.

Table 1 Respondents' recruitment patterns between sites[2]

	Recruited from			
Respondent's location	Delft	Greenpoint	Khayelitsha	Total
Delft	119	0	0	119
Greenpoint	31	71	0	102
Khayelitsha	0	0	104	104
Total	150	71	104	325

Greenpoint is the only anomaly to the intra-regional recruitment observed by the recruitment patterns across the various sites and appears to have some network links to Delft. The table shows that 31 respondents from Greenpoint were recruited by participants in Delft. The recruitment behaviour shows that the social networks of the recruits do not typically extend across regional boundaries, except in the case of Greenpoint and Delft.

The extent of drug use across the sites is reflected in the external drug-related arrest data from the South African Police, shown in table 2 (South African Police Services, 2016).

Table 2 Drug-related arrests per station in the Western Cape for 2015/2016

Location of SAPS Station	**Number of drug-related arrests**	**Drug related arrests as a percentage of all arrests by station**
Delft	3 035	34.14%
Seapoint (serves Greenpoint)	798	18.54%
Khayelitsha	827	10.54%

[2] Seeds are excluded.

The number of drug-related arrests is highest in Delft. While it may appear that drug use may be higher or more problematic in this area, such an inference simply from arrest data is difficult due to the cross-regional movement of individuals between station territories, the extent of police activity and a bias associated with the observability of substance users which is reflected in arrest datasets. For example, Caulkins (2007) warns that observations in arrest data may reflect a higher proportion of individuals partaking in 'risky' transactions such as those outdoors with street merchants rather than a reflection of actual sale and consumption. Therefore, while the number of arrests in Delft is far higher than that of the other areas, there is insufficient evidence to conclude that this is indicative of an increased prevalence of drugs.

Taking a closer look at the demographic and socio-economic makeup of each of the sample regions, it is clear from a cross-tab of race and site that race is closely associated with region.

Table 3 Number of respondents per race category at each site

SITE	**Race**			
	Coloured	**African**	**Other**	**Frequency**
Delft	109 (86.5%)	16 (12.7%)	1 (0.8%)	126
Greenpoint	77 (74.8%)	20 (19.4%)	6 (5.8%)	103
Khayelitsha	2 (1.9%)	106 (98.1%)	0 (0.0%)	108

As a result of the historical system of apartheid, there are observed racial clusters within regions in South Africa. It is clear from table 3 that each region tends to be almost homogeneous with respect to race, except for Greenpoint, which has greater variation in its race profile. The 'other' category includes Caucasian individuals and foreigners; these individuals are clearly underrepresented in the sample. None of the respondents identified themselves as being 'Indian'. African individuals are also underrepresented in the sample from Delft; according to national population estimates, 46.2% of Delft residents are Black African (Burnhams et al., 2016).

Females constitute 35.9% of the sample, which is a higher proportion than reported in other studies. Treatment data for South Africa in 2006 showed women that made up 19.1% of all admissions into treatment centres (SACENDU, 2006). When disaggregated per drug type, females continue to be less likely to use substances. The ratio of male to female drug users is 10:1 for cannabis; 5:1 for mandrax/sedatives; and 3:1 for amphetamines/club drugs (Peltzer et al., 2010; Shishana, 2006).

The mean monthly income is R746.11 (approximately US$48.33). The range of income (R0 – R 10 000 per month) indicates a sample of low-income earners relative to the broader population of South Africa. As previously discussed, the incentive structure of the data sampling process largely excludes wealthier individuals from the final sample. It is evident that respondents have very little disposable income each month and, therefore, it is probable that economic decisions for these individuals become exceedingly important due to the constraints of scarcity (Banerjee and Duflo, 2007). This sample also precludes any significant influence of substance distribution via the internet.

The level of income which identifies an individual as being in poverty is a contentious issue and a range of estimates have been put forward. The most recent calculation of the poverty line for South Africa is R1 319 (Budlender et al., 2015), which is determined by calculating the money needed to meet minimum daily energy requirements over a month. This figure of basic subsistence living is far higher than the mean income level of the sample and classifies 85.4% of the sample as being 'poor' according to this definition. There is a clear exclusion of wealthy individuals who use drugs in the current data.

The proportion of employed individuals within the sample is 44%; this includes self-employment and part-time employment. The remaining 56%, with no form of employment, rely on other sources of income for survival, such as support from friends and family, income from illegal sources, grant receipts, and money from ad hoc jobs and begging, also known as 'skarrel'.

Within the sample, 62% of the individuals are likely to be highly addicted substance users. This is determined using the CAGE statements included in the questionnaire. The CAGE tool is a very simple and useful tool for a quick indication of substance addiction (O'Brien, 2008; Ewing, 1984). Respondents were asked the following questions, adapted from the CAGE tool:

(1) Have you ever felt you should **cut down** on your substance use?
(2) Do you get irritated (**annoyed**) when people speak badly about your drug use?
(3) Have you ever felt bad or **guilty** about your substance use?
(4) Have you ever engaged in substance first thing in the morning to steady your nerves or get rid of a downer (**eye-opener**)?

The respondents were able to answer 'always', 'sometimes' or 'never' to the CAGE statements. The high addiction variable considers an affirmative answer to be 'always'. It is generally accepted that a positive response to two or more of these questions is an indication of a potentially problematic substance-user (Ewing, 1984). Therefore, the variable for a high intensity of use indicates that respondents answered in the affirmative for two or more of the statements.

The bulk of the survey questions related to their use of and access to methamphetamine, heroin, cocaine, ecstasy, methaqualone and methcathinone ('CAT'). Observing the percentage use of each drug across the three sites indicates that there are differences in either drug preference or availability between the sites. Methamphetamine, marijuana and methaqualone are the most widely used drugs among the sample of respondents, with methamphetamine being most popular. Heroin had been used by respondents from Delft and Greenpoint, but very few individuals from Khayelitsha reported having used heroin in their lifetime. Cocaine, CAT and MDMA/Ecstasy are not widely used by the sample. Table 4 describes the number of users reporting to have 'ever used' each of the substances studied. All respondents are poly-drug users, therefore the table below presents multiple response items.

Table 4 Reported percentage of individuals that had 'ever used' each substance across the three study sites

Substance	Delft	Greenpoint	Khayelitsha	All sites
		Proportion of users (%)		
Methamphetamine	98.4	96.1	96.3	97.0
Marijuana	97.6	94.2	97.2	96.4
Methaqualone	86.5	83.5	97.2	89.0
Alcohol	90.5	78.6	92.6	87.5
Opioids	38.9	51.5	1.9	30.9
Methcathinone	3.2	6.8	1.9	3.9
MDMA/Ecstasy	28.6	22.5	5.6	19.3
Cocaine	21.4	31.1	2.8	18.4

Due to the low prevalence of the use of ecstasy, methcathinone (CAT) and cocaine the resulting sample size of users of these drugs is insufficient. They have, therefore, been excluded from the analysis. The study excludes marijuana because – though it is widely used in South Africa, and commonly used amongst respondents – the wide range of plant varieties, minimal processing requirements before sale, local production and growing, and variation in purity make it difficult to accurately compare prices (Howell et al., 2015; UNODC, 2010).

4.4. Respondents' drug career pathway

Details on the age at which each respondent began using each of the eight substance types is used to map the average pathway of substance initiation. The gateway hypothesis is frequently discussed in the literature and is a popular way of thinking about the trajectory of drug usage (Kandel, 1992). As previously noted, the hypothesised pathway is for users to begin their substance careers with the use of alcohol and cigarettes, progressing to psychostimulants with negligible medical implications (referred to as 'soft' drugs), and finally initiating the use of heavier drugs (referred to as 'hard' drugs) and the abuse of medically-prescribed drugs.

Table 5 reflects the mean age of drug-initiation disaggregated by drug-type and region. From the totals column, it is apparent that alcohol has the lowest age of initiation, but is very close to that of marijuana. Methaqualone appears to be the drug which respondents used next. This transition is likely since marijuana and methaqualone are often sold and used together, therefore individuals would fluidly transition to using methaqualone if marijuana was already being consumed. If we continue to follow the trajectory given by following the average age of initiation, methamphetamine is the next substance initiated, followed by heroin.

Table 5 Mean and median age of respondents when they first used each of the substance varieties surveyed, disaggregated by site

Substance		Site			Total
		Delft	Greenpoint	Khayelitsha	
Alcohol	**Mean**	16.1	16.6	15.8	16.1
	Median	16.0	16.0	16.0	16.0
	Std. dev.	5.0	3.9	3.9	4.4
Marijuana	**Mean**	16.6	16.8	15.2	16.2
	Median	16.0	16.0	15.0	16.0
	Std. dev.	5.4	5.5	2.7	4.7
Heroin	**Mean**	24.4	23.9	23	24.2
	Median	23.0	22.0	23.0	23.0
	Std. dev.	7.1	9.1	7.1	8.1
Methaqualone	**Mean**	19.4	20.3	17.8	19.1
	Median	18.0	18.0	17.0	18.0
	Std. dev.	5.9	6.3	3.4	5.4
Methamphetamine	**Mean**	22.7	25.0	20.3	22.6
	Median	20.0	23.0	18.0	20.0
	Std. dev.	8.2	9.3	6.0	8.2

While this is consistent, on average, with the gateway effect, there are many anomalies within the sample. A mapping of the transition from a respondent's initial substance (or substance set) to the subsequent substance used is shown in the following matrix (table 6). This matrix shows that, while the average trajectory is aligned to the 'gateway hypothesis' there are a number of anomalies within the sample.

Table 6 maps the trajectory of drug use from users within the study sample. The figures are based on a ranking from data on the year in which the respondent included the various substances in their consumption portfolio. Substances initiated in the same year are grouped into a single category, although it should be noted that they may have been initiated at distinct times within that year. Therefore, even though the information is not granular, it is able to show a basic trend. The highlighted cells indicate the most common transition from the first substance used (rows) to second substance used (column).

Table 6 Transition matrix mapping respondents' first substance used to the second substance used

	Second substance used						
	Alcohol	**Marijuana**	**Hard drug**	**Alcohol + marijuana**	**Alcohol + hard drug**	**Marijuana and + hard drug**	**No change**
First substance used							
Alcohol (23%)	0	0.4	0.3	0	0	0.3	0.0
Marijuana (34%)	0.4	0	0.4	0	0.3	0	0.0
Hard drugs (10%)	0.5	0.3	0	0.1	0	0	0.1
Alcohol and marijuana (12%)	0	0	1	0	0	0	0.0
Alcohol and Hard drugs (4%)	0	0.9	0	0	0	0	0.1
Marijuana and a hard drug (10%)	0.6	0	0	0	0	0	0.5
All at once (7%)	0	0	0	0	0	0	1.00

Given the first drug of use, on the left hand side, the probability of the sample respondent using either alcohol, marijuana, 'hard' drugs or a combination of the three is shown within the matrix. The majority of drug users in this sample began using marijuana as their first substance with 43% of the sample first using marijuana alone, 65% using it alone or with a combination of other substances. For the respondents using purely marijuana as their first substance, there seems to be an equal number that use alcohol next and hard drugs as their second substance initiated. The second most common substance of first use is alcohol, with 23% of the sample using alcohol only and 46% using alcohol in combination with other substances. There does appear to be a higher proportion of individuals following using alcohol with using marijuana as opposed to hard drugs. The transition matrix does not indicate that the most common drug-pathway trajectory starts with marijuana and transitions to mixed proportions of 'hard' drug and alcohol use. Alcohol is also commonly used as the first substance; in such cases, marijuana is the most common second drug of use. It is not common in this sample that 'hard' drugs are used as the first substance initiated.

Also of interest is the trajectory which respondents pursue in the sequence of drugs used once the individual begins using 'hard' drugs, which is shown in table 7.

Table 7 Transition matrix to map respondents' first 'hard' substance used to second 'hard substance used

	Second 'hard' substance used						
	Metha-qualone	**Metham-phetamine**	**Heroin**	**Metha-qualone and Metham-phetamine**	**Metha-qualone and heroin**	**Metham-phetamine and heroin**	**No change**
First 'hard' substance used							
Methaqualone (45%)	0	0.89	0.04	0	0	0.01	0.06
Methamphetamine (34%)	0.68	0	0.14	0	5.3	0	0.13
Heroin (5%)	0.26	0.53	0	0.16	0	0	0.05
Methaqualone and Methamphetamine (13%)	0	0	0.18	0	0	0	0.82
Methaqualone and heroin (1%)	0	0	0	0	0	0	1
Methamphetamine and heroin (1%)	0.50	0	0	0	0	0	0.50
All at once (1%)	0	0	0	0	0	0	1

From table 7 it is evident that methaqualone is the most common first 'hard' drug used within the sample, with 45.4% using methaqualone alone as the first 'hard' substance and a further 13.65% using methaqualone in combination with other drugs as their first plunge into the use of 'hard' substances. Methamphetamine was the first hard drug used for 33.83% of respondents, with an additional 13.65% using methamphetamine in combination with other drugs as their first drug. Heroin appears to be the least frequently used as the first drug when respondents initiate hard drug use.

Methamphetamine has been observed to be rapidly increasing in prevalence in the Western Cape region over the past two decades, superseding methaqualone as the most popular psychostimulant substance used (Watt, 2014). The frequency of methaqualone being used as the first substance, as observed in table 7, may be due to a larger proportion of respondents being born in a period where methamphetamine was not widely available. This is described in table 8.

Table 8 First 'hard' drug used disaggregated over birth years

Year of Birth	Methaqualone	Meth-amphetamine	Heroin	Meth-aqualone and Meth-amphetamine	Meth-aqualone and heroin	Meth-amphetamine & heroin	Meth-amphetamine, methaqualone and heroin
	%	%	%	%	%	%	%
1990-1999 (n=91)	25.9	48.2	1.8	20.5	0.9	0.9	1.8
1980-1989 (n=132)	48.6	30.3	7.7	12	0	0.7	0.7
1970-1979 (n=57)	59.3	25.4	6.8	6.8	1.7	0	0
Prior to 1969 (n=24)	83.3	8.3	8.3	0	0	0	0
Total	45.4	33.8	5.6	13.1	0.6	0.6	0.9

The sub-group of respondents born after 1990 accessed methamphetamine as their first 'hard' substance used. However, these respondents constitute only 30% of the sample. Respondents born before 1990 typically used methaqualone first and subsequently included methamphetamine and heroin in the portfolio of substances consumed. These respondents make up the largest proportion of the sample, therefore the overall average first 'hard' substance is observed to be methaqualone.

Heroin is not frequently used first by participants, as shown in table 8, and this is partly because fewer survey participants were heroin users, but also may be a result of access or price. Globally, opium cultivation was drastically cut in 2001, but has since rebounded dramatically at an estimated 229% higher potential production than pre-2001 levels (UNODC, 2014). However, heroin appears to be declining in its frequency as the first substance used amidst increasing heroin prevalence (UNODC, 2014; Pasche and Myers, 2012). The potential explanation for this inconsistency is that, while heroin prevalence may be increasing, methamphetamine tends to crowd out heroin out as the first 'hard' substance used. Furthermore, existing research is based on treatment data which may contain significant bias in the types of primary drugs such studies would typically observe. Substance users are likely to seek treatment at the point of 'problematic' drug use. Heroin, being a drug associated with a likelihood of overdose and other health implications (UNODC, 2010) is likely to induce treatment-seeking behaviour far more easily than methamphetamine. In addition, other studies show that the majority of heroin users in treatment centres are Caucasian (Peltzer et al., 2010) – a population segment that was not prominent in this study. Therefore, the heroin consumer market is not represented in entirety by this data.

5. Assumptions and limitations

Due to the nature of data on illegal substances generally, there will inevitably be some 'messiness' in the data used for this study. This does not mean that valuable conclusions cannot be made from the data, but rather that one should proceed cautiously, using robust methods when making conclusions with noisy data (Caulkins, 2006).

The RDS sampling process mitigates much of the homophily bias, relative to other chain referral methods currently available. There was a reported degree of scepticism among respondents as to the anonymity of the research, resulting in non-participation of groups of individuals. In particular females, Caucasians and individuals of a high economic status are underrepresented by the sample. The geographic locations sampled from influence this result as only Greenpoint has a significant Caucasian population and significant proportion of individuals with a high economic status. The sample consists largely of poor, street-dwelling individuals, which is likely to be a result of the value of the incentive not being sufficient to attract participation from individuals who have a higher opportunity cost for their time. Attempts were made to seed individuals of a higher economic status, but, because of scepticism, this was not successfully achieved (Burnhams et al., 2016).

As this is a pilot dataset, the sample is relatively small, as only 100 respondents were targeted from each site, with the final sample being slightly more than the target at 337 respondents. Sample size impacts the level of accuracy of the econometric analysis, especially in the case where the asymptotic properties of estimators are required to relax the assumption of normally distributed errors in regression modelling. Small sample sizes are problematic when analysing less popular drugs such as cocaine, MDMA/Ecstasy and methcathinone; for this reason, these substances were excluded from the current research.

The lack of particular data points makes an economic analysis of the dataset challenging. The most limiting of these is a question relating to the amount of drugs consumed over any particular period of time in order to estimate demand, which could be used to calculate various elasticities for the sample population. Furthermore, there appeared to be some confusion when reporting prices as to the quantity being reported on, resulting in the exclusion of some data points.

Cross-sectional datasets – such as the one used for this research – are limited in that dynamic effects or behaviours of drug users cannot be inferred. There is also the limitation of

accounting for unobserved heterogeneity within the dataset using fixed effects estimation or a difference-in-difference approach.

The data are also geographically limited to the Western Cape region of South Africa. Since drug availability differs across South Africa, and because of intra-country socio-economic differences, the findings are potentially applicable only to this relatively small area.

6. Theoretical framework

The following section introduces the framework upon which the data collected on poly-substance users in the Western Cape is analysed. This data is useful for identifying differences paid by different individuals for the same drug in the same region. One-on-one transactions enable factors such as the ability to negotiate, the social capital held, trust and loyalty to influence the sale and final price. It is expected that prices may fluctuate according to who is purchasing the illicit substance in question and, therefore, that certain patterns exists in the price paid for drugs and the observable characteristics and/or situation of the purchaser.

Similar to the approach used by Lahaie et al. (2015), a model is formulated where personal demographic and economic variables relating to the consumers of psychostimulants are tested in order to identify non-zero effects on the price that the consumer paid for their last purchase.

(3) $$P_i = P + \beta' X + \varepsilon_i$$

The set of negotiated prices (P_i) is expressed as the overall market price (P) – assumed to be constant for all respondents - and a matrix of observable characteristics (X) that directly or indirectly affect the final price paid for a particular drug. The size and direction of the influence of each row in (X) is contained in vector(β). The error term (ε_i) indicates the effect on the final purchase price of unobserved characteristics or external factors. The variables contained in X include gender, age, intensity of use, site, whether the substance was purchased in a public area, whether the substance was purchased from a known dealer, employment status, perceived purity of the substance, and the main source of income of the individual purchasing the drugs. Since purity is both unobservable by the consumer and the researcher, it is not included in the model since consumers (and occasionally dealers) cannot include this factor in their negotiation process. The dealers' portrayal of purity to the consumer results in a perception of purity which the consumer can factor in to their decision-making process. Therefore, a variable indicating perceived purity is included rather than actual purity.

The model is tested by estimating a multivariate ordinary least squares (OLS) regression using the dataset introduced in section 4.The data are weighted using the RDS II (Volz-Heckathorn) population weights discussed in previous sections.

7. Results and discussion

The data was analysed in multiple stages with increasing complexity and depth of insight. This section begins with estimated population proportions of various sub-populations within the poly-substance using population of the three sites in the Western Cape. Subsequent to this, average prices paid by individuals from each sub-population are estimated for each site. This bivariate analysis gives some insights into the differences paid by various sub-populations. This is further tested in a multivariate analysis of the log of substance price against various demographic, geographic and economic variables.

7.1. Population estimates

The technique of estimating population proportions from an RDS sample is a relatively new method and the most comprehensive discussion on the topic for use with STATA is currently available from Schonlau and Liebau (2012). This approach is used to mitigate the extent of homophily and network-size bias within the recruitment behaviour. The idea behind this is that individuals with larger network sizes are more likely to be observed within the sample. Secondly, it is also assumed that individuals recruit those similar to themselves. The original RDS estimators adjust for both of these sources of bias.

Another commonly used estimator in RDS datasets is the Volz-Heckathorn or RDS II estimator (Schonlau and Liebau, 2012; Volz and Heckathorn, 2008). This estimator adjusts for network-size bias by weighting each observation by the inverse of its reported network size, but does not calculate or adjust for the effect of homophily bias. This estimator is more appropriate for continuous data where selection within sub-population groups is not pertinent.

Bootstrap standard errors (BSE) used for estimating the population proportions are preferable for both RDS I and II estimators (Schonlau and Liebau, 2012). For this reason, only BSE are shown in table 9.

The variables presented below are, in and of themselves, valuable in determining the makeup of the drug-using population in the Western Cape region. The variables may also have some influence on the final price paid for a particular drug; this is discussed in greater detail in the sections to follow. Both the RDS I and RDS II estimators are included in this analysis.

Table 9 RDS I and RDS II estimates of population proportions of a selection of sub-populations

		RDS I				RDS II (Volz-Heckathorn)			
	Sample prop.	**Population prop.**	**BSE**	**95% CI**		**Population prop.**	**BSE**	**95% CI**	
Race									
Coloured	0.56	0.61	0.07	0.47	0.75	0.57	0.05	0.47	0.67
Black African	0.42	0.38	0.07	0.23	0.52	0.42	0.05	0.31	0.52
Other	0.02	0.02	0.01	0.00	0.03	0.02	0.01	0.00	0.03
Gender									
Female	0.36	0.45	0.06	0.34	0.56	0.46	0.05	0.35	0.55
Male	0.64	0.55	0.06	0.44	0.66	0.54	0.05	0.45	0.65
Addiction Level									
Low	0.62	0.68	0.05	0.59	0.77	0.68	.04	0.59	0.77
High	0.38	0.32	0.05	0.23	0.41	0.32	.04	0.23	0.41
Employment status									
Employed	0.44	0.42	0.05	0.32	0.52	0.41	0.05	0.32	0.51
Unemployed	0.56	0.58	0.05	0.48	0.68	0.59	0.05	0.49	0.68
Source of income									
Friend/family	0.13	0.13	0.04	0.05	0.22	0.15	0.05	0.04	0.23
Employment	0.54	0.52	0.07	0.41	0.63	0.52	0.05	0.41	0.63
Illegal source	0.10	0.08	0.02	0.04	0.12	0.07	0.02	0.03	0.11
Grants	0.07	0.09	0.03	0.02	0.16	0.10	0.04	0.03	0.18
Handouts/ad hoc	0.17	0.18	0.04	0.10	0.26	0.17	0.04	0.09	0.24

The results of the RDS I for estimating the population proportions of each race group, showed a high degree of homophily. This indicates a potential undersampling of the Coloured sub-population and oversampling of Black African individuals. However, as discussed previously, the three sites have differing proportions of the racial sub-populations. For example, Khayelitsha residents are predominantly Black African. Therefore, the high level of homophily is likely to be highly influenced by intra-site recruitment.

The population proportion of female psychostimulant users in the Western Cape regions is estimated to be higher than the sample proportion of female drug-users. This is to be expected since drug usage by females is still taboo in most communities and as such female users would not be as willing to come forward and reveal information about their drug-use behaviour (Burnhams et al., 2016; Kimani et al., 2014). However, it is important to balance this information with the notion that the estimated under-representation is actually an accurate reflection of the gender proportions. Treatment data for South Africa in 2006 indicate that women made up 19.1% of all admissions into treatment centres (Peltzer et al., 2010) and men have been observed to be 8-9 times more likely to use illicit substances than females (Van Heerden, 2009).

There is an estimated over-representation of highly addicted users. Respondents would have tended to recruit individuals who are heavy drug users because of the eligibility requirements of the study; therefore, the extent of heavy usage is slightly over-estimated by the sample proportion.

7.2. Distribution of price data

The mean, median and mode price paid by respondents, per quantity, for each of the three focal substances is reflected in table 10. Methamphetamine and heroin are generally sold in 'bankies'. There may be differing quantities within each 'bankie'; however, it is usually 1g or a single-use quantity (roughly 0.25g or less). Methamphetamine is also commonly sold in 'straws'. This is, as the name would suggest, a drinking straw filled with the substance which is ready-to-use. Methaqualone is sold in tablet form.

Table 10 Descriptive statistics of the aggregated price of methaqualone, heroin and methamphetamine from three regions of the Western Cape arranged in price order

	N	Mean	Median	Mode	SD	Min	Max
Purchase of single-serving quantity							
Price of methaqualone *(single use, half-tablet)*	84	25.45	25	30	4.49	20	32
Price of heroin *(single use, bankie)*	42	27.17	30	30	4.64	20	40
Price of methamphetamine *(single use, straw)*	113	29.09	30	30	8.65	15	60
Price of methamphetamine *(single use, bankie)*	252	34.39	30	30	12.42	10	100
Purchase of larger quantity							
Price of methaqualone *(full tablet)*	73	49.52	50	60[a]	8.95	30	60
Price of methamphetamine *(per gram, bankie)*	26	181.54	165	Multi-modal[b]	73.52	80	400

[a]There are 26 observations at a price of R60 and 25 at R40, this is closer to a bi-modal distribution.

[b] The modal price categories contain three observations each and are: R120; R150; R160; R180 and R200

The average point-in-time prices of methamphetamine, methaqualone and heroin shown above are organised according to the affordability of a single use, with the exception of the final two rows which represent purchases of higher quantities. Current studies of drug use in the region observe that methamphetamine is becoming increasingly popular and that, currently, it is the most widely used drug after cannabis (Hobkirk et al., 2015). The popularity of methamphetamine in the current sample, as well as in previous research, does not appear to be a result of a lower single-serving price. Hobkirk et al. (2015) describe the reported reasoning for methamphetamine popularity, as the nature of the high which gives the feeling of an "ability to do anything you want to" (pp. 101), as well as pressure to conform to social trends.

The median and mode for a single serving of each substance is R30,00, with the exception of the median methaqualone half-tablet price. The mean for all substances, aside from a methamphetamine 'bankie', is lower – indicating that some consumers were able to obtain their goods for less than the centralised 'going rate'. The average methamphetamine price is positively skewed, indicating the existence of influential observations at a price higher than the 'going rate'.

The mean prices observed above indicate some level of price variation within each particular product and quantity category. Interestingly, the final end-user price is typically denominated

in multiples of five. This is consistent with the findings of Caulkins and Reuter (2010), as well as those of Wendel and Curtis (2000). It is suggested that the reason for this phenomenon is the necessity of completing transactions quickly. Dealers will typically adjust the quantity sold through drug 'cutting' before adjusting the price.

7.3. Price differentials by population group and region

The prices observed in the sample tend to differ significantly across respondents. Geographical variations are to be expected, in accordance with Caulkins (2006). However, Lahaie et al. (2015) illustrate how price differentials within a single geographic area may also occur. Price differentials observed by consumers of methamphetamine, methaqualone and heroin are independently shown and discussed in the sections below using a bivariate analysis of the continuous price data and discrete categorical data. The difference in the price paid by each sub-population group is central to this section. The differences are tested using a two-sample t statistic when two sub-population groups are compared. In the case of multiple sub-populations, an ANOVA test is performed to determine whether the means of two or more sub-populations differ, by comparing the variation between sub-population groups to the variation within each sub-population group. The corresponding p-values resulting from the tests for mean equivalence are shown in each table.

7.3.1. Methamphetamine

Methamphetamine use has been on the rise in the Western Cape over the past two decades with increasing numbers of users being admitted to treatment facilities (Hobkirk et al., 2015). Of the respondents from Delft, Greenpoint and Khayelitsha, 94%; 90% and 95%, respectively, reported using methamphetamine in the month prior to participation in the study. Overall, 97% of the poly-drug-using sample reported to have tried methamphetamine at some point in their lives, and 93% had used the substance in the previous month.

Table 11 Descriptive statistics for the price of a single-serving methamphetamine 'bankie' at each site

Site	Mean	Median	Mode	Standard deviation (SD)	Minimum	Maximum
1. Delft (n=107)	31.92	30	30	12.51	15	100
2. Greenpoint (n=51)	34.80	30	20	16.15	20	100
3. Khayelitsha (n=94)	36.99	32.5	30	9.16	10	60
Total (n=252)	34.39	30	30	12.42	10	100
p-value	0.00					

The average and median price of methamphetamine for a single-serving methamphetamine 'bankie', shown in table 11, is highest in Khayelitsha and, on average, lowest in Delft. At least two sites have significantly different mean methamphetamine prices. The price data are slightly positively skewed, indicating that the mean is somewhat influenced by transactions at a price higher than the common 'going rate'. This may be indicative of the concealed actual quantity and quality of substances purchased (eg. the ability of dealers to 'cut' the drugs), or the ability of dealers to charge inflated prices to certain customers. However, there may be conflating factors, such as increased price due to purity levels, premiums for credit, or discounts for holding social capital.

Table 12 shows an analysis of the methamphetamine price across sub-population groups for all sites, while table 13 disaggregates the price data by site. The sub-population categories were determined by identifying the potential observable characteristics that may have an influence on price. Level of education was considered but not included because the available information on educational attainment lacked granular detail. Language spoken is also not included because of the high correlation between this variable and the variables indicating race and site. This reasoning is applied for the analysis of each substance.

Table 12 Descriptive analysis of the price of a 'per use' methamphetamine 'bankie' across sub-population groups

Sub-population group		N	Mean	Median	SD
Gender	Male	155	36.3	30.0	11.7
	Female	97	31.4	30.0	13.0
	Total	252	34.4	30.0	12.4
	(p-value)		0.00		
Employment status	Unemployed	158	33.8	30.0	11.2
	Employed	94	35.5	30.0	14.2
	Total	252	34.4	30.0	12.4
	(p-value)		0.29		
Location of purchase	Private	209	34.4	30.0	11.7
	Public	39	32.2	30.0	12.2
	Total	248	34.1	30.0	11.8
	(p-value)		0.27		
Perceived purity	Low	165	33.3	30.0	12.3
	High	87	35.3	30.0	12.5
	Total	252	34.3	30.0	12.4
	(p-value)		0.06		
Dealer offers sales on credit	No	174	34.2	30.0	11.9
	Yes	78	34.9	30.0	13.5
	Total	252	34.4	30.0	12.4
	(p-value)		0.68		
Intensity of use	Low	160	33.8	30.0	9.7
	High	92	35.4	30.0	16.2
	Total	252	34.4	30.0	12.4
	(p-value)		0.35		
Income source	Family and friends	32	38.6	30.0	17
	Employment	116	35.3	30.0	11.3
	Illegal sources	16	33.4	30.0	19.4
	Social support	16	32.2	30.0	9.3
	Handouts	35	33.9	30.0	12.2
	Total	215	35.2	30.0	13
	(p-value)		0.28		
Race	Coloured	135	32.8	30.0	13.2
	African	115	36.5	30.0	11.2
	Other	2	22.5	22.5	3.5
	Total	252	34.4	30.0	12.4
	(p-value)		0.03		

Table 13 Descriptive statistics of the price of a 'per use' methamphetamine 'bankie' across sub-population groups, disaggregated by site

		Site											
		Delft (n=107)				Greenpoint (n=51)				Khayelitsha (n=94)			
Sub-population group		**N**	**Mean**	**Med.**	**SD**	**N**	**Mean**	**Med.**	**SD**	**N**	**Mean**	**Med.**	**SD**
Gender	Male	48	34.7	30.0	14.1	24	35.6	35.0	13.2	83	37.4	37.5	9.5
	Female	59	29.7	30.0	10.6	27	34.1	25.0	18.6	11	34.1	30.0	5.8
	Total	107	31.9	30.0	12.5	51	34.8	30.0	16.2	94	37.0	32.5	9.2
	(p-value)		0.04				0.73				0.27		
Employment status	Unemployed	68	31.2	30.0	11.8	23	30.0	25.0	12	67	37.6	40.0	9.1
	Employed	39	33.2	30.0	13.6	28	38.8	40.0	18.2	27	35.4	30.0	9.4
	Total	107	31.9	30.0	12.5	51	34.8	30.0	16.2	94	37.0	32.5	9.2
	(p-value)		0.42				0.05				0.28		
Location of purchase	Private	104	32.0	30.0	13.9	17	37.6	40.0	13.8	88	36.7	30.0	9.3
	Public	2	30.0	30.0	-	33	31.4	25.0	12.8	4	40.0	40.0	8.2
	Total	107	31.9	30.0	13.6	50	33.5	30.0	16.6	94	36.9	30.0	9.2
	(p-value)		0.83				0.11				0.49		
Perceived purity	Low	86	32.2	30.0	14.5	34	30.6	25.0	13.1	45	37.6	40.0	8.3
	High	21	31.0	30.0	9.2	17	43.2	40.0	18.6	49	36.4	30.0	9.9
	Total	107	31.9	30.0	13.6	51	34.8	30.0	16.6	94	37.0	32.5	9.2
	(p-value)		0.70				0.00				0.53		
Dealer offers credit	No	68	31.2	30.0	11.1	32	34.8	30.0	17.4	74	36.7	30.0	9.0
	Yes	39	33.2	30.0	14.7	19	34.7	40.0	14.2	20	38.3	40.0	10.0
	Total	107	31.9	30.0	12.5	51	34.8	30.0	16.2	94	37.0	32.5	9.2
	(p-value)		0.42				0.98				0.49		
Intensity of use	Low	72	29.9	30.0	7.3	19	35.5	40.0	12.8	69	37.5	30.0	9.5
	High	35	36.0	30.0	18.7	32	34.4	27.5	18	25	35.7	40.0	8.3
	Total	107	31.9	30.0	12.5	51	34.8	30.0	16.2	94	37.0	32.5	9.2
	(p-value)		0.02				0.81				0.41		
Income source	Family & friends	17	35.6	30.0	16.7	4	57.5	45.0	28.7	11	36.4	40.0	6.4
	Employment	38	31.2	30.0	11.1	27	37	40.0	13.7	51	37.4	40.0	9.4
	Illegal sources	3	50.0	30.0	43.6	7	26.4	25.0	7.5	6	33.3	30.0	8.2
	Social support	14	30.7	30.0	9.0	-	-	-	-	2	42.5	42.5	3.5
	Handouts	4	35.0	30.0	10.0	12	27.9	20.0	13.4	19	37.4	30.0	10.8
	Total	76	33.0	30.0	14.3	50	35	30.0	16.3	89	37.1	35.0	9.2
	(p-value)		0.73				0.03				0.31		
Race	Coloured	94	32.4	30.0	13.2	39	33.5	30.0	13.7	2	37.5	37.5	3.5
	African	13	28.5	30.0	4.3	10	42.5	40.0	23.5	92	37.0	30.0	9.3
	Other	-	-	-	-	2	22.5	22.5	3.5	-	-	-	-
	Total	107	31.9	30.0	12.5	51	34.8	30.0	16.2	98	37.0	32.5	9.2
	(p-value)		0.29				0.49				0.94		

Table 12 shows the price paid for methamphetamine for each sub-population, aggregated across all sites. This representation identifies where potential patterns in the transaction price for methamphetamine may exist. Table 13 indicates potential structural dissimilarities in the way dealers transact deals with various client sub-populations on each of the three sites.

There are three types of variables: those describing the product, those describing the customer, and the purchasing process itself. In licit markets, price is to a large extent dependent on the quality of a product. A similar trend would be expected between price and quality (or in the case of psychostimulant substances, purity) in illicit markets. In the methamphetamine market in Greenpoint, a higher perceived purity is associated with a higher selling price. However, in Delft and Khayelitsha there is no significant price distinction across perceived levels of purity. This may indicate higher uncertainty around purity in these two sites.

For variables describing the customer, the aggregated analysis shows that there is a significant difference in the prices paid for methamphetamine across the two gender sub-populations. On average, females in the sample reported lower prices than their male counterparts. This is a consistent observation across all sites; however, it is only significantly so in Delft. Potential reasons for this observation may include the possession of social capital held by women in the illicit substance (from Figure 1 it is observed that female seeds have extensive networks within their local substance-using communities) or in-kind payments or bartering using prostitution or sexual favours.

Prices also tend to differ significantly across the sub-populations defined by race for the aggregated data across all sites. The Coloured sub-population reported a discounted average price for methamphetamine compared to the Black African sub-population. The category indicating ‘other’ race, while significantly discounted, only contained two observations, discrediting the significance of this discount. As these two observations were included in the ANOVA, a t test was also performed to test whether the conclusion that at least two means differ was a result of this inclusion. The p-value from the t test comparing the mean price paid by Black African and Coloured sub-populations indicates a significant dissimilarity at a 2% level of confidence. However, as can be seen from the introductory discussion of the data, race is highly correlated to site. Therefore, some of the dissimilarity may be on account of the regional price differences shown in table 11.

Indeed, table 13 shows that there are only a few observations for certain race sub-populations. Furthermore, the differences in means across race groups lose significance once the data are disaggregated by site.

The observed variation in price patterns supports the hypothesis that methamphetamine markets in each region operate in distinct ways, and that this distinction may not be fully accounted for simply by including a categorical variable indicating region in a multivariate regression model. Separate estimation by site may be required.

7.3.2. Methaqualone (Mandrax)

Methaqualone, a drug sold in tablet form, is used by 89% of the respondents across all three sites. However, price data are only available for Delft and Greenpoint. Only two price observations exist for Khayelitsha, making the sample size too small for any useful inference. Table 14 shows the average price of a half-tablet of methaqualone for each site.

Table 14 Descriptive statistics for the price of a per-serving methamphetamine 'bankie' across all sites

Site	Mean	Median	Mode	Standard deviation (SD)	Minimum	Maximum
1. Delft (n=34)	21.85	20.00	20.00	2.30	20	25
2. Greenpoint (n=48)	28.02	30.00	30.00	3.85	20	32
3. Khayelitsha (n=2)	25.00	25.00	Bi-modal[a]	7.07	20	30
All sites (n=84)	25.45	25.00	30.00	4.49	20	32
(p-value)	0.00					

[a]There are only two observations (R20 and R30) for Khayelitsha

From this table it can be seen that the price of a methaqualone half-tablet is lowest in Delft, at R21,85 (median: R20,00) and highest in Greenpoint at R 28,02 (median: R30,00).
Respondents at these two sites reported significantly different methaqualone prices. When Khayelitsha is excluded and a two-sample t test is performed on the methaqualone mean price across Delft and Greenpoint, dissimilarity with a high level of confidence results. It is also apparent that Greenpoint has a greater variation in prices than Delft. The prices reported are most frequently R30 per half-tablet in Greenpoint and R20 per half-tablet in Delft.

Table 15 shows an analysis using the methaqualone price paid across sub-population groups for all sites, and table 16 disaggregates the price data by site. The difference in the average price paid by each sub-group is tested using either a two-sample ttest or ANOVA (for multiple mean comparison).

Table 15 Descriptive analysis of the price of a 'per use' methaqualone half-tablet across population groups across all sites

Sub-population group		N	Mean	Median	SD
Gender	Male	47	25.6	25.0	4.4
	Female	37	25.2	25.0	4.6
	Total	84	25.5	25.0	4.5
	(p-value)		0.67		
Employment status	Unemployed	37	24.3	25.0	4.3
	Employed	47	26.3	30.0	4.5
	Total	84	25.5	25.0	4.5
	(p-value)		0.04		
Location of purchase	Private	67	24.7	25.0	4.3
	Public	17	28.4	30.0	4.0
	Total		25.5	25.0	4.5
	(p-value)		0.00		
Purity	Low	58	25.3	25.0	4.5
	High	26	25.8	27.5	4.6
	Total	84	25.5	25.0	4.5
	(p-value)		0.67		
Credit availability	Not available	40	25.1	25.0	4.5
	Available	44	25.7	26.5	4.5
	Total	84	25.5	25.0	4.5
	(p-value)		0.56		
Intensity of use	Low	46	25.6	25.0	4.5
	High	38	25.3	25.0	4.5
	Total	84	25.5	25.0	4.5
	(p-value)		0.80		
Source of income	Friend/family	13	23.6	20.0	4.6
	Employment	40	25.6	25.0	4.6
	Illegal source	11	26.6	30.0	4.5
	Grants	8	22.6	22.0	3.4
	Handouts/odd jobs /'skarrel'	10	27.7	30.0	3.9
	Total	82	25.4	25.0	4.5
	(p-value)		0.01		
Race	Coloured	63	25.0	25.0	4.4
	Black African	18	27.2	30.0	4.3
	Other	3	23.3	20.0	5.8
	Total	84	25.5	25.0	4.5
	(p-value)		0.52		

Table 16 Descriptive statistics of the price of a 'per use' methaqualone half-tablet across population groups disaggregated by site[3]

		Site							
		Delft (n=34)				Greenpoint (n=48)			
Sub-population group		**n**	**Mean**	**Median**	**SD**	**n**	**Mean**	**Median**	**SD**
Gender	Male	15	22.1	20.0	2.5	30	27.4	30.0	4.1
	Female	19	21.6	20.0	2.2	18	29.0	30.0	3.3
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.54				0.17		
Employment status	Unemployed	21	21.5	20.0	2.3	15	27.9	30.0	3.6
	Employed	13	22.4	22.0	2.3	33	28.1	30.0	4.0
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.30				0.85		
Location of purchase	Private	34	21.9	20.0	2.3	31	27.8	30.0	3.8
	Public	0	-	-		17	28.4	30.0	4.0
	Total	34	21.9	20.0	2.3	48	28	30.0	3.8
	(p-value)		-				0.66		
Perceived purity	Low	25	21.9	20.0	2.3	31	28.1	30.0	3.8
	High	9	21.7	20.0	2.5	17	27.9	30.0	4.0
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.78				0.92		
Credit availability	Not available	16	21.8	20.0	2.3	23	27.3	30.0	4.3
	Available	18	21.9	20.0	2.3	25	28.7	30.0	3.3
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.92				0.19		
Intensity of use	Low	20	21.9	20.0	2.4	25	28.7	30.0	3.4
	High	14	21.7	20.0	2.3	23	27.3	30.0	4.2
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.77				0.22		
Source of income	Friend/family	9	21.7	20.0	2.5	4	28.0	30.0	5.4
	Employment	15	22.0	20.0	2.5	23	28.0	30.0	3.9
	Illegal source	1	20.0	20.0		10	27.3	30.0	4.2
	Grants	7	21.6	22.0	1.8	1	30.0	30.0	-
	Handouts/odd jobs /'skarrel'	1	22.0	22.0	-	9	28.3	30.0	3.5
	Total	33	21.8	20.0	2.3	47	28.0	30.0	3.9
	(p-value)		0.00				0.58		
Race	Coloured	31	21.9	20.0	2.3	32	28.1	30.0	3.8
	Black African	3	21.7	20.0	2.9	13	28.8	30.0	3.1
	Other	0	-	-	-	3	23.3	20.0	5.8
	Total	34	21.9	20.0	2.3	48	28.0	30.0	3.8
	(p-value)		0.81				0.43		

[3] Khayelitsha was not included in the bivariate analysis because there are only two price data points available

Table 15 shows the analysis of the methaqualone half-tablet price for each sub-population, aggregated over all sites. Table 16 disaggregates this over data extracted from Delft and Greenpoint. This representation identifies potential patterns in the transaction price for methaqualone. However, the variation here is far smaller than that for methamphetamine. Respondents typically pay R20 or R 30 for a half-tablet.

In table 15, the average price paid across three sub-population groups is significantly different. Respondents who were employed reported paying higher prices than those who were unemployed. Furthermore, when methaqualone was purchased in a public area – such as on the street, or in a bar or nightclub – respondents reported that they paid higher prices for methaqualone. Lastly, there is a significant difference between prices paid by two or more of the sub-groups that is determined by their source of income. Social support recipients pay, on average, lower prices for methamphetamine than other respondents.

As observed in table 14, respondents from Delft pay significantly lower prices than those residing in Greenpoint. In Delft, methaqualone mostly sells for R20 and in Greenpoint it mostly sells for R30. Differences in the prices at these two sites appear to have influenced the observed differences in methaqualone price across sub-populations. For example, a greater proportion of employed individuals reside in Greenpoint and this has indirectly influenced the observation of a significant premium paid by employed individuals. Being employed or unemployed in each of the sites in isolation does not result in a significantly different price paid for methaqualone.

In Delft, there are still significant price dissimilarities across the sub-populations with regard to the source of a respondent's income. For this site, respondents receiving their income from illegal activities report paying the lowest prices for methaqualone.

There is far less variation among the price observations for methaqualone than for methamphetamine. However, price differences between Delft and Greenpoint indicate that the location where the substance is purchased makes a sizeable difference in the price one would be likely to pay.

7.3.3. Heroin

Heroin is less prevalent in the sample than both methamphetamine and methaqualone, although a relatively large proportion of residents in Greenpoint report using this drug. Of

respondents in Delft, 39% admitted to having tried heroin; in Greenpoint, 51% reported having tried heroin and only two individuals form Khayelitsha admitted to having tried it. Overall, 31% of the sample of poly-substance users had tried heroin before and 22% had used the substance in the preceding month. None of the respondents in Khayelitsha had used heroin in the preceding month; price and purchasing data were therefore not collected from them.

Table 17 Descriptive statistics for the price of a per-serving heroin 'bankie' (approx. 0.25g) for across all sites

Site	Mean	Median	Mode	Standard Deviation (SD)	Minimum	Maximum
Delft (n=15)	30.67	30.00	30.00	2.58	30	40
Greenpoint (n=27)	25.22	25.00	Multi-modal[a]	4.41	20	35
Total (n=42)	27.17	30.00	30.00	4.65	20	40
(p-value)	0.00					

[a] The modal price categories contain eight observations each are: R20; R25 and R30

The mean price of a 'per serving' quantity of heroin is R27,17, with the cheapest price observed R10 and the most expensive R40. The most frequently observed price for heroin is R30 across both sites and, importantly, Delft only has one observation that is not R30. For this reason, it will be difficult to observe price differentials in the Delft sample. Heroin is, on average, reported to be significantly cheaper – R25,22 (median R25,00) compared to R30.67 (median: R30,00) – in Greenpoint than in Delft.

Table 18 depicts the variation in the heroin price across sub-populations, aggregated over all sites. Table 19 shows the variation in the heroin price paid by different sub-populations with Greenpoint and Delft separately. There is very little variation in the reported prices in Delft, with 93% of respondents paying R30 for a 'single serving'. The variation across groups is, therefore, entirely reflective of the single individual paying R40 for heroin.

Table 18 Descriptive statistics of the price of a 'per use' heroin bankie across sub-population groups

Sub-population group		N	Mean	Median	SD
Gender	Male	24	27.0	30.0	5.3
	Female	18	27.4	30.0	3.6
	Total	42	27.2	30.0	4.6
	(p-value)		0.79		
Employment status	Unemployed	22	27.7	30.0	5.1
	Employed	20	26.6	25.0	4.2
	Total	42	27.2	30.0	4.6
	(p-value)		0.41		
Location of purchase	Private	18	29.2	30.0	4.1
	Public	24	25.6	25.0	4.5
	Total	42	27.2	30.0	4.6
	(p-value)		0.01		
Perceived purity	Low	24	27.0	30.0	5.3
	High	18	27.4	30.0	3.6
	Total	42	27.2	30.0	4.6
	(p-value)		0.79		
Credit availability	Unavailable	21	26.8	30.0	5.2
	Available	21	27.5	30.0	4.2
	Total	42	27.2	30.0	4.6
	(p-value)		0.62		
Intensity of use	Low	15	26.5	30.0	4.6
	High	27	27.5	30.0	4.7
	Total	42	27.2	30.0	4.6
	(p-value)		0.52		
Source of income	Friends/ family	3	30.0	30.0	0
	Employment	21	27.3	30.0	5.2
	Illegal source	9	28.1	30.0	2.9
	Social support	1	30.0	30.0	
	Handouts/ odd jobs/ 'skarrel'	7	23.6	20.0	4.8
	Total	41	30.7	30.0	2.7
	(p-value)		0.47		
Race	Coloured	33	27.5	30.0	4.5
	Black African	6	29.2	30.0	3.8
	Other	3	20.0	20.0	0
	Total	42	27.2	30.0	4.6
	(p-value)		0.07		

Table 19 Descriptive statistics of the price of a single use heroin 'bankie' across population groups, disaggregated by site[4]

		Site							
		Delft (n=15)				Greenpoint (n=27)			
Sub-population group		**N**	**Mean**	**Med.**	**SD**	**N**	**Mean**	**Med.**	**SD**
Gender	Male	7	31.4	30.0	3.8	17	25.2	25.0	4.9
	Female	8	30.0	30.0	0	10	25.3	25.0	3.8
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.30				0.95		
Employment status	Unemployed	11	30.9	30.0	3.0	11	24.6	25.0	4.7
	Employed	4	30.0	30.0	0	16	25.7	25.0	4.3
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.57				0.52		
Location of purchase	Private	15	30.7	30.0	2.6	3	22.0	23.0	1.7
	Public	-	-	-	-	24	25.6	25.0	4.5
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		-				0.19		
Perceived purity	Low	5	32.0	30.0	4.5	19	25.7	25.0	4.8
	High	10	30.0	30.0	0	8	24.1	25.0	3.2
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.16				0.41		
Credit availability	Unavailable	7	31.4	30.0	3.8	14	24.5	25.0	4.2
	Available	8	30.0	30.0	0	13	26.0	25.0	4.7
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.30				0.39		
Intensity of use	Low	7	30.0	30.0	0	8	23.5	21.5	4.4
	High	8	31.4	30.0	3.5	19	26.0	25.0	4.3
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.37				0.19		
Source of income	Friends/ family	3	30.0	30.0	0	-	-	-	-
	Employment	7	31.4	30.0	3.8	14	25.2	25.0	4.6
	Illegal source	3	30.0	30.0	0	6	23.6	27.5	4.8
	Social support	1	30.0	30.0	-	-	-	-	-
	Handouts	-	-	-	-	7	25.2	20.0	4.4
	Total	14	30.7	30	2.7	27	26.2	25	9.8
	(p-value)		0.87				0.60		
Race	Coloured	12	30.8	30.0	2.9	21	25.5	25.0	4.0
	Black African	3	30	30.0	0	3	28.3	25.0	5.8
	Other	-	-	-	-	3	20.0	20.0	0
	Total	15	30.7	30.0	2.6	27	25.2	25.0	4.4
	(p-value)		0.63				0.15		

[4] Khayelitsha was not included as only two individuals reported using heroin and it was used more than 30 days prior to the questionnaire; therefore, pricing data were not collected.

The preceding tables (18 and 19) show bivariate analyses of the price of a single serving of heroin across sub-populations, with the second table disaggregating the price analysis by site. In table 18, it appears that the mean heroin price differs across the variables for location of purchase and across race sub-populations.

It is already known, from table 17, that the price of a single serving of heroin is significantly lower in Greenpoint than in Delft. Table 19 shows that purchases are only made in public areas in Greenpoint. Therefore, the significance of mean differences between purchasing in private areas and in public areas – as observed in table 18 – is largely a result of public purchases being observed in Greenpoint where prices are on average lower.

Differences across sub-population grouping by race are significant at the 10% level in Greenpoint. Using Tukey's method for a pairwise comparison of means, it is clear that the significant p-value from the ANOVA is caused by the difference between 'other' and the Black African and Coloured race categories. Significantly different prices are not observed for Black African and Coloured sub-populations.

Heroin prices appear to be relatively similar in Delft. Once again, the differences between sites proved to be highly significant, which resulted in the false appearance of significant average price differences across sub-populations. The confounding outcome on final purchase price resulting from the array influencing variable is controlled for in the following multivariate analyses.

7.4. Multivariate analysis

On account of the complexity within the system of buyers and sellers of illicit psychostimulant substances, a multivariate regression approach is applied to the dataset. This approach is useful in that it allows for the correlation between two variables to be examined while holding the remaining system constant. This approach was limited due to non-responses in the dataset, particularly for methaqualone and heroin use. In the case of heroin, a multivariate approach could not be successfully applied.

7.4.1. Methamphetamine

An ordinary least squares (OLS) multivariate regression was used to determine the effect of the included variables on the reported price of methamphetamine, holding all other variables

at a constant level for analysis. Population weights are included in the estimation to mitigate the prevalence of bias due to network size. These estimated weights assist us to predict what the sample would have looked like in the absence of differing personal network sizes and brings the analysis closer to the true population. The original RDS population weight estimator is appropriate for categorical dataset and likelihood models. However, since the pricing data are continuous, the RDS II (Volz-Heckathorn) estimator is applied to calculate the weights. For comparison, for each of the tables in the following section, an unweighted regression can be found in the appendix. Sandwich estimators are used to compute the variance-covariance matrix (Spiller, 2009).

The presence of multicollinearity and heteroscedasticity was tested for and both were found to be of negligible significance. The results of the OLS regression analysis of the price of methamphetamine across population groups are shown in table 20.

Table 20 Multivariate OLS regression showing the associations between individual characteristics and methamphetamine retail prices in the Western Cape

	(1)	(2)	(3)	(4)
	Log (price of methamphetamine, per serving 'bankie')			
Log (income)	0.01	0.01	0.01	0.03
	(0.02)	(0.02)	(0.02)	(0.02)
Employed	0.05	0.05	0.06	0.08
	(0.05)	(0.05)	(0.05)	(0.06)
Highly addicted	0.07	0.07	0.06	-0.05
	(0.08)	(0.08)	(0.08)	(0.06)
Age	0.01	0.01	0.01	0.00
	(0.02)	(0.02)	(0.02)	(0.02)
Age squared	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Female	-0.20***	-0.20***	-0.21***	-0.25***
	(0.06)	(0.06)	(0.06)	(0.05)
High purity	0.06	0.06	0.04	0.01
	(0.05)	(0.05)		(0.06)
Race (base = Coloured)				
Black African	-0.05	-0.05	-0.07	-0.03
	(0.07)	(0.07)	(0.07)	(0.06)
Purchased from same person		0.01	0.00	0.02
		(0.05)	(0.05)	(0.05)
Bought in public			-0.18**	-0.18**
			(0.09)	(0.08)
Source of income (base = employment)				
Friends & Family				0.36***
				(0.07)
Illegal Source				-0.10
				(0.08)
Social support				0.05
				(0.08)
Handout				-0.01
				(0.08)
Sites (base= Delft)				
Greenpoint	0.02	0.02	0.10	0.23**
	(0.10)	(0.10)	(0.11)	(0.10)
Khayelitsha	-0.01	-0.00	0.01	0.03
	(0.08)	(0.09)	(0.08)	(0.09)
Constant	3.50***	3.48***	3.55***	3.53***
	(0.40)	(0.39)	(0.38)	(0.37)
Observations	243	243	239	209
R-squared	0.14	0.15	0.18	0.29

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The effect of gender on the price paid for methamphetamine is striking in its magnitude and significance in the model. In the final regression, females are estimated to pay 25% less for a serving of methamphetamine than males, with other factors such as site and other purchasing

behaviours held constant. The effect appears to increase when more variables are included in the model. The reason for this price distinction along gender lines in unclear, although other research has indicated that females may receive preferential treatment within illicit substance markets. Women are thought to hold a significant amount of social capital. This may include, but is not limited to, a women's lower affinity to violence (Anderson, 2001), more stable payment behaviour (Anderson, 2005) and the provision of shelter and protection to drug users and dealers (Anderson, 2005). Dealers have been observed to compete for women as clients by giving favourable transaction terms and a high-quality product (Anderson, 2005).

The discount in prices paid by women is disconcerting in light of the numerous studies which show that women are more vulnerable to the negative physiological effects of methamphetamine use (Centre for Substance Abuse Treatment, 2009). While the research is limited in this area, Liechti et al. (2001) observe that the intensity of the desired psychoactive effects of methamphetamine is higher for women than for men. Women also experience increased negative side-effects, are more likely to develop dependencies and risk negative birth outcomes if the substance is consumed during pregnancy (Centre for Substance Abuse Treatment, 2009).

Social capital from dealer loyalty does not appear to lead to more favourable prices. Purchasing methamphetamine from the same person is associated with lower prices, but this effect is not significant and no conclusive evidence can be drawn from this association.

The prevalence of in-kind payments was tested on this model through the inclusion of a sex-for-drugs variable as well as a variable indicating whether the respondent had stolen to pay for illicit substances. Neither of these variables proved significant in the model specification. This was then extended to include an interaction term between sex-for-drugs and gender. The interaction terms also showed no significance; they were subsequently excluded from the model. It should be noted that the insignificance of this variable may have occurred as a result of respondents are sensitive to revealing whether they used sexual favours or theft as a means to acquire illicit substances, and may have responded untruthfully. To mitigate against this effect in future surveys of a similar nature, one could look to techniques for collecting sensitive data, for example, Randomised Response technique (Warner, 1965 ;Blair, Imai and Zhou, 2015)

Neither being employed nor the quadratic term for age is significantly associated with methamphetamine price. The age variable and age squared were tested for joint significance

and were found to be only weakly jointly significant (p = 0.15). The relationship between age and the price purchased follows a concave down, quadratic function which has a turning point at approximately 17 years of age. At this point the price relative to age increases by greater percentage per year. This may indicate a tendency for dealers to offer youth lower prices for the substance to attract them to begin using methamphetamine. This would be an astute growth strategy for the dealer since they have the potential to increase the price as consumers grows older and becomes increasingly dependent on the substance. A further variable indicating the length of drug use was tested under the hypothesis that experience has a role to play in transaction efficiency (Lakhdar, 2013). However, the variable was excluded from the final model because of the combination of high collinearity with the variable for age and relative insignificance when age was excluded. The variable for age was more effective in explaining drug-use tenure.

The perception of a high quality product being bought is weakly significant and is associated with an increase in price. Since buyers do not know the actual quality of the product until they use it, they may suspect that the dealer may not be disclosing the true level of purity. The 'Expected Purity Hypothesis' argued by Caulkins (1994) does not appear to apply to the current context. This hypothesis proposes that a consumer's perception of purity and potency is the key factor influencing drug prices. The low significance rather indicates that a 'market for lemons' is prevalent in the sale of methamphetamine. Dealers selling low quality methamphetamine are better off selling low quality drugs at a higher price, as this may signal high quality, and larger profit margins accrue to the dealer. This creates a moral hazard and the use of price to signal purity becomes wholly unreliable. The result is that users cannot know the true quality based on price or perceived purity. There is additional uncertainty about the true quality since the drug quality is largely unknown even to the seller since, prior to the sale reported by respondents, the substance would have been sold through a chain of dealers and at each point after manufacture there is the possibility of undisclosed dilution of the drug (Caulkins, 2006). This makes the observation and perception of purity difficult for substance users and is likely to contribute to the low significance of perceived purity in the model.

Respondents who rely on income from illegal activities, and those receiving handouts, are associated with paying lower prices when purchasing methamphetamine; however, this is a weakly significant relationship. The base case in this scenario – income from employment – is predicted to result in poly-drug users paying a price in between their 'skarrelling' and

family-dependent counterparts. Those reliant on family and friends for income are estimated to pay significantly more for methamphetamine than other groupings of income source. Compared to those relying on employment for income, those relying on friends and family are estimated to pay a price premium of 20%.

Previous research has identified that individuals with stable sources of income are favoured by dealers and may be able to access illicit substances at lower prices (Anderson, 2005). As reliance on friends and family is a highly unreliable and sporadic source of income, this gives some support to this hypothesis. However, by this argument, those receiving handouts should also be classified as unreliable, yet they do not appear to pay a premium for methamphetamine. Previous studies have indicated that sellers of illicit substances do not always behave in a profit-maximising manner in their businesses, but have the tendency to sell at reduced prices to those they know are worse off (McKenna, 2014; Dwyer and Moore, 2010). They are also observed to assist other dealers when they are unable to access well-priced drugs to sell on. This behaviour may explain why other dealers and those relying on handouts do not pay a premium for drugs.

Selling illicit substances in public places is expected to increase the risk and, therefore, the price of methamphetamine. Increasing the risk of selling a product is hypothesised to increase a supplier's cost of bringing goods to the market, leading to increased prices, in a similar way that increasing inputs would influence the price. In illicit markets, transactions made in an area where law enforcement is strong are thought to incur higher prices as they incorporate the risk of arrest and prosecution into prices (Reuter and Kleinman, 1985). However, the model estimated here indicates the opposite. This may be a failure of the hypothesis or a failure of law enforcement practices to significantly increasing the risks of selling illicit substances in public areas, enough to increase costs.

7.4.2. Methaqualone (Mandrax)

The number of methaqualone users in the sample is considerably smaller than that of methamphetamine users and there are no prices reported for methaqualone in Khayelitsha. As with the analysis of methamphetamine prices paid, an OLS regression was used to determine the *ceteris paribus* effect associated with various demographic groups and the price paid for methaqualone. Probability weights were assigned to individual observations to mitigate the resultant sampling bias arising from differences in the network size of respondents. Multicollinearity and heteroscedasticity were once again negligible. The results of the OLS

regression analysis of the price of methaqualone across population groups are shown in table 21.

Table 21 Multivariate OLS regression showing the association of population characteristics and methaqualone retail prices in the Western Cape region of South Africa

	(1)	(2)	(3)	(4)
	Log (price of methaqualone half-tablet)			
Log (income)	0.00	-0.00	-0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Employed	-0.04	-0.04	-0.03	-0.03
	(0.03)	(0.03)	(0.03)	(0.03)
Highly addicted	-0.04	-0.04	-0.04	-0.05
	(0.03)	(0.03)	(0.03)	(0.04)
Age	-0.02	-0.02	-0.01	-0.01
	(0.02)	(0.02)	(0.01)	(0.02)
Age squared	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Years of use	0.01**	0.00	0.01*	0.01**
	(0.00)	(0.00)	(0.00)	(0.00)
Female	0.00	0.01	0.01	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
High purity	0.02	0.02	0.03	0.04
	(0.04)	(0.04)	(0.04)	(0.03)
Race				
Black		0.02	0.02	0.04
		(0.04)	(0.04)	(0.04)
Bought from same person		0.07**	0.07	0.08**
		(0.04)	(0.04)	(0.04)
Bought in public			-0.03	-0.02
			(0.07)	(0.07)
Source of income				
Friends & Family				0.01
				(0.05)
Illegal Source				0.03
				(0.05)
Grant				0.02
				(0.05)
Handout				0.07
				(0.05)
Site				
Greenpoint	0.22***	0.21***	0.23***	0.18***
	(0.04)	(0.04)	(0.05)	(0.06)
Constant	3.55***	3.40***	3.40***	3.35***
	(0.26)	(0.27)	(0.26)	(0.27)
Observations	81	81	81	80
R-squared	0.46	0.51	0.52	0.55

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The sample size in the estimation of the model in Table 21 is far smaller than that of methamphetamine. This is intensified from the non-response for the methaqualone price variable from respondents in Khayelitsha. The model appears to explain a large proportion of the variation in prices value through the linear regression model estimated above (R-squared is far higher than the model estimated for methamphetamine) although this is mostly driven by the geographic variable.

The difference in the price paid for methaqualone is significantly different between Delft and Greenpoint and there appears to be a unique 'going rate' price at each site. Greenpoint respondents were predicted to pay prices that are, on average, 27% higher than users in Delft. Apart from the sharp difference between the prices paid at these two sites, there is very little variation in the price for a half-tablet. This may be a result of the inability to change the quality of the product substantially by cutting resulting in a more standardised product.

The number of years an individual used methaqualone is significant and predicts a 1% increase in the price paid for a half-tablet for every additional year of mandrax use. The variable indicating whether the purchase was made from the same person is significant and indicates a premium of 7% associated with repeated transactions with a familiar dealer. This does not support the hypothesis that dealers charge more for unknown individuals (Chalmers and Bradford, 2013) as was expected. Other variables in the model are not significant and are negligible in size.

7.4.3. Heroin

The total number of data points for the price of heroin is 44 and these data represent respondents from Delft and Greenpoint. In addition to a small sample size, there is also very little variance in the price data. In Delft (n=15), 93% of the heroin-using respondents reported a price of exactly R 30 for the substance. In Greenpoint (n=29), the price of heroin was more varied, with the price most frequently reported as R 30, R25 or R20. Because of the small sample size, a multivariate analysis for heroin was not executed.

8. Conclusion

This study has covered new ground in the South African illicit psychostimulant economy by performing a detailed analysis on the characteristics, initiation pathways and transaction prices paid for the more commonly used psychostimulant substances amongst low-income individuals in the Western Cape. Psychostimulant use is associated with a myriad of negative side effects including risks to public safety, lower productivity levels, health complications, environmental degradation and the potential to threaten governance. Therefore, it is imperative that the consumption of illicit substances is understood so that optimal mechanisms for mitigating the aforementioned effects can be developed and implemented.

The data for this research were extracted using the RDS technique for sampling hidden populations. The sample consisted of poly-substance users from the Western Cape Province, where there are estimated to be the highest number of psychostimulant users in South Africa (Peltzer et al., 2010). Respondents reported the age at which they began using each substance, the analysis of which only provided inconclusive evidence for the 'gateway hypothesis' proposed by Kandel (1992). We do observe that many current poly-substance users began using marijuana before alcohol and hard drugs which is not in alignment with Kandel's hypothesis. However, very few respondents used a 'hard' drug as an initial substance, evidence that less harmful and more accessible substances were being consumed first, which is more consistent with Kandel's hypothesis. It was also observed that methamphetamine is increasingly being used as the first 'hard' substance, which aligns to other local literature.

The price data were used to understand how individual transactions are priced across observable purchaser characteristics, location and perceived quality. There were sufficient data for analysis for methamphetamine, methaqualone (mandrax) and heroin; although the use of methaqualone and heroin in one of the sites was too low for analysis. The sample of drug users from three regions shows that, for methamphetamine, there appears to be a significant difference in the prices paid according to gender, region and for other observable demographic characteristics such as age, employment status and race. For methaqualone, prices tend to differ between the locations where the drug was sold but observable client characteristics do not influence price significantly. This may largely be due to the inability to alter the product's quality because it is sold in tablet form. While the bivariate analysis shows that heroin prices also differ across regions, the data did not allow for a more in-depth

analysis of this difference owing to the small sample size of heroin users; therefore, evidence of regional differences in the price for heroin is apparent in the bivariate cross-tabulations but it would require more data to model this effect holding other variables constant.

The occurrence of price differentials for transactions with close geographic proximity is similar to the findings of Caulkins (2006) and Lahaie et al. (2015). This is a likely to be a result of high transit costs incurred by suppliers (as drugs cannot be transported openly), high search costs incurred by consumers and the prevalence of information asymmetries between regions. Asymmetrical information also exists between buyer and seller; therefore, dealers may charge more for a product if they believe their customer is not aware of the 'going rate' or if they are expected to have a higher 'willingness to pay'. Furthermore, since dealers are uncertain of the type of customer they are dealing with, they may give preferential prices to repeat customers, customers possessing social capital with the dealer or those whom the dealer has assessed to be 'good' customers. This is found to be most noticeable in the way females pay significantly lower prices for methamphetamine. This research has highlighted the need to pay close attention to the rise in substance use, particularly among the youth and women. Dealers of illicit substances that can be 'cut' (e.g. methamphetamine and heroin) are able to manipulate prices for favoured customers as well as a means to attract new customers. It is imperative that these population groups are protected through improving access to opportunities and other demand reduction strategies The UNODC recommends strategies targeting families to be most effective for targeting the youth, but also discuss schools initiatives and employment initiatives (UNODC, 2017).

This study has shown resilience to increasing nominal prices for illicit substances. This highlights the need for an acceleration of current efforts to reduce supply and demand, considering, in particular, the needs and challenges of unemployed and low-income users. This finding, as well as the complexity and magnitude of the substance economy, contrasts the notions that the rising numbers of illicit substance-related arrests are an indicator of regulatory 'success'. This puts into question this measure of success, as the market prevails with unscathed accessibility of illicit substances at relatively constant nominal prices.

Furthermore, the complexity of the economy indicates that there can be no single policy or regulatory response to serve all local sub-market contexts. South Africa's history has resulted in differing contexts between provinces, cities, and even nearby suburbs within a city. The resulting recommendation to policy-makers is to address the issues of problematic substance

by focusing on localised, community-orientated responses such as treatment centres, education in schools and for families, and social development.

This research serves as a precursory step to further analysis of the illicit substance economy. A salient message arising from this study is the need to attend to the complexity of the illicit substance economy. The finding show how this market system is dynamic, responsive and resilient. There are anticipated shortcomings of over-simplifying the analysis or using traditional economic theory to a system where the prices of a transaction have many structural and behavioural influences.

There is a need for more data on the drug economy in South Africa in order to attempt to resolve the societal ills that the widespread use of drugs produces. This RDS technique is an effective way to collect data from hidden populations of low-income drug users (Burnhams et al., 2016). For future data collection on the South African drug economy, an inclusion of additional economic variables would be beneficial. This is so that important foundations to understanding the substance economy – such as the price elasticity of demand – can be calculated. Furthermore, an accurate measure of the amount of drugs purchased within a time period (e.g. the number of methamphetamine 'bankies' purchased in the previous week) would be useful as well as an indication of the price paid for each of the weekly purchases. A variable indicating the total amount spent on drugs in a set time period (for example, the total amount spent on drugs in the past month) would be useful to compare to the total monthly income a person receives.

A qualitative analysis of the interactions between male and female drug users and dealers would be a valuable extension of the findings of this research. Understanding how females are viewed in the context of the marketplace for psychostimulant substances is of interest, particularly in light of the different roles played in society and the varying levels of vulnerability experienced by each gender group.

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Appendix I: Assumptions for price data cleaning

The responses to survey questions relating to the price and purity of a particular substance were cleaned in the process of data preparation before analysis. The cleaning process included the following refinements:

- The mid-point of any range provided was used.
- Methamphetamine and heroin were sold in grams and per serving amounts; a dummy variable was created to indicate which of the two options was being reported.
- Outliers were removed. Due to the phrasing of the question, it appears that some respondents gave an aggregated price response instead of a 'per serving' response; in this case these observations were set to missing. Since 'per serving' prices typically fall between the range R20-R50, observations falling outside two standard deviations of the mean were also set to missing. The final range of acceptable responses for a 'per use' amount of methamphetamine is between R 0 and R 108,68.