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Precursors and Prices: Structuring the Quebec Synthetic Drug Market

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Résumé

Information recueillie sur les marchés des drogues de synthèse est beaucoup moins avancée que les études sur d'autres marchés de drogues illicites. La classification relativement récente des drogues de synthèse comme substances illicites, couplée avec ses caractéristiques distinctes qui empêchent son observation, a entravé le développement d'évaluations complètes et fiables des caractéristiques structurelles des marchés. Le but de cet article est de fournir un aperçu fiable sur la dynamique interne du marché des drogues synthétiques, en particulier sur ses caractéristiques structurelles et organisationnelles. En utilisant l'information obtenue à partir de 365 drogues de synthèse saisies par les policiers pendant un an, cette étude sera la fusion de deux techniques, soit la composition des drogues illicites et des analyses économiques, afin de tirer des évaluations fiables des caractéristiques structurelles du marché du Québec de drogues synthétiques. Les résultats concernant l'analyse de la composition des drogues indiquent que le marché des drogues synthétiques au Québec est probablement composé d'un nombre élevé de petites structures, ce qui indique un marché compétitif. L'analyse économique a également fourni des informations complémentaires sur le marché des drogues. Selon la région géographique les couts de la production et les relations entre trafiquant et consommateur influencent le prix des drogues. Les résultats de cette recherche mettent l'accent sur la nécessité de concevoir des politiques qui tient compte des différences régionales dans la production de drogue et reflète la nature compétitive de ce marché.

Mots-clés : Drogues de synthèse, Structure du marché, Analyse de la composition des drogues, Analyse économique, Déterminants des prix

Abstract

Research gathered on synthetic drug markets trails behind studies on other illegal drug markets. Synthetic drug's relatively recent classification as an illicit substance, coupled with its distinct characteristics that insulate it from detection has hindered the development of reliable assessments of the markets structural features. The purpose of this study is to provide reliable insight into the inner dynamics of Quebec's synthetic drug industry, focusing on its organizational features. Using information derived from 365 synthetic drugs seized by law enforcement over a one year period, this study will merge two techniques, drug composition and economic analyses, under a common framework to derive reliable and comprehensive assessments of the structure of Quebec's synthetic drug market. Drug composition analysis examines the drug's chemical and physical profile to make inferences about the market structure while the economic analysis examines price determinants for the same market, providing further insight into its dynamics and distinctive features. Findings from the drug composition analysis indicate that the synthetic drug market in Quebec is likely to be composed of a high number of small structures, indicating a competitive market. The economic analysis provided complementary information, finding that both differential production costs and trafficker-consumer relations may influence price variations, depending on the region. This study concludes by emphasizing that drug composition analysis should be diligently pursued by both researchers and enforcement organizations alike to effectively target and enhance our understanding of the intricate processes that underlie the synthetic drug market.

Keywords: Synthetic drugs, Market structure, Drug composition analysis, Economic analysis, Price determinants

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Preliminary Chapter: Assessing the Synthetic Drug Market

Introduction

The production and export of synthetic drugs in Canada has garnered significant attention in recent years. The increased level of interest in this market has been triggered by large border seizures and recent reports published by narcotics bodies, putting synthetic drugs at the forefront of law enforcement agendas and in the media spotlight. Despite this heightened attention, it has not been accompanied by reliable assessments of the market. Very few analyses of basic elements of the synthetic drug market have been conducted, particularly in regard to its structural features. Further, of the sparse set of studies that have assessed its organizational characteristics significant discrepancies have emerged. Recent reports issued by national intelligence bodies have implied that a few stakeholders control significant shares of the synthetic drug market (Canadian Security Intelligence Services (CSIS), 2010; Royal Canadian Mounted Police (RCMP), 2010), contrasting with decades of literature that states illegal crime groups operate within ephemeral and competitive structures (Block & Chambliss, 1981; Reuter, 1983; Haller, 1990; Potter, 1994). However, the former allegations are based primarily on claims by media accounts, with news sources labeling Canada a "global drug lord" (Glenny, 2009) and drawing parallels between the Canadian synthetic drug market and highly organized Colombian drug enterprises (Godfrey, 2012). These significant charges in light of the paucity of research highlight the necessity of conducting comprehensive and reliable assessments of this illicit market. The purpose of this paper is to provide an empirical analysis of the inner dynamics of Quebec's synthetic drug industry, focusing on its structural attributes and organizational features.

Accurate knowledge about the structural characteristics of the synthetic drug market is critical to effectively evaluate the influence of illicit traffickers, determine the level of organization among members involved in this market, and to examine how organizational structure influences criminal behaviour. Awareness of these market features not only allow us to develop an enhanced understanding of the multi-faceted nature of this market, but also the ability to create effective law enforcement interventions. When police lack knowledge about the organizational characteristics and structure of drug markets, their interventions are often ineffective and may even be counterproductive (Yawnghwe, 1993). With reliable assessments of this market, law enforcement agencies and political bodies can implement evidence based and effective programmes and policies.

However, there are many challenges to studying and acquiring an accurate understanding of this industry, specifically in regard to accessing market participants. Relative to other drug markets, synthetic drug actors are highly insulated, often operating within closed social networks and/or in clandestine facilities, hindering their detection. To overcome challenges with studying market participants, recent studies have emerged that use properties of the market, the drugs themselves as a unit of analysis to reliably examine hidden market participants and overall market structure (Dujourdy et al, 2003; Zingg, 2005; Esseiva et al, 2007). Although drugs are frequently seized through law enforcement procedures, given police and judicial mandates, their use often ends as a justification for arrest and court room evidence. However, with the aid of chemical extraction, these seized drugs can also provide forensic intelligence to gain reliable insight into the structural characteristics and organizational attributes of the drug market. Adopting and building off

methods designed by these studies, the current study will assess the synthetic drug market using two distinct properties of the market, seized synthetic drug tablets and their retail price. The first method will use information derived from the tablets to conduct a drug composition analysis, allowing us to analyze the structure of the market based off the manufacturer's production methods. The second will use price data, permitting an economic analysis of this same market and providing further insight into its dynamics and distinctive features. This multi-pronged approach to analyzing the market merges two separate analyses, drug composition and economic analysis, under one common framework, applying innovative data sources to overcome challenges traditionally encountered when studying illicit markets' structural attributes.

This dissertation is designed in article format and is divided into the following sections. The preliminary chapter will begin by providing the overall context for the study, informing us of the market's history and distinct characteristics. This will be followed by an assessment of studies that have examined the market's structural features and a review of methodological tools to overcome barriers to obtaining reliable analyses of this market. The second section will outline the data sources and methods that have been adopted in this study and how they have been adapted to fit the available data. Applying these techniques, the third section will comprise the core of the dissertation, the article, which assesses the structural features of the synthetic drug market. The concluding chapter provides an in-depth discussion of the limitations and policy implications of the study's findings.

Synthetic Drugs: A Definition

Since their inception into the public sphere synthetic drugs have consisted of a wide range of substances, which is reflected in the wealth of names designating these drugs, including Adam, E, euphoria, hug drug, M&M, rave, X, the love drug, the party pill, hug, beans, and clarity lover's, to name a few (Health Canada, 2009). This plethora of names has caused some confusion and synthetic drugs are frequently misnamed as a result (Zingg, 2005). Generally, synthetic drugs may be defined as illegal substances that have been produced primarily from chemical synthesis, with the use of various precursors (Zingg, 2005). This broad definition comprises a wide array of drugs all constituting a variety of different chemical substances, due to a multitude of synthesis methods and inexperienced or resourceful manufacturers. Further, numerous manufacturers are continuously adapting their production methods to create new synthetic drugs that overcome illegal barriers, causing the composition of drugs available on the market to constantly evolve. These new drugs are dubbed “legal highs” and are created by modifying the molecular structure of an illicit psychoactive substance to create a new compound that mimics its stimulant effect, but remains within the confines of the law. Recent examples include “bath salts” which are synthetic cathinones with a similar chemical structure to amphetamines and a stimulant effect comparable to cocaine and methamphetamine (Loeffler, Hurst, Penn & Yung, 2012). As authorities detect the presence of these new compounds and respond by passing new bans, producers continue to evolve the structure of their products to circumvent the latest law. Consequently the composition of synthetic drugs within the market is constantly evolving with new designer drugs continuously being introduced into the market. To reflect

this wide diversity of synthetic drugs on the market while remaining within the confines of illegal synthetic drugs, this paper will adopt a definition that closely aligns with designations used by both law enforcement agencies and international drug organizations, such as the United Nations Office on Drugs and Crime (UNODC). Consistent with these bodies, synthetic drugs will encompass amphetamine type substances (ATS), including amphetamine (speed), methamphetamine (crystal meth, ice), and 3, 4-methylene-dioxy-N-methylamphetamine, (MDMA, ecstasy).

Towards a Criminal Market

Synthetic drugs have not always been classified as illegal substances. Their materialization into the licit market and eventual criminal classification highlight the distinct characteristics of this market and fluctuations in their use. First synthesized in 1887 by a German chemist, the wholesale demand and supply of amphetamine did not begin until approximately half a decade later (Gahlinger, 2004). In the late 1930's, as pharmaceutical companies and physicians became cognizant of their stimulant and alleged beneficial medical properties, they emerged into the legal domain marketed to the general public and prescribed for a variety of conditions, including depression, asthma, fatigue and obesity (Gahlinger, 2004). Eager to enhance soldier performance this trend also caught on with the military who began to supply combatants with synthetic drugs in efforts to increase productivity and stamina levels (Rasmussen, 2009). These provisions for troops began during the 1936 Spanish war (Iverson, 2008) and were greatly expanded during the Second World War, as American, German and Japanese armies, searching for a competitive advantage, provided these drugs to their troops (Grinspoon & Hedblom, 1975). The drugs

addictive properties, their ability to create pleasurable feelings via increased serotonin and dopamine levels in the brain, combined with the intense marketing and prescription of these drugs created the conditions for a surge in dependence problems among the population (Rasmussen, 2009). In response to the significant growth in the abuse of these drugs and the rising awareness of their detrimental side effects, amphetamines discontinued to be legally prescribed, were removed from military use, and ultimately criminalized in the United States in 1985 after more than half a century of legal use (Hammersley, Khan & Ditton, 2002).

Initially accompanying synthetic drugs' transition into an illegal substance was a recorded decrease in their consumption, attributed to both the severance of a reliable supply chain and changes in consumer preferences (Rasmussen, 2009). Recreational consumers no longer had the same secure access to these drugs that they had become accustomed too, having to turn to illicit and therefore unverifiable sources to obtain the same product (Rasmussen, 2009). In addition, during this period cocaine experienced a dramatic surge in popularity, with many users turning to it as an alternate stimulant (Rasmussen, 2009). However, this decline of synthetic drug use was relatively short lived, as a rave subculture developed in the late 1990's, which promoted and highly popularized the use of synthetic drugs (Gross, Barrett, Shestowsky & Pihl, 2002). Raves were large parties characterized by all night techno music, flashing lights, dancing, and the use of synthetic drugs. These illegal drugs were a core element of these parties, as they enhanced the experience by increasing positive emotions and creating a feeling of cohesiveness, generating the perception that one can experience the feelings of others (Gross et al, 2002). Furthermore, economically it

became a rational choice among users as synthetic drugs are cheaper than cocaine per dose and their "high" lasts significantly longer (Rasmussen, 2009). In response to this increased market demand and the ease with which these drugs can be manufactured synthetic drug use experienced a revival and in turn, clandestine laboratories proliferated (Pietschmann, 1997).

While a growth in the demand and supply of illicit synthetic drugs (Pietschmann, 1997) has generated an interest in this criminal phenomenon, it has not been accompanied by an increase in knowledge about this market. However, this history of the market informs us on some of the unique and diverse properties of the market that generate from the drug's production methods. Distinct from other markets, the pharmaceutical nature of synthetic drugs allows for production facilities to be established near consumer markets, as they can be produced through a variety of synthesis method with basic laboratory equipment and widely available precursors. The chemicals to manufacture synthetic drugs may be easily obtained through legal businesses including batteries, match heads, cold medication, acetone, brake cleaner, and propane (Cherney, O'Reilly & Grabosky, 2006). In addition synthetic drugs can be made using either precise laboratory tools such as magnetic stirrers, or easily assembled equipment from accessible products, including coffee filters, pop bottles, and hot plates (Chiu, Leclerc & Townsley, 2011). Further facilitating the ease of production, after obtaining the necessary equipment, due to the relatively small spaces required to produce small to large batches of synthetic drugs laboratories may be set up in a variety of areas, including car trunks and motel rooms (Cherney et al, 2006). In light of the potentially limitless production areas, the synthetic drug market is not geographically

centralized around a restricted number of source countries, in contrast to heroin and cocaine markets, meaning that distribution chains are generally shorter and there is greater fluidity between positions (Chiu et al, 2011).

Further differentiating the synthetic drug market, not only are the chemicals to produce these drugs relatively easy to acquire, but, once obtained with some experience, the commercial production of synthetic drugs is relatively quick. Natural plant based drugs (i.e. cannabis and heroin) require the agricultural process of planting and cultivation, favourable soil and weather conditions in addition to a chemical conversion so that they may be sold to users. Commercial production at this level is capital and labour intensive when compared to the production of synthetic drugs. Synthetic drugs are synthesized through chemical methods with relatively short time periods. The ease with which synthetic drugs may be produced in a variety of environments highlights the potential breadth of actors who may be involved in this industry and the ability of actors to set up multiple covert facilities, influencing assessments of the market's overall structure.

This is reflected in the demographics of synthetic drug markets, which has been reported to consist of a higher portion of non-marginalized, middle to high class individuals, including young professionals and students, influencing the social dynamics of this market (Massari, 2005). Many of the relationships between consumers and distributors are social, with distributors often being consumers themselves, selling their product in private locations and within networks with close social ties (Massari, 2005). The backgrounds and relationships between traffickers influences the operations of these markets as illicit actors from the middle class may not only have more incentives, but also

the resources to conduct transactions in clandestine facilities. The ability to quickly set up production facilities in a variety of environments, coupled with the market's unique demographics, stress the unique features of this market, specifically those that insulate actors from detection.

Structural Assessments of the Synthetic Drug Market

The defining characteristics of the synthetic drug market emphasizes the importance of conducting reliable studies with methods that take into account its defining features, particularly those which hide illicit actors from the purview of researchers. To date, few reports have provided reliable examinations of the market and even fewer of the Canadian market, despite claims that large sophisticated groups operate within the country's synthetic drug trade. The Canadian Security Intelligence Service (CSIS) 2010 in their Organized Crime Report claim that clandestine 'super labs' (although they fail to define the size of these "large" laboratories) have flourished in Canada to meet the demands of consumer countries, such as Australia and New Zealand (CSIS, 2010). Also supporting these claims is the RCMP Criminal Intelligence Division in their 2009 report on the Illicit Drug Situation in Canada. This report stated that not only are organized crime groups alleged to be in charge of "economic based laboratories" (covert laboratories whose sole goal is to make profits by responding to both national and international demand), but comparatively speaking, they are present in higher numbers than "addiction-based labs" (smaller laboratories that are used to produce synthetic drugs for personal use) (RCMP, 2010). These claims suggest that the synthetic drug market consists of highly structured groups

that monopolize the illegal market, producing wholesale quantities of synthetic drugs to meet the demands of consumer countries.

However, these statements by national agencies that encourage a rigid perspective of criminal collectives should be interpreted with caution, as much of the data and methods used to derive their conclusions are undisclosed. By failing to identify their methods, it has prevented external, independent researchers from reviewing and evaluating how the results were obtained. It has been stated that drug market reports based on classified methods that have not been subject to review lack evidence of ongoing methodological improvements (Kilmer, Caulkins, Bond & Reuter, 2010). The lack of substantive evidence to support the conclusions in the reports allows individuals to question the veracity of their results.

In contrast to CSIS, the RCMP Criminal Intelligence Report (2010) reveals one of their data sources. In the 2010 report, the RCMP stated that their findings relied primarily on seizure data. However, in addition to lack of detail on this data source (they only state that seizure data was used), seizure data has been criticized for not being a valid indicator of drug markets due to its potential to fluctuate in response to factors that are not related or reflected in actual changes in the drug market. To begin with, police seizures inform us of police strategies and thus the activities of these authorities, rather than actual market behaviour. Seizure data may vary in tandem with shifts in law enforcement priorities, indicating enhanced police targeting and funding, rather than increases in production (Bouchard et al, 2011). While it is hypothesized that using seizure data taken from a wide array of regions will compensate for different law enforcement mandates and thus provide a reflective picture of the drug market, the above report did not indicate the sources of this

data we are therefore unable to assess whether the findings may reflect actual trends in the market. In addition, it is important to emphasize that the overall sizes of annual seizures may be influenced by a single seizure, reflecting one large consignment rather than any significant structural change in the overall industry. To obtain reliable assessments of market trends and features multiple sources should be consulted for more impartial and accurate observations of illicit activities. As with reliable studies into illicit activities, law enforcement authorities should integrate a number of different methods and sources into their research, for example using consumer self-reports and wastewater analysis, which uses the level of drug residues in wastewater to assess the combined usage of drugs, to augment the reliability of findings about market trends.

Providing a transparent examination of the organizational structure of synthetic drug markets was a multi-site European study conducted by the Gruppo Abele (2003) Over a three year period, three research teams analyzed urban European synthetic drug markets; Barcelona (Montañes, Barruti, Pallarés, & Domínguez, 2003), Amsterdam (Blickman, Korf, Siegel, & Zaitch, 2003), and Turin (Massari, Mareso, Monzini, & Veglio, 2003). Applying a multifaceted approach that relied primarily on qualitative research tools, including interviews with police officers and drug traffickers they established that many groups operated in a loosely structured, flexible decentralized market, with few barriers to entry or exit. Their research was highly valuable as two of the drug markets they observed were at different stages of development; allowing them to make distinctions and learn about variations in structure. A young market, Spain, consisted primarily of small amateur labs that manufactured a relatively small amount of pills destined for local consumption

(Montañes et al, 2003). In contrast the Netherlands had developed into a more professionalized market that consisted of small groups and a network structure that relied on the outsourcing of specialists, such as chemists and individuals involved in the trade of precursors (Blickman et al, 2003). Regardless of degree of professionalization their research allowed them to determine that the synthetic drug market was highly adaptable and an "extremely fluid and multifaceted phenomena" (Gruppo Abele, 2003, p. 223).

While this report provides an extensive analysis of the synthetic drug market, the primary method to investigate the synthetic drug market by the Gruppo Abele was through the use of interviews with active, former, and indirect participants involved in the synthetic drug trade. Although this method provides a technique to learn about the structure through insider accounts of the drug markets, these sources may only provide partial accounts and misrepresent the sphere and characteristics of the drug market as a whole. In addition, these methods primarily relied on data obtained at the retail level, not allowing for insight into higher level players, and thus more influential actors in the market. To overcome these limitations in their data, quantitative data was also obtained, although to a lesser extent, to examine the market. Highlighting the challenges with gaining a comprehensive understanding of the nature of illicit phenomenon, the report concluded by emphasizing the necessity of conducting further analyses of this drug market at both the local and international level (Gruppo Abele, 2003).

Underscoring the necessity of conducting up to date analyses of the synthetic drug market is the adaptive nature of these markets in response to shifts in the market and law enforcement policies. According to the 2011 World Drug Report, in response to enhanced

law enforcement targeting and stricter government controls on precursors, manufacturers relocated operations to less prosecuted locations and modified the chemical composition of their drugs, substituting alternative, deregulated precursors (UNODC, 2011). This flexibility was observed after governments restricted the availability of two commonly used precursors, ephedrine and pseudoephedrine. In response to these new controls manufacturers adapted their production methods, replacing these precursors with one that shared a similar chemical structure, norepinephrine (UNODC, 2011). Another innovative method that manufacturers have used to overcome these enhanced restrictions has been to convert uncontrolled precursors into controlled precursors after shipment, to reduce the risk of detection during transport (UNODC, 2011). Dobkin and Nicosia (2009) also highlighted the ability of producers to modify their methods in response to police tactics. After a crackdown on two major precursor suppliers the researchers noted that although synthetic drug purity initially decreased it quickly returned to pre-crackdown levels as manufacturers replaced the precursor ephedrine with pseudoephedrine, a synthetic substitute. This ability to adapt in light of increased prosecution can be further applied to the positioning of players, as demonstrated by a qualitative study conducted by Chiu et al (2011) who examined a synthetic drug market in Australia using crime script analysis. Through the examination of multiple court documents that recorded the sequence of actions of lab manufacturers, researchers concluded that not only were producers' methods highly flexible, but so were the roles of offenders, who could fluidly move among different positions filling gaps in illegal actors (Chiu et al, 2011). This degree of flexibility highlights the fluidity of the synthetic drug market as well as the potential for structural

features to adapt over time as groups respond to market changes, emphasizing the necessity of up to date research that reflects current trends.

Innovative Assessment Methods

The current lack of validated information about drug markets may be attributed to the paucity of innovative methodological tools to assess them (Bouchard, 2007). To overcome the distinct barriers with analyzing synthetic drug markets requires that we use innovative methods that extend beyond traditional techniques. As mentioned, traditional methods such as interviews with illicit participants pose significant challenges to obtaining reliable insights. This is also extended to established investigative methods commonly used to make inferences about drug markets, including wiretaps, police surveillance, and informants, which are rife with problems including fractional accounts and apocryphal information that may lead to misrepresentations of the problem (Esseiva et al, 2007). The history of this market, its evolution from a pharmaceutical product synthesized in legal facilities to an illicit substance produced in unregulated clandestine laboratories, informs us of the characteristics that entrench it from our view, only permitting fragmented insight into its inner dynamics. These distinct properties of the market render conventional methods to assessing this industry inadequate and require that researchers apply innovative techniques. Recognizing these challenges, alternative methodologies have recently emerged, including drug composition and economic analysis, providing valuable tools to assist in the development of reliable and comprehensive analyses of illicit markets.

Drug Composition Analysis

Drug composition analysis uses seized drugs to assess illicit market features. This method relies on the central component of the market, the drugs themselves, as the central unit of analysis, bypassing limitations inherent in using illicit actors to assess the market. Drug composition analysis examines the drug's chemical makeup and physical properties to make inferences about the market structure. Given the diversity of synthetic drugs, the variety of production methods, the organic impurities that are formed at different stages of the synthesis process, an infinite number of cutting agents, and numerous settings on pressing devices each synthetic drug is presumed to carry a unique profile based on its physical attributes (e.g. colour and logo) and chemical characteristics (the number of and concentration of different substances present in the tablet). It is assumed that these characteristics are unique to each producer and can be used to identify batches of synthesized drugs, serving as an identifying personal signature. Thus, drug composition analysis is uniquely placed to derive information about the manufacturer.

After the first step in data composition analysis, the extraction of the drug's chemical profile and the systematic measurements of its physical profile by trained chemists, the data can be analyzed to identify drugs that share chemical compositions and physical features. Drugs produced by the same manufacturer can be identified by linking drugs with similar characteristics (tablets with the same concentration of active substances and organic impurities and/or physical features). By grouping drugs with similar profiles it allows us to examine the number of producers in a given area, the output of a given manufacturer, trends in production methods, and distribution networks, revealing the

organizational characteristics and structural attributes of the market. Based on the aforementioned premise, that each drug carries the manufacturer's unique signature, if the combined seizure data indicates numerous and different tablets, this may suggest the presence of a competitive market where multiple, independent producers or small groups are responsible for the synthetic drug market. If the results reveal a high percentage of similar tablets, it may indicate a monopolistic and centralized market where only a few players or groups are responsible for the majority of drug production. Thus, this method allows us to assess the market using an accessible unit of analysis, the drugs themselves, to provide a rare glimpse into the structure and social organization of drug manufacturers.

To accurately conduct a drug composition analysis numerous characteristics of the synthetic drug market need to be taken into account when interpreting results. In addition to the aforementioned distinguishing traits of the synthetic drug market, it is also essential to note the two distinct steps in the synthetic drug manufacturing process: the pre-tabletting stage, which involves the chemical synthesis of the active substance, and the post-tabletting stage, the compression of the powder into tablet form. The first step, the pre-tabletting component of production, comprises the creation of the drug's chemical composition, including the active substance and organic impurities that are formed during synthesis as well as any cutting agents that are added to the final product. This stage is influenced by numerous factors including the method of synthesis, the chemicals used, and the quality of the precursors (Milliet, Weyermann & Esseiva, 2009). Following this step is the post-tabletting stage, which creates the physical appearance of the tablet and involves the compression of the powder into its final shape (Milliet, Weyermann & Esseiva, 2009). This

step often involves a tableting machine, which determines the weight, diameter, logo, and other physical features of the tablet. Punches and other settings on the device may be changed to produce different physical features. After the compression of the tablet, the samples remain static with no further changes to its structure until after purchase or seizure (Milliet, Weyermann & Esseiva, 2009). It is essential to factor in these two stages when conducting a drug composition analysis, as they may be conducted in different locations and reflect separate actors.

Providing a framework on how to reliably use drug composition data to analyze illicit drug markets has been extensive research in Europe. In particular a project funded by the European Commission, the Collaborative Harmonisation of Methods for Profiling of Amphetamine Type Stimulants (CHAMP), has significantly contributed to the development of advanced techniques to extract drugs' chemical and physical profiles and methods to apply this information into a drug intelligence context. In attempts to create a harmonized profiling methodology and a common drug database, these researchers conducted numerous studies to analyze links between seizures (Weyermann et al, 2008). Two particularly relevant studies, taking the two separate stages of production into account examined individually the ability of organic impurities (Weyermann et al, 2008) and physical features (Marquis et al, 2008) to discriminate both between and within seizures.

The first study examined the organic impurities that are created during synthesis from a sample of 26 MDMA seizures obtained from Finland and Germany in addition to 80 MDMA tablets that were collected from seizures by laboratories in Finland, Netherlands, France, and Switzerland (Weyermann et al, 2008). The researchers used the gas

chromatography spectrometry method, developed by the Netherlands Forensic Institute (NFI), to extract the tablets chemical profile and used a fixed correlation value to determine whether drugs' profiles were linked or not. Using this statistical test, researchers demonstrated that organic impurities could be used to establish connections within seizures and distinguish between different seizures (Weyermann et al, 2008). These findings demonstrated the potential of statistical tools to illustrate links between drugs. The second study, which examined tablets' physical characteristics, using the squared Euclidean or the Manhattan distance, determined that diameter, thickness, weight, and score of the drug were all reliable characteristics to distinguish between drugs from different seizures. The findings allowed researchers to conclude that the drug's physical properties brought complementary information to the organic impurity analysis (Marquis et al, 2008). However, given that two separate tableting machines with the same settings can produce similar physical characteristics it was emphasized that physical characteristics should be used in tandem with other information for more accurate interpretations (Marquis et al, 2008).

A further study which examined the value of both sets of characteristics, chemical and physical, also determined that organic impurities provided more reliable evidence for linking tablets between seizures (Milliet, Weyermann & Esseiva, 2009). This study demonstrated that many tablets with similar chemical compositions may be pressed into tablets with different physical appearances. The study concluded by emphasizing that despite chemical compositions providing stronger evidence of links between seizures, each stage of production provides distinct information about the production process and is thus

relevant to the analysis whether each used on individually or combined together (Milliet, Weyermann & Esseiva, 2009).

Further research has provided a model for practical applications of drug composition analysis, including studies that have categorized and identified links between heroin (Dujourdy et al, 2003; Esseiva et al, 2007) and synthetic drug (Zingg, 2005) seizures. These studies detail how to assess the illegal synthetic drug market by analyzing links between drugs with shared compositions and physical attributes. Using seizure data obtained over six years researchers extracted and analyzed the physical and chemical profiles from 67 different heroin seizures, identifying 34 chemical groups. Linking drugs according to a fixed correlation value, their findings determined that the heroin market may consist of fewer producers relative to the cocaine market (Esseiva et al, 2007). Applying this method to the synthetic drug market Zingg (2005) analyzed 1000 synthetic drugs seized from 1997 to 2000. Based off his analysis Zingg (2005) found a high number of distinct profiles, implying a high number of producers in the market. The practical application of this method demonstrates its utility in assessing the organization of clandestine markets.

Economic Analysis: Price Determinants

A further method to analyze the synthetic drug industry is through an economic analysis. The core data source of this analysis are prices, which are a basic element of the market and can reveal the economic forces and factors at work in illicit enterprises. Drug prices are a valued research tool to analyze illegal drug industries, as they are a fundamental component of drug markets (Caulkins & Reuter, 1996; Caulkins & Baker,

2010). As we know little about the synthetic drug market we also know little about price variations therein and the factors that account for such price variations. Price data has been used extensively to inform drug policies and provide insights about drug markets, including the effectiveness of law enforcement interventions (Caulkins & Reuter, 2010) and to monitor changes in the structure of illicit drug markets (Rhodes, Hyatt & Scheiman, 1994). These studies rely primarily on price oscillations over time to make inferences about changes in the drug market. However, to reliably use price data to analyze illegal drug markets, it is essential that the determinants of illicit drug prices are comprehensively understood; otherwise we risk making faulty conclusions and attributing price fluctuations to unrelated factors. In addition knowledge of the determinants of these price variations can provide information about the internal dynamics of the illicit market, revealing production costs, behavioural trends, market structure, consumer trends, demand and supply and other factors that lead to the final setting of prices. Currently there is a lack of empirical knowledge about synthetic drug markets, particularly in regards to their price determinants. Current research on drug markets demonstrate that they are influenced by both the same economic rules as legal markets as well as unique factors associated with operating in an illegal market. To begin with, drug prices are governed by similar market forces as legal commodities (Reuter & Haaga, 1989; Pietschmann, 1997; Ritter, 2006), complying with basic economic supply and demand principles (Ritter, 2006). In its most basic form, changes in the market are reflected in the supply or demand of a commodity, which subsequently impacts its price. Price changes occur to restore market equilibrium, where supply equals demand, so as to regulate product shortages or excesses (Moore et al, 2005).

Research on the heroin drug market has demonstrated that one of the effects of a shortage of heroin supply is an increase in price, although the purity or volume may also be influenced to compensate for shortages (Moore et al, 2005). In addition, according to economic theory the structure of the market influences the degree to which drugs are marked-up from their wholesale cost to their retail price. In markets where the structure more closely resembles a monopoly, prices generally have a higher mark-up, as market controllers can set prices without fear of being undermined by other competitors. This potential to set prices higher in monopolistic industries is particularly applicable to the drug market which has a relatively low price elasticity of demand (Costa Storti & De Grauwe, 2009). In contrast, within a competitive market price mark-ups will generally be lower, resulting in lower prices for consumers. Competition between traffickers drives prices down as actors attempt to attract business and users have the option to select from a variety of suppliers (Costa Storti & De Grauwe, 2009). However, recent research has been exploring how the unique characteristics of illicit markets, may make it diverge from conventional licit market models (Caulkins & Reuter, 2010).

Although drugs comply with some of the same principles as legal goods, current prices of illicit drugs are significantly higher than were they sold in a legal market (Moore, 1990; Miron & Zwiebel, 1995). To account for these price disparities, additional distinct factors, tied to their illegality, also influence the retail price of drugs (Caulkins & Reuter, 1998). While operating in an illegal market reduces some costs associated with running an enterprise, additional risks incurred by the product's criminality significantly increases expenses. Operating in an illegal market allows fewer expenses due to drugs small volume

and the ability of drug participants to transport or store drugs illegally (e.g. in abandoned warehouses), which means that shipping and storage costs are often minimal (Caulkins & Reuter, 1998). In addition, drug traffickers products are not taxed and marketing costs are negligible, as advertising attracts unwanted law enforcement attention. Thus, marketing is generally limited, if any, to the physical modification of the drug's packaging with a brand, such as a stamp of a logo (Caulkins & Reuter, 1998). However, these financial benefits are overshadowed by the costs associated with the risks of operating in an illegal market, which are primarily responsible for drugs' high prices. These risks include violence, law enforcement seizures of their product, incarceration, and associated legal costs (Caulkins & Reuter, 1998). In a period with high rates of drug associated violence in the U.S., during the late 1980s, Caulkins and Reuter (1998) determined that the risk of being a victim of serious violence was responsible for 40% of total costs of supplying cocaine to customers. These additional risks significantly hike up transaction costs and subsequently the drugs final retail price.

In addition, drug prices vary widely from transaction to transaction. A major determinant of these fluctuations is the quantity of drugs that are sold during each sales transaction. As the quantity of drugs purchased per transaction increases there is a corresponding decrease in the price per unit sold (Caulkins & Padman, 1993). Although quantity discounts are also observed in licit markets, the degree that drugs are marked-up in illicit markets is significantly higher (Caulkins & Reuter, 1998). In the illicit drug market, drugs often pass hands multiple times through players to the different market levels, from the wholesale supply to the final purchase by individual users (Caulkins & Reuter, 1998).

With each subsequent movement of the product down the distribution chain, the quantity of the drug sold generally decreases with the price per unit increasing, with bulk purchases transpiring at the wholesale level for the lowest prices and individual drug purchases at the end user level with the highest cost per unit (Caulkins & Padman, 1993). The greatest mark-ups in this process occurs between the price paid by the bulk dealer who purchases directly from the supplier and the final transaction between the trafficker and consumer (Caulkins & Reuter, 1998).

The high number of players required to covertly move drugs from producer to final user constitutes another main cost of drug trafficking, the labor cost (Caulkins & Reuters, 1998). This inefficient distribution system that is often necessary for drugs to clandestinely pass drugs from top market levels through to lower levels influences the share of profits that each player receives, and thus what the drug is sold for. These labor costs may be influenced by technological advances that improve business efficiency in licit economies, such as improved communication and transport services. With improved and easier communication between suppliers, purchases may become more efficient requiring fewer intermediaries to process transactions and pass on messages (Costa Storti & De Grauwe 2009). In addition, recent trends that have increased accessibility to transport and overall licit travel has permitted illicit drug manufacturers to more easily blend in and decrease the chances of detection (Costa Storti & De Grauwe, 2009). Illicit markets that operate more efficiently, with fewer intermediaries and less risk, have fewer costs to pass on to consumers.

In addition to a drug traffickers costs, drug purchasers' expectations and credence of the drug's purity also influences prices. This was demonstrated by the "Expected Purity Hypothesis" developed by Caulkins (1994), which states that a key factor that influences drug prices are consumers' perceptions of the drug's potency. Given that drugs are "experience goods" purchasers are often unable to assess their quality until after consumption (Reuter & Caulkins, 2004; Caulkins, 2007). Additionally, even after consumption it is difficult for the user to estimate the drugs purity, as some cutting agents have psychoactive effects distorting their perception of the drugs quality (Reuter & Caulkins, 2004). Thus, consumers, unable to assess the drug's true quality may rely on other factors, such as the drugs image, brand, and drug traffickers reputation to evaluate the quality and hence the price they will pay, during the time of purchase.

This finding has been confirmed in both the cannabis (Lakhdar, 2009) and cocaine market (Evrard, Legleye, Cadet-Taïrou, 2010). Lakhdar (2009) found that heavy users of cannabis expectation of the cannabis' potency rather than its true potency influenced the price they paid, with the price increasing approximately 1.2% when the customer's perception of the drugs potency increased by 10%. He also demonstrated that consumer's expectations of the products quality were influenced by the drug's brand, although brands were only minimally correlated with the drug's true quality (Lakhdar, 2009). Evrard et al (2010) also found that prices were partially influenced by an user's perception of quality, which primarily depended on the information provided by the trafficker. Thus, this provides us with evidence, that prices are marginally influenced, by the consumers' credence of the

drug's potency and that drug customers may become victims of strategic manipulation by traffickers to increase their profits (Reuter & Caulkins, 2012).

Despite extensive research that has examined various determinants of drug prices, only a few have examined how the drugs true or perceived quality, or brand influences prices, and none were found to empirically examine how these factors influence the determinants of synthetic drug prices. Given the unique characteristics of synthetic drug markets, higher costs associated with production, the logos associated with synthetic drug tablets, and drug participant (traffickers and users) demographics, it is essential to examine separately whether these factors influence synthetic drugs' retail prices. Extensive research has identified numerous interacting factors that influence drug prices, however few studies have examined how the quality, brand of the drug, and a purchaser's perception of the drug can impact prices, despite the fact that there is evidence that these factors may play a large role in the synthetic drug market.

To begin with, the production costs associated with manufacturing synthetic drugs may be significantly higher than the costs associated with producing organic drugs, such as heroin, cocaine, and cannabis. In organic markets, markets in which drugs are produced using agriculture methods, production costs are relatively cheap. For example, the raw materials to produce heroin are very low, forming a marginal portion of its final price, with prices being marked up 99% from wholesale in its country of origin to the retail price it is sold for in the United States (Caulkins & Reuter, 1998). Consequently, production costs are so insignificant that they have not been shown to influence prices (Reuter & Caulkins, 2012). However, in contrast some scholars have suggested that the quality of synthetic

drugs drives price fluctuations in some markets (Antonopolous, Papanicolaou & Simpson, 2010). The manufacture of synthetic drugs requires acquiring and synthesizing various chemicals, and these associated production costs may be higher. Although, studies have not specifically determined the costs of these chemicals on the black market, one study that has examined the costs of operating a synthetic drug laboratory may suggest that raw materials consist of a larger share of drug traffickers' total costs. Using data obtained from the internet, Bouchard et al (2011) assessed that it costs approximately $200 to produce one ounce of meth in a small lab, excluding the cost of anhydrous ammonia, labor and risks. This one ounce, which is cut with fillers to expand its volume by two or three ounces, is then sold for approximately $1500 an ounce. Thus, this indicates that if meth is diluted to three times its volume, drugs are marked up approximately 22.5%. Consequently, production costs for small labs play a larger role in contributing to total costs, possibly meaning that the drugs composition, and therefore quality, has a greater influence on its price.

However, higher production costs may not apply to all synthetic drug manufacturers. Studies have demonstrated that some producers may steal the raw materials to produce synthetic drugs (Sexton, Carlson, Leukefeld & Booth, 2006) and manufacture laboratory equipment out of inexpensive products, such as coffee filters (Chiu et al, 2011), significantly reducing production costs. In addition, large laboratories that produce synthetic drugs in bulk may obtain their raw materials at a lower price, reducing production costs. Thus, for synthetic drug manufacturers for whom ingredients form a significant

portion of their total costs, it may be assumed that its quality plays a greater role in the final retail price, as these drugs cost more to produce.

Furthermore, synthetic drug consumers may place a greater emphasis on visual characteristics, specifically the drug's logo. Logos have only relatively recently appeared on illegal synthetic drugs as a method to market drugs (Duterte, Jacinto, Sales & Murphy, 2009). Originally synthetic drugs were consumed as small white tablets, however this changed in the late 1990s when producers began to imprint a variety of distinct colours and logos on ecstasy tablets (Duterte et al, 2009). It is suggested that synthetic drug distributors may choose specific brands for their pills to convey messages to consumers about their product (Duterte et al 2009). Thus, drug consumers, who are unable to evaluate the quality of the pill during the time of purchase may rely more on the drugs brand to make inferences about its composition and quality more so than in other drug markets. Consequently, drug brands perceived to represent drugs of higher quality may be sold for higher prices.

To contribute to our overarching understanding of the synthetic market, it is essential to explore these factors to gain insight into the inner workings of the market. To date research has allowed us to determine that drug prices in the illicit market are governed by many of the same rules as legal economies, and additional factors related to operating in an illicit economy, including risks of apprehension, drug purchasers expectations and credence of the drug's purity, as well as threats or use of violence. However studies have neglected to examine how or whether these same or additional distinct factors have the same effect on synthetic drug markets. Learning about specific factors that set prices in synthetic drug markets can allow us to make inferences about the distinct features of this

market. From what we know, synthetic drug production is different from other organic markets, which may play a role in influencing the final prices. This study will explore price determinants for synthetic drugs to identify specific factors which may reveal more about the internal characteristics of this market.

The Current Study

Providing a systematic and empirical analysis of the synthetic drug market and applying methods aimed to overcome the unique challenges of assessing the synthetic drug market, this study will examine the social organization of synthetic drug producers using two methods: drug composition and economic analysis. The first method will assess the structure of this market by examining the drugs produced by manufacturers, while the second method will capture its distinct characteristics by examining the price determinants of these drugs. The application of two methods is incorporated to help fill the gap in knowledge about this market and assist in overcoming the limitations associated with using a single method. This explorative study, using drug properties will provide for a reliable and comprehensive assessment of the structural attributes and organizational characteristics of the synthetic drug market, allowing us to enhance our knowledge and create policies based on empirically validated findings.

Methodology

The methodological limitations inherent in examining clandestine markets benefit from multi-pronged approaches that augment the validity of a study's results. This study will merge two methods that allow for the examination of the synthetic drug industry from both the perspective of the manufacturer and the consumer in order to conduct a comprehensive analysis of the market's features. The first assessment, from the manufacturer's perspective, will be conducted with the aid of data composition analysis. This approach examines the social organization of production by analyzing the recipes that each manufacturer uses to produce the drug, relying on the premise that each drug carries the manufacturer's signature, based on the drug's distinct colour, logo, and composition, including its active substance(s) and cutting agent(s). The second method, economic analysis, will assess this same market from the consumers' perspective by examining factors that influence the prices users pay for synthetic drugs. While the first method will identify how the market is structured, the latter will further validate the findings, while providing additional insight about distinct features of this market based off price variations. These methods were selected as the most suitable to respond to the analytical aim of the research, in light of the nature of the data and emerging research that provides a model on how to use seized drugs as the unit of analysis.

Sources of Synthetic Drug Tablets

Drug composition data for seized drugs is rare in Canada, as there are no common databases and the analysis of seized drugs is not incorporated into regular law enforcement procedure. Although illicit drugs are frequently seized by authorities, their chemical analysis is limited to specific requests made by law enforcement or the Courts. Due to the

limited analysis of drugs in it was exceptional that we were able to obtain a large enough sample to conduct a drug composition analysis to assess the synthetic drug market within Quebec. This study obtained 365 synthetic drugs through a unique project commissioned by the federal government in response to a growing concern over the rising consumption of synthetic drugs. The project was designed to raise awareness about the contents of synthetic drug tablets across the Quebec province and to inform users of the disconnect between a drug's appearance and its chemical composition, aiming to demonstrate that physical features are not reliable sources of information about a drug's contents. Due to the objectives of this project, the drugs analyzed in the study were limited to a sample of 365 drugs seized by municipal and provincial police forces across Quebec between June 2007 to 2008. In attempts to obtain drug samples from all areas of Quebec municipal police forces, the Service de police de la Ville de Montréal, Service de police de la Ville de Longueuil, Service de police de la Ville de Laval, Service de police de la Ville de Québec, and the provincial police force, Sûreté du Québec, all contributed samples of their seizures from their respective regions for analysis. These drugs were analyzed by chemists at Health Canada who extracted and systematically classified the synthetic drugs into categories based on their chemical composition (active substance and cutting agents) and physical features (score, colour, and logo) providing detailed information for each tablet.

Among the total 365 tablets that were collected in this sample there were four major active substances (MDMA, MDA, methamphetamine and amphetamine), and over forty adulterants, cutting agents and/or by products of the chemical reactions present. Forty-four substances were identified in all of the seized tablets. The most popular substance was

caffeine (61.1%; n=223), followed by methamphetamine (57.3%; n=209) and MDMA (28.2%; n=103). These 44 substances, listed in order of prevalence from highest to lowest, included caffeine, methamphetamine, MDMA, diphenhydramine, procaine, dimethylsulfone, MDA, amphetamine, ketamine, phenylacetic acid, clonazepam, ephedrine and/or pseudoephedrine, lidocaine, lorazepam, methylphenidate, citalopram, nitrazepam, quetiapine, 5-methoxy-N,N-diisopropyltryptamine, 5-methoxymethylisopropytryptamine, acetaminophen, benzylpiperazine, celecoxib, codeine, dextro and/or levo methorphan, deomperidone, flurazepam, glucosamine, metotrimeprazine, methylaminorex, N,N-dimethylamphetamine, nexus, niacinmaide, niacin, oxycodone, penicillin V potassium, Phenylpropanolamine, piperonal, psilocybin, sildenafil, tadalafil, trifluoromethylphenylpiperazine, vardenafil and zopiclone.

Of the four active substances in this sample, methamphetamine was the most popular present in 57% of all tablets. Following methamphetamine was MDMA, which was found in 28% of all the seized drugs. MDA and amphetamine were both present, but in significantly lower quantities. Only 6% of all drugs contained MDA and 4% possessed amphetamine. Of the forty different cutting agents that were present in this sample the three most popular were caffeine (61.1%), procaine (8.5%) and dimethylsulfone (8.5%). Eighty different tablets were identified among the 365 seized synthetic drugs, each tablet a different combination of the forty-four active substance(s) and/or cutting agent(s). The most popular tablet contained methamphetamine and caffeine (27.4%). The broad definition of synthetic drugs, endless substances used to dilute these tablets and a variety of different production methods accounts for the wide array of drugs with different chemical

compositions that fall under this designation. Consistent with this sample, reports on synthetic drugs have frequently found that seized tablets consist of a wide range of pharmacological constituents (Cole et al, 2002; Parrot, 2003; Kalasinsky, Hugel & Kish, 2004). Of the substances present in these drugs, MDMA has been increasingly less present (European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), 2011), which is consistent with this study where only a fraction of all drugs contain MDMA (n=99; 27%).

The wide range of tablets with different chemical compositions was also consistent with their physical characteristics, which contained both a high number of different logos (n= 122) and colours (n=12). Of the different logos in the sample, the most popular were a symbol of a "star" and "on star", which both, individually, accounted for 3.8% (n=14) of all drugs. The drugs were one of twelve different colours, the most prevalent being white, accounting for 61.4% (n=224). Synthetic drugs in other studies are also characterized by a diverse range of physical characteristics, with many tablets carrying a high number of different logos (Parrott, 2003; Teng et al, 2006).

All the synthetic drugs in this sample were classified according to the region that they were seized in, providing us with valuable information on potential regional differences in synthetic drug trafficking across Quebec. Drugs were seized in nine different areas across Quebec, including Abitibi-Temiscamingue, Bas Saint-Laurent, Cote-Nord, Estrie, Gaspesie, Mauricie, Montreal, Outaouais, and Quebec. Additional information regarding the context and details of the seized drugs was supplied by law enforcement investigative files, including the drug's retail price and whether the trafficker was selling his/her product as ecstasy or speed, irrespective of the actual composition.

These drugs were seized from a variety of different locations with the majority coming from private residences (42%; n=153) followed by street seizures (10%; n=36) and seizures obtained from undercover agents (9.3%; n=34). The drug's in the this sample were also obtained from seizures made on the road, related to the Highway Safety Code (n=31), during arrests (n=18), from vehicles (n=14), in penitentiaries (n=13), from police searches (n=11), in parking lots (n=10), from stash houses (n=9), at afterhours locations (n=8), from schools (n=7), from bars (n=3), in hotel rooms (n=3), from hospitals (n=3), from driving accidents (n=2), a youth centre (n=1), a blind pig party (n=1), a festival (n=1) and at a rave (n=1).

A range of synthetic drug prices in Quebec was documented in this sample. Although the majority of drugs were sold for $10 (n= 133; 53%), prices varied from a minimum of $2.50 to a maximum of $20.00. Prices were relatively consistent across regions, with average prices being slightly higher in Montreal ($9.82) than the rest of Quebec ($8.72). As prices were obtained only for 261 of the drugs, this subsample will comprise the economic analysis. The prices obtained in this seizure closely resemble prices of ecstasy in Western regions across Europe. The 2006 Annual Report by the European Monitoring Centre for Drugs and Addiction stated that in the majority of countries ecstasy retail prices varied between EUR $4-9 (EMCDDA, 2011). Also closely following the prices in this analysis were prices found in the UK ecstasy market, which observed that the average price of a tablet in 2003 cost £5.30 (Schifano et al, 2006). However a comparison of prices from this sample to other regions is limited, as our data does not provide

information per gram and therefore can only be compared to studies that have examined the price of the drug per tablet and not based on the drug's purity.

There is some concern about using prices for drug analysis, specifically when they have been obtained through purchases made by undercover police officers. Law enforcement agents that are present in a short term capacity may lack the social capital, and thus the trust and contacts to obtain drugs at a retail price that reliably reflects the illicit market. As noted by Caulkins (2007), retail prices fluctuate and are "embedded in the social relationships" between a dealer and consumer (p. 15). This study attempts to overcome this concern by using prices that were derived from multiple sources, including information obtained through police investigative files, former drug traffickers, in addition to purchases made by undercover agents.

Analytical Scheme

Using these data sources the analytical scheme of this paper will unfold in three steps. First a network analysis using the drug composition data will provide an initial description of the market, grouping seized drugs according to their shared characteristics. Second, with this same data, a cluster analysis will be conducted to statistically model these features and create a structural variable, by determining the optimal number and nature of clusters for all the seized drugs. Lastly, the price data will be incorporated to examine how the structural variable and the marketing variable, whether it was sold as ecstasy or speed, influence price variations across the province. In sum, this multi-faceted approach allows us to describe and statistically model the structural features of the drugs compositions, as well as examine their influence on price variations across the province.

Network Analysis: Precursor Structuring

Providing a model to apply this analytical strategy is extensive research that has examined statistical methods to determine cutting points for whether a drug originates from the same production batch (Dujourdy et al, 2003; Esseiva et al, 2003; Zingg, 2005; Anderson et al, 2007; Esseiva et al, 2007; Marquis et al, 2008; Weyermann et al, 2008; Esseiva, Gasté, Alvarez & Anglada, 2011). According to these studies, the pearson correlation has consistently been determined to be the most reliable method to see whether two or more drugs share enough characteristics to have originated from the same manufacturer. In these studies researchers link drugs based on detailed information including the quantity and concentration of each substance present in the tablet (Esseiva et al, 2003; Zingg, 2005; Anderson et al, 2007). However, the data obtained for the current study, contrary to previous research, does not provide the percentage of each ingredient, only whether a substance is present or not in the tablet, precluding us from conducting a pearson correlation. Given the aims of the above project this level of chemical analysis was not integrated into data that was shared with us, and it was exceptional that we were able to receive any information in regard to the composition of the tablets. Accounting for the differences in data, we have adapted the analysis procedures accordingly to reflect this, substituting pearson correlation with a network analysis. This lack of detail in the data, also explains why prices, were included in the study, as they served as a tool to confirm the findings from another approach.

Network analysis proved to be a suitable method to analyze the market with drug composition data given the dichotomous nature of the current data. This method is a

descriptive technique that examines links between actors to infer additional information from these relationships (Wassermann & Faust, 1994). Network analysis has been extensively applied in the field of criminology by examining the relational ties between actors to provide information about the market structure, including organized crime groups (McIllwain, 1999; Morselli, 2009; Bright, Hughes & Chalmers, 2012) and terrorist cells (Krebs, 2002). Data sources have been innovative, including judge sentencing comments (Bright et al, 2012) and criminal biographies (Morselli, 2005). Although traditionally used with individuals, this study will replace social actors with seized drugs as the unit of analysis. This substitution is based on the aforementioned premise that a seized drug carries the manufacturer's signature, and is therefore reflective of the producer. Thus, the market structure will be assessed by examining the links between seized drugs using network analysis.

The network analysis proceeded in a number of steps, all with the aid of UCInet, a software suite which permits the analysis of network data. First, all the data for the physical (logo and colour) and chemical characteristics (active substance and cutting agents) for the 365 drugs were input into a cross table, according to whether it shared one or more of these defining features with another tablet in the sample. Thus, if two tablets shared three of the same characteristics (e.g. both contained methamphetamine, diphenhydramine and were the colour blue) they were linked across the table with the number three. This method not only allowed us to group the tablets according to shared features, but also permitted us to examine the strength of this relationship between tablets. Thus, if a drug shared five characteristics with one tablet and only one with another, the stronger link between the

former would be reflected in the final analysis. Following the input of this data, two calculations were conducted, the density and clustering coefficient, to examine the overall connectivity and clusters present in the data. Density provides an analysis of the degree of connectivity of a network between subjects, while the clustering coefficient examines the degree of clusters in the network. Both methods are recommended to be applied as group size may influence the clustering coefficient, larger samples reducing its size (Hanneman & Riddle, 2005). This analysis supplied us with an ability to examine the connectivity and degree of clustering in the current sample, which is indicative of its structural features.

Cluster Analysis

To statistically model and empirically validate the relationships from the above descriptive analysis as well as to provide for the creation of a dependent variable that reflects the market's structural features, a cluster analysis was performed with SPSS software. Prior to conducting this analysis, due to the high variation in chemical and physical drug profiles, some variables had to be regrouped into larger categories or eliminated to affect a reliable analysis. It was determined that the chemical variables' values would be regrouped according to quality, allowing for the preservation of some detail of the data, while variables that described the physical characteristics of the synthetic drugs with low frequencies had to be eliminated, as they could not be assimilated into larger categories.

For the regrouping of the chemical variables, quality was determined based on its level of purity; whether the drug only contained active stimulant ingredient(s) (either amphetamine, methamphetamine, MDMA or MDA), or whether its purity had been

contaminated with cutting agent(s). After consulting two toxicology and pharmacology reference books (Ebadi, 2008; Barceloux, 2012), these criteria permitted the identification of three groups, Grade A, Grade B, and Grade C Drugs; Grade A Drugs were considered the highest quality tablets, consisting only of the active ingredient (e.g. MDMA), Grade B Drugs, were deemed medium quality tablets, consisting of one active ingredient and one or more fillers (e.g. MDMA and caffeine), and Grade C Drugs the lowest quality tablets, composed exclusively of one or more cutting agents (e.g. caffeine). Ten drugs were excluded from the analysis, as they did not meet the criteria (e.g. a tablet that contained psilocybine, the active ingredient found in mushrooms). To ensure the correct classification of the seized drugs into their appropriate categories they were also verified by a professor of neuro-pharmacology at Université de Montreal. However, given that the data did not provide information about the concentration of each substance caution should be exercised when interpreting these groups, as it is possible that a tablet designated as a Grade A drug has a very low purity with 95% cutting agent and 5% active ingredient. Based on the above classification, synthetic drugs in the Quebec market consisted primarily of Grade B Drugs (n=227), followed by Grade A Drugs (n=71), and Grade C Drugs (n=57).

Second, it was necessary to narrow the more than 107 values that characterize the physical and visual characteristics of synthetic drugs (each a descriptor of the drug's quality, colour or logo) to include only the variables that had a frequency of three or more. All the variables for the drug's colour were included, while only 20 of the 93 logos were selected. The rational for choosing only a fraction of all the logos was empirical, as all variables had to have a sufficient number of cases (n=3) to effect a reliable analysis;

variables that had low frequencies (e.g. the american airlines logo with a frequency of one) were not included. Given the above considerations, the clustering variables include the following: the drug's quality (Grade A, Grade B, and Grade C Drugs), colour (white, blue, yellow, mauve, orange, pink, and green) and logo (*bomb, capsule, heart, couche-tard, e, lightning bolt, star, kärv, mercedes, MSN, on star, pepsi, pinup, 7up, playboy, puma, shell V power, transformers, versace* and no logo). Consequently this resulted in a less descriptive approach comparative to the network analysis.

Originally, the cluster analysis had been designed to distinguish between the two stages of production, pre-tabletting, the synthesis of the drug, and post-tabletting, the pressing of the drug into its final shape. Two separate cluster analysis were preliminary conducted, the first exclusively examining the chemical characteristics of the drug and the second, solely the physical features of the drug, allowing us to distinguish and make comparisons between these two production stages. However, the high number of logos and colours with low frequencies precluded us from conducting a reliable cluster analysis for the drug's physical features. Even when the variables with insufficient cases were eliminated from the analysis, the high number of dichotomous variables did not permit a reliable cluster anlaysis and any further removal of variables hindered the interpretation and validity of the results. Given the inability to capture the differences between the two stages of production through a cluster analysis, the two characteristics were combined for an overall cluster analysis. In addition, a separate descriptive analysis was incorporated into the study to account for and examine the similarities and differences between a tablet's chemical composition and physical appearance.

Price Analysis

The clusters that were formed from taking into account both the tablets chemical and physical characteristics not only allowed us to identify how many drug categories there are in Quebec, but also permitted us to further accomplish the analytical aim of the research by creating a dependent structural variable to affect statistical tests that take into account how this variable and the marketing variable (whether it was sold as ecstasy or speed) influence synthetic drug prices. Given that there were four qualitative independent variables (a marketing variable and a cluster variable subdivided into three categories) and one quantitative dependent variable a one way analysis of variance (ANOVA) was selected as the most reliable test to predict prices. The dependent variable for this analysis was the drug's price and the independent variables included both the structural variable and whether the trafficker was selling his product as ecstasy or speed, regardless of the composition. Although the dependent variable only closely followed a normal curve, this method was still selected as the variation was only moderate.

Given that the data was disaggregated to the regional level, a comparative analysis within different areas of the province was also completed to examine if there were geographical variations in price determinants. Due to the low number of seizures in some areas, a comparative analysis was only conducted between a large urban city, Montreal (n=108) in relation to the rest of Quebec outside Montreal (n=143). Thus, these ANOVA analyses were designed to help learn about what shapes the illegal prices of synthetic drugs for the Quebec province, as well as in different regions across Quebec.

The ensemble of these three methods, network, cluster, and economic analysis, make for a complete demonstration of the structural organization of the synthetic drug market in Quebec. A descriptive section is generated by the network analysis, followed by a statistical demonstration that further supports the analytical constructs presented in the network analyses and creates the key variable that is carried over to the ANOVA in which the aim of the study is met: an explanation of the market. This innovative approach demonstrates a method to assess synthetic drug markets, where the primary actors are elusive. Using properties of the market, this technique takes these most visible parts of this clandestine industry, the seized drugs, to access the most hidden, the drug producers themselves. The results of these three analyses will be presented in the following article.

Article: Precursors and Prices: Structuring the Quebec Synthetic Drug Market

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Introduction

Research gathered on the synthetic drug market trails behind studies on other illegal drug markets. Synthetic drug's relatively recent classification as an illicit substance, coupled with its distinct properties that insulate it from detection, has hindered the development of comprehensive and reliable assessments of the markets structural features. Of the sparse set of analyses many are fragmented or contingent on multiple assumptions, only providing glimpses into the market's organizational dynamics. Further, of the few studies significant discrepancies have emerged, with Canadian national agencies advancing the notion that a few stakeholders control significant shares of Canada's synthetic drug market (Canadian Security Intelligence Service (CSIS), 2010; Royal Canadian Mounted Police (RCMP), 2010), contrasting with recent reports on the synthetic drug market in Europe (Gruppo Abele, 2003), and echoing discredited allegations by academics about organized crime groups (Cressey, 1969). Despite these bold claims that sophisticated groups dominate the country's synthetic drug trade they lack evidential support and there are few alternative reports to turn to. To fill this void, it is necessary to move beyond standard analyses and import innovative approaches that allow us to reliably assess these clandestine features of the market. Overcoming these barriers, this study will merge two approaches, drug composition and economic analysis, under a common framework to provide an innovative and systematic model that uses properties of the drug market to obtain reliable assessments of its organizational features and structural attributes.

Assessments of the Synthetic Drug Market

The necessity of innovative and reliable approaches to assess the synthetic drug market follows from the covert nature of illicit players in these markets and the inconsistencies that have emerged from the sparse set of analyses. In regard to the reports that have advocated a highly structured image of the Canadian synthetic drug market, the Canadian Security Intelligence Service (CSIS) 2010 in their Organized Crime Report have claimed that clandestine 'super labs' (although they fail to define the size of these "large" laboratories) have proliferated in Canada to meet the demands of consumer countries, including Australia and New Zealand (CSIS, 2010). Also supporting these claims is the RCMP Criminal Intelligence Division in their 2009 report on the Illicit Drug Situation in Canada. This report states that not only are organized crime groups alleged to be in charge of "economic based laboratories" (covert laboratories whose goal is to make profits by responding to both national and international demand), but comparatively speaking, they are present in higher numbers than "addiction-based labs" (smaller laboratories that are primarily for a consumer's personal supply) (RCMP, 2010). These statements suggest that large organizations play an integral role in the market, responsible for supplying the bulk of consumer demand. Running these large laboratories to meet this wholesale demand requires a high degree of organization, encouraging a rigid and structured perspective of these criminal collectives.

However, these claims should be interpreted with caution, as much of the data and methods are undisclosed, preventing independent researchers from reviewing and evaluating how the results were obtained. It has been stated that drug market reports based

on classified methods that have not been subject to review lack evidence of ongoing methodological improvements (Kilmer, Caulkins, Bond & Reuter, 2010). The lack of substantive evidence to support the conclusions made in these reports allows individuals to question the veracity of their results. Providing a glimpse into their methodology, the RCMP (2010) revealed that their findings primarily rely on seizure data. However, in addition to lack of detail that was provided for this source (they only state that seizure data was used), seizure data has been criticized for not being a valid indicator of drug markets due to its potential to fluctuate in response to factors that are not related to or actual changes in the drug market, such as a single, significant seizure or shifts in law enforcement priorities (Bouchard et al, 2011). To begin with police seizures inform us of police strategies and thus the activities of these authorities, rather than actual market behaviour. Seizure data may vary in tandem with shifts in law enforcement priorities, indicating enhanced police targeting and funding, rather than increases in production (Bouchard et al, 2011). While it may be alleged that seizure data taken from a wide array of regions will compensate for different law enforcement mandates and thus provide a reflective picture of the overall drug market, as the report did not indicate the sources of this data we are unable to assess whether the findings reflect actual trends in the market. In addition, it is important to emphasize that the overall sizes of annual seizures may be influenced by a single significant seizure, reflecting one large consignment rather than any significant structural change in the overall market (Bouchard et al, 2011).

In contrast to these reports, a recent multi-site European study has emphasized a competitive and ephemeral synthetic drug market (Gruppo Abele, 2003). Over a three year

period, research teams analyzed three European synthetic drug markets; Barcelona (Montañes, Barruti, Pallarés & Domínguez, 2003), Amsterdam (Blickman, Korf, Siegel & Zaitch, 2003), and Turin (Massari, Mareso, Monzini & Veglio, 2003). Applying a multifaceted approach that relied primarily on qualitative research tools, including interviews with police officers and drug traffickers, they established that many groups operated in a loosely structured, flexible, and decentralized market, with few barriers to entry or exit. Their research was highly valuable as two of the drug markets they observed were at different stages of development; allowing them to make distinctions and learn about variations in structure. A young market, Spain, consisted primarily of small amateur labs that manufactured a relatively small amount of pills destined for local consumption (Montañes et al, 2003). In contrast, the Netherlands had developed into a more professionalized market that consisted of small groups and a network structure that relied on the outsourcing of specialists, such as chemists and individuals involved in the trade of precursors (Blickman et al, 2003). Regardless of degree of professionalization their research allowed them to determine that all three markets were highly adaptable and an "extremely fluid and multifaceted phenomena" (Gruppo Abele, 2003, p. 223).

Although this latter report provides an extensive analysis of the synthetic drug market, the primary method to investigate the synthetic drug market by the Gruppo Abele was through the use of interviews with active, former, and indirect participants involved in the illicit trade. While this method provides a technique to learn more about the structure through insider accounts of the drug markets, these sources may only provide partial or misinformed accounts and thus misrepresent the sphere and characteristics of the drug

market as a whole. In addition, these methods primarily relied on data obtained at the retail level, not allowing us to see the higher level, and thus more influential, actors in the market. To overcome these limitations in their data, quantitative data was also obtained to examine the market, although to a lesser extent. The report concluded by emphasizing the necessity of further studying the market in this and other regional and global contexts.

While research on illicit markets rely primarily on traditional sources, including both direct and peripheral actors in the drug trade for insight, few researchers have turned to the central component of the drug market; the drugs themselves as a unit of analysis. Drugs are frequently seized through law enforcement procedures however, given police and judicial mandates, their use often ends as a justification for arrest and court room evidence. With the aid of chemical extraction, these seized drugs can also serve another purpose providing forensic intelligence to gain reliable insight into the structural characteristics and organizational attributes of the drug market. Using seized drugs, specifically drug composition data, as the basis of the current research, this study will assess the structural features of the Quebec synthetic drug market, providing a rare glimpse into the social organization of covert drug manufacturers. In addition, drug prices, a fundamental component of the market, will also be incorporated to assess this market. These prices will be merged with the drug composition data to provide a more comprehensive understanding of the market's dynamics and structural features.

Drug composition analysis uses seized drugs to assess illicit market features. This method relies on the central component of the market, the drugs themselves, as the central unit of analysis, bypassing methodological limitations inherent in using illicit actors to

assess the market. Drug composition analysis examines the drug's chemical makeup and physical properties to make inferences about the market structure. Given the diversity of synthetic drugs, the variety of production methods, the organic impurities that are formed at different stages of the synthesis process, an infinite number of cutting agents, and numerous settings on pressing devices each synthetic drug is presumed to carry a unique profile based on its physical attributes (e.g. colour and logo) and chemical characteristics (the number of and concentration of different substances present in the tablet). It is assumed that these characteristics are unique to each producer and can be used to identify batches of synthesized drugs, serving as an identifying personal signature.

After the first step in data composition analysis, the extraction of the drug's chemical profile and systematic measurements of its physical profile by trained chemists, the data can be analyzed to identify drugs that share chemical compositions and physical features. Drugs produced by the same manufacturer can be identified by linking drugs with similar characteristics (tablets with the same concentration of active substances and organic impurities or physical features). By grouping drugs with similar profiles it allows us to examine the number of producers in a given area, the output of a given manufacturer, trends in production methods, and distribution networks, revealing the organizational characteristics and structural attributes of the market. Based on the aforementioned premise, that each drug carries the manufacturer's unique signature, if the combined seizure data indicates numerous and different tablets, this may suggest the presence of a competitive market where multiple, independent producers or small groups are responsible for the synthetic drug market. If the results reveal a high percentage of similar tablets, it

may indicate a monopolistic and centralized market where only a few players or groups are responsible for the majority of drug production. Thus, this method allows us to assess the market using an accessible unit of analysis, the drugs themselves, to provide a rare glimpse into the structure and social organization of drug manufacturers.

Providing a framework on how to reliably use drug composition data to analyze illicit drug markets has been extensive research in Europe. In particular a project funded by the European Commission, the Collaborative Harmonisation of Methods for Profiling of Amphetamine Type Stimulants (CHAMP), has significantly contributed to the development of advanced techniques to extract drugs' chemical and physical profiles and methods to apply this information into a drug intelligence context. In attempts to create harmonized profiling methods and a common drug database, these researchers have conducted numerous studies to analyze links between seizures (Weyermann et al, 2008). Two particularly relevant studies, taking the two separate stages of production into account examined individually the ability of organic impurities (Weyermann et al, 2008) and physical features (Marquis et al, 2008) to discriminate both between and within seizures.

The first study examined the organic impurities that are created during synthesis from a sample of 26 MDMA seizures obtained from Finland and Germany in addition to 80 MDMA tablets that were collected from seizures by laboratories in Finland, Netherlands, France, and Switzerland (Weyermann et al, 2008). The researchers used a gas chromatography spectrometry method, developed by the Netherlands Forensic Institute (NFI), to extract the tablets chemical profile and used a fixed correlation value to determine whether drugs' profiles were linked or not. Using this statistical test, researchers

demonstrated that organic impurities could be used to establish connections within seizures and distinguish between seizure batches (Weyermann et al, 2008). These findings demonstrated the potential of statistical tools to illustrate links between drugs. The second study, which examined tablets' physical characteristics, using the squared Euclidean or the Manhattan distance, determined that diameter, thickness, weight and score of the drug were all reliable characteristics to distinguish between drugs from different seizures. The findings allowed researcher to conclude that the drug's physical properties brings complementary information to the organic impurity analysis (Marquis et al, 2008). However, given that two separate tableting machines with the same settings can produce similar physical characteristics it was emphasized that physical characteristics should be used in tandem with other information for more accurate interpretations (Marquis et al, 2008).

Further research has provided a model for practical applications of drug composition analysis, including studies that have categorized and identified links between heroin (Dujourdy et al, 2003; Esseiva et al, 2007) and synthetic drug (Zingg, 2005) seizures. These studies detail how to assess the illegal synthetic drug market by analyzing links between drugs with shared compositions and physical attributes. Using seizure data obtained over six years researchers extracted and analyzed the physical and chemical profiles from 67 different heroin seizures, identifying 34 chemical groups. Linking drugs according to a fixed correlation value, their findings determined that the heroin market may consist of fewer producers relative to the cocaine market (Esseiva et al, 2007). Applying this method to the synthetic drug market Zingg (2005) analyzed 1000 synthetic drugs

seized from 1997 to 2000. Based off his analysis Zingg (2005) found a high number of distinct profiles, implying a high number of producers in the market. The practical application of this method demonstrates its utility in assessing the organization of clandestine markets.

A further method to analyze the synthetic drug industry is through an economic analysis. The core data source of this analysis are prices, which are a basic element of the market and can reveal the economic forces and factors at work in illicit enterprises. Drug prices are a valued research tool to analyze illegal drug industries, as they are a fundamental component of drug markets (Caulkins & Reuter, 1996; Caulkins & Baker, 2010). As we know little about the synthetic drug market we also know little about price variations therein and the factors that account for such price variations. Price data has been used extensively to inform drug policies and provide insights about drug markets, including the effectiveness of law enforcement interventions (Caulkins & Reuter, 2010) and to monitor changes in the structure of illicit drug markets (Rhodes, Hyatt & Scheiman, 1994). These studies rely primarily on price oscillations over time to make inferences about changes in the drug market. However, to reliably use price data to analyze illegal drug markets, it is essential that the determinants of illicit drug prices are comprehensively understood; otherwise we risk making faulty conclusions and attributing price fluctuations to unrelated factors. In addition knowledge of the determinants of these price variations can provide information about the internal dynamics of the illicit market, revealing production costs, behavioural trends, market structure, consumer trends, demand and supply and other factors that lead to

the final setting of prices. Currently there is a lack of empirical knowledge about synthetic drug markets, particularly in regards to their price determinants.

Determinants of Illegal Drug Prices

Multiple factors influence the amount that illicit drugs are sold for. Drug markets are influenced by both the same economic rules as legal markets as well as unique factors associated with operating in an illegal market. To begin with, drug prices are governed by similar market forces as legal commodities (Reuter & Haaga, 1989; Pietschmann, 1997; Ritter, 2006), complying with basic economic supply and demand principles (Ritter, 2006). In its most basic form, changes in the market are reflected in the supply or demand of a commodity, which subsequently impacts its price. Price changes occur to restore market equilibrium, where supply equals demand, so as to regulate product shortages or excesses (Moore et al, 2005).

Although drugs comply with some of the same principles as legal goods, current prices of illicit drugs are significantly higher than if they were sold in the legal market (Reuter & Kleiman, 1986; Moore, 1990; Miron & Zwiebel, 1995). To account for these price disparities are additional distinct factors, tied to their illegality, which also influence their retail price (Caulkins & Reuter, 1998). While operating in an illegal market reduces some costs associated with running an enterprise, additional risks are incurred by the product's criminality and significantly increases risk expenses including violence, risk of arrest, and judicial costs (Caulkins & Reuter, 1998). These additional risks significantly hike transaction costs and subsequently the drugs final retail price. Despite extensive studies on the determinants of drug prices, few have examined the factors that influence the

retail cost of synthetic drugs. Knowledge of these factors can reveal information about the inner dynamics that characterize this clandestine market.

Analytical Scheme

Aiming to provide a comprehensive picture of the structural attributes of Quebec's synthetic drug market, this study will proceed in three steps. First a network analysis using the drug composition data will identify links between drugs with shared characteristics, providing a detailed description of the market's structure. Building off these findings, a cluster analysis will be conducted to statistically model these structural features and provide for the creation of a structural variable for the final economic analysis. Lastly, the price data will be incorporated to examine how this structural variable and other market indicators influence price variations across the province. In sum, this study will allow us to examine the industry at both the retail level, through an analysis of price determinants, and the production level, through the composition of the drugs that manufacturers produce, providing for a comprehensive analysis of the market's features.

Sources of Synthetic Drug Tablets

This study relies on 365 synthetic drugs that were obtained through a project commissioned by the federal government in response to concern over increased use of synthetic drugs. In partnership with the provincial and municipal police forces in Quebec a sample of seizures made by law enforcement agencies in Quebec between June 2007 and 2008were analyzed by Health Canada who extracted and systematically classified the synthetic drugs into categories based on their chemical composition (active substance and

cutting agents) and physical features (score, colour, and logo). Among these tablets, there were four major active substances (MDMA, MDA, methamphetamine, and amphetamine), and over forty adulterants, cutting agents, and/or by products of the chemical reactions. The wide range of tablets with different chemical compositions was also consistent with their physical characteristics, which contained both a high number of different logos (n= 122) and colors (n=12). All the synthetic drugs in this sample were seized in nine different areas across the Quebec province: Abitibi-Temiscamingue, Bas Saint-Laurent, Cote-Nord, Estrie, Gaspesie, Mauricie, Montreal, Outaouais, and Quebec. This information provides us with valuable information on potential regional differences and a more representative picture of the Quebec province, reflecting both small remote regions and densely populated urban centres.

Additional information regarding the context and details of the seized drug in this sample was also supplied from law enforcement investigative files, which included whether the drug trafficker was selling his/her product as ecstasy or speed, irrespective of the actual composition and the retail price of the drug. The majority of drugs were sold as speed (n=244; 66.8%) and under one quarter as ecstasy (n=88; 24.1%). Prices of drugs in the Quebec province ranged from a minimum of two dollars and fifty cents Canadian to a maximum of twenty dollars with the majority being sold for ten dollars (n=133). In addition prices are relatively similar across the different regions. On average prices are slightly higher in Montreal, $9.82 and have a higher minimum price of $5.00, than in comparison to the rest of Quebec, with an average price of $8.72 and a minimum price of $2.50. This large variance in drug prices allows us to examine whether a drug's quality and brand or

whether a drug traffickers sells his product as ecstasy or speed influences the drug's final price. As prices were obtained only for 261 of the drugs, this subsample will comprise the economic analysis. The prices obtained in this seizure closely resemble prices of ecstasy in other Western regions across Europe. The 2011 Annual Report by the European Monitoring Centre for Drugs and Addiction (EMCDDA) stated that in the majority of countries ecstasy retail prices varied between EUR $4-9. Also closely following the prices in this analysis were prices found in the UK ecstasy market, which observed that the average price of a tablet in 2003 cost approximately £5.30 (Schifano et al, 2006).

Providing a model to utilize drug composition data as an intelligence tool is extensive research that outlines statistical methods to determine whether drugs originate from the same production batch (Dujourdy et al, 2003; Esseiva et al, 2003; Zingg, 2005; Anderson et al, 2007; Esseiva et al, 2007; Weyermann et al, 2008; Marquis et al, 2008; Esseiva et al, 2011). These studies found that the pearson correlation serves as the most reliable statistical tool to determine cutting points at which drugs with shared characteristics belong to the same manufacturer. In these studies researchers link drugs based on detailed information including the quantity and concentration of each substance present in each tablet (Esseiva et al, 2003; Zingg, 2005; Anderson et al, 2007). However, contrary to this research, the data in the current study does not provide the percentage of each ingredient, precluding us from adopting the pearson correlation. Given the aims of the above project this level of chemical analysis was not integrated into data that was shared with us, and it was exceptional that we were able to receive any information in regard to the composition of the tablets. Accounting for the differences in data, the analysis procedures were adapted

accordingly, substituting the pearson correlation with network analysis to overcome this limitation.

Profiling the Synthetic Drug Market

The network analysis permitted a detailed view of the drug's composition and physical attributes and how they were directly connected according to these features. From the analysis, eighty different chemical compositions were identified among the 365 seized synthetic drugs, each tablet a different combination of the active substance(s) and/or cutting agent(s). The most popular tablet in the sample contained methamphetamine and caffeine (n=100), comprising 27.4% of all seized synthetic drugs. Other popular profiles included MDMA (n=18), MDA (n=19), and methamphetamine (n=27). The wide range of tablets with different chemical compositions was also consistent with their physical characteristics, which contained both a high number of different logos and colours. Of the 122 different logos in the sample, the most popular were a symbol of a "star" and "on star", which both, individually, accounted for 3.8% (n=14) of all drugs. The drugs were one of twelve different colours, the most prevalent being white (n=224).

A drug's logo and colour rarely indicated the drug's chemical composition; tablets that shared the same physical appearance frequently represented two different chemical compositions. An analysis of the chemical compositions for the tablets did not demonstrate any patterns into how the logos were selected. Most logos appeared once in the sample, with only 65 of the 122 logos appearing two or more times. A small fraction of all the tablets, 16 groups in total ranging from a minimum of two to a maximum of six tablets, were identified as sharing both the same physical appearance and chemical composition.

With the exception of the above mentioned 48 tablets, divided into 16 groups, drugs that shared chemical compositions had a high number of different physical features. Among all tablets that exclusively contained methamphetamine and cocaine (n=100) they carried 41 different logos. In this sample, a tablet's colour and logo were rarely exclusive to a tablet's chemical composition. This may reflect that the two stages of synthetic drug manufacturing process, the pre-tabletting stage, which involves the chemical synthesis of the active substance, and the post-tabletting stage, the compression of the powder into tablet form, are being conducted in different locations and reflect separate actors.

Further deception was also detected in the synthetic drug market through an examination of the contents of the drugs sold as ecstasy or speed. Only 43% of the drugs sold as ecstasy and 66% of the drugs sold as speed contained the active substance that they were being sold as. This deception in the synthetic drug market is commonly observed, as toxicoepidemiologic monitoring of illegal street drugs has shown that substances marketed as ecstasy or speed can contain a wide variety of compounds and frequently do not contain the active ingredient (Spruit, 2001; Cole et al, 2002; Parrott, 2003).

Drug profiles within each region were also observed to be heterogeneous. All the regions consisted of a wide array of tablets with varying chemical compositions and physical properties. Montreal had the lowest variability among tablets with a total of 35 tablets with different chemical compositions for the total 124 seized drugs in the area. Mauricie had the greatest within region variability with 19 tablets that carried distinct chemical compositions out of the total 25 sampled drugs. This same trend was also reflected when examining the tablet's physical characteristics, with seizures in each region

possessing a high number of different logos. Within each of the nine different regions approximately half of all tablets sampled possessed different logos. Drugs seized in Saguenay possessed the most homogenous physical features with just under half of all drugs possessing different logos, 20 logos for the total of 41 sampled tablets. The most extreme variability was observed in Mauricie with almost all drugs carrying different logos, 21 logos for the 24 tablets.

To characterize the structure of the network using the 365 drug profiles, two cohesion analysis tools, density and clustering coefficient, were conducted using a network analysis software program, UCInet. Density provides an overall analysis of the degree of connectivity of a network between subjects, while the clustering coefficient identifies the degree of local clusters in the network, examining the degree of connectivity between one tablet to all the tablets directly linked to it. Both methods are recommended to be applied as group size may influence the clustering coefficient, with larger samples reducing the coefficient (Hanneman & Riddle, 2005). This sample contained high connectivity with a density at 61% and a clustering coefficient at 83%. Accounting for this high density, within a sample with a high number of different (drugs with different compositions and physical features), were that most tablets could be linked based on one or two shared characteristics. In this sample most drugs contained either methamphetamine (n=208) or caffeine (n=222). However, of these tablets, most contained additional adulterants (e.g. diphenhydramine or dimethylsulfone), making it distinct from the others. Further distinguishing tablets from one another, were the wide array of physical characteristics. Although the majority of tablets in this sample were white, there were 122 different logos for the 365 tablets. Therefore even

though many drugs shared a few similar chemical characteristics, few also shared the same physical appearance. When the drug's physical and chemical features were looked at collectively, there was high variability between tablets, with only 48 drugs (13%) possessing identical characteristics with one or more tablet.

The Structural Features of the Market

The second step in the assessment of the market's structural features was a cluster analysis. Although this method performs the same assessment of the market as the network analysis (they both organize the drugs into groups according to shared properties) it was also incorporated into the research design as it served two additional purposes: (1) it allowed for a statistical demonstration that empirically validates the relationships from the above descriptive analysis; and (2) it provided for the creation of a dependent variable that reflects the structural features of the market. However, due to the nature of the data, the cluster analysis provided less detail of the market's features, as the high variation in chemical and physical drug profiles meant some variables had to be regrouped into larger categories or eliminated in order to affect a reliable cluster analysis. Thus, within the framework of this study, the cluster analysis served a practical objective, aforementioned, while the network analysis served to provide more detail about the characteristics that link the drugs, and thus insight into the structure of the market.

For the cluster analysis, It was determined that the chemical variables' values would be regrouped according to quality, allowing for the preservation of some detail of the data, while variables that described the physical characteristics of the synthetic drugs with low frequencies had to be eliminated, as they could not be assimilated into larger categories. For

the regrouping of the chemical variables, quality was determined based on the drug's level of purity; whether the synthetic tablet only contained active stimulant ingredient(s) (either amphetamine, methamphetamine, MDMA or MDA), or whether its purity had been contaminated with cutting agent(s). After consulting toxicology and pharmacology reference books, these criteria permitted the identification of three groups, Grade A, Grade B, and Grade C Drugs (Ebadi, 2008; Barceloux, 2012); Grade A Drugs were considered the highest quality drugs, consisting only of the active ingredient (e.g. MDMA), Grade B Drugs, were deemed medium quality drugs, consisting of one active ingredient and one or more cutting agents (e.g. MDMA and caffeine), and Grade C Drugs the lowest quality tablets, composed exclusively of one or more cutting agents (e.g. caffeine). Ten drugs were excluded from the analysis, as they did not meet the criteria (e.g. one tablet solely contained psilocybine, the active ingredient found in mushrooms). To ensure the correct classification of the seized drugs into their appropriate categories they were also verified by a professor of neuro-pharmacology at the Université de Montréal[1]. However, given that the data did not provide information about the concentration of each substance caution should be exercised when interpreting these groups, as it is possible that a tablet designated as a Grade A drug has a very low purity with 95% cutting agent and 5% active ingredient. Based on the above classification, synthetic drugs in the Quebec market consisted primarily of Grade B Drugs (n=227), followed by Grade A Drugs (n=71), and Grade C Drugs (n=57).

Second, it was necessary to narrow the more than 107 values that characterize the physical and visual characteristics of synthetic drugs (each a descriptor of the drug's quality, colour or logo) to include only the variables that had a frequency of three or more.

Only seven of the drugs' possible twelve colours and 20 of the 93 logos were included. The rational for choosing only a fraction of all the colours and logos was empirical, as all variables had to have a sufficient number of cases (n=3) to effect a reliable analysis; variables that had low frequencies (e.g. the *american airlines* logo with a frequency of one) were not included. Given the above considerations, the clustering variables include the following: the drug's quality (Grade A, Grade B, and Grade C Drugs), colour (white, blue, yellow, mauve, orange, pink, and green), and logo (*bomb*, *capsule*, *heart*, *couche-tard*, *e*, *lightning bolt*, *star*, *kärv*, *mercedes*, *MSN*, *on star*, *pepsi*, *pinup*, *7up*, *playboy*, *puma*, *shell V power*, *transformers*, *versace* and *no logo*).

Incorporating the concise list of variables into the analysis, four distinct clusters emerged. Findings were similar to the network analysis, with a wide array of physical characteristics being shared among a high range of drugs with different compositions. The most distinctive feature that divided each cluster was its quality. One cluster grouped Grade A Drugs, two grouped Grade B Drugs, and one grouped Grade C Drugs, permitting us to assess which logos and colours are most likely to be associated with drugs of different quality. Table 1 (below) demonstrates the division into four clusters and the characteristics of each drug according to the categories. The findings from the cluster analysis can be summarized as follows.

Table 1: Distinctions between Clusters

Variable	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Cluster 4 (%)	Chi2 sig.
Grade A	100.0	0.0	0.0	0.0	.000
Grade B	0.0	99.0	100.0	0.0	.000
Grade C	0.0	1.0	0.0	99.0	.000
Bomb	0.0	3.0	2.9	0.0	.252
Capsule	1.4	1.0	0.0	7.0	.006
Heart	4.0	3.0	0.0	0.0	.060
Couche Tard	5.6	0.0	3.6	1.7	.151
E	8.5	0.0	0.0	0.0	.000
Lightning Bolt	1.4	1.0	2.9	0.0	.479
Star	1.4	11.0	2.9	0.0	.001
Kärv	0.0	1.0	2.9	0.0	.242
Mercedes	0.0	0.0	3.6	0.0	.043
MSN	0.0	5.0	0.0	0.0	.002
On Star	4.0	0.0	6.6	1.7	.058
Pepsi	5.6	0.0	1.4	0.0	.026
Pin up	4.0	2.0	5.0	0.0	.281
Playboy	0.0	0.0	8.8	0.0	.000
Puma	0.0	4.0	1.4	0.0	.105
7up	0.0	0.0	3.6	0.0	.043
Shell V Power	2.8	0.0	2.9	0.0	.224
Transformers	1.4	6.5	0.0	0.0	.003
Versace	4.0	1.0	0.7	0.0	.147
No logo	12.6	21.4	0.0	7.0	.001
White	59.1	4.3	100.0	64.2	.000
Blue	5.6	14.1	0.0	5.3	.000
Yellow	1.4	10.8	0.0	8.9	.000
Mauve	1.4	11.9	0.0	0.0	.000
Orange	4.2	9.7	0.0	8.9	.003
Pink	18.3	32.6	0.0	3.5	.000
Green	2.8	9.7	0.0	1.7	.001

Cluster 1, or Grade A Drugs (consist only of the active substance), possessed a high number of different logos, the most popular being the letter "*e*" (8.5%), followed by *couche tard* (5.6%), and *pepsi* (5.6%). Other drug logos included *capsule*, *heart*, *lightning bolt*, *star*, *versace*, *pinup*, *on star* and *shell v power*. However, all logos that characterized Grade A Drugs were also shared with drugs of lower quality, with the exception of the logo "*e*",

which was observed exclusively within Grade A Drugs. Furthermore, all possible colours present in the sample were observed among Grade A Drugs; the most popular being white (59.1%), followed by pink (18.3%) and blue (5.6%). Thus, a drug's logo and colour is rarely indicative of the drug's quality. While some logos and colours have a higher likelihood of being associated with Grade A Drugs, they may also represent a different quality drug.

Turning to Cluster 2, Grade B Drugs also contained a high number of different logos, with the most popular being *star* (11%). Many of the same logos as Grade A Drugs, including *capsule*, *heart*, *lightning bolt*, *star*, *pinup*, *transformers*, and *versace* were shared with Grade B Drugs. In addition, Grade B Drugs could be any of the seven possible colours (white, blue, yellow, mauve orange, pink and green). However, in contrast to Grade A Drugs, the most popular colours among Grade B Drugs were pink (32.6%), mauve (11.9%) and yellow (10.8%).

Both the second and third clusters were composed exclusively of Grade B Drugs, having been divided between the two clusters. However, the second group of Grade B Drugs was distinct from the first in that it was composed exclusively of white pills. Furthermore, an analysis of their chemical compositions demonstrated that among the Grade B Drugs in the third cluster, they were composed primarily of methamphetamine and caffeine, while the drugs in the second cluster had a high number of different chemical profiles. Both clusters also shared many of the same logos, including *bomb*, *lightning bolt*, *star*, *karv*, *pin up*, *puma*, and *versace*. However, the most popular logos in cluster three were *playboy* (8.8%) and *on star* (6.6%).

The fourth cluster, Grade C Drugs had a low number of logos; consisting only of four different logos in total: *capsule* (7%), *couche tard* (1.7%), *on star* (1.7%) or no logo (7%). The few logos present in this cluster may be explained by the fact that many logos were excluded from the cluster analysis, as they had too low of a frequency. Similar to the first two clusters, Grade C Drugs contained all possible colours, with the exception of mauve. The most popular colour was white (64.2%), distantly followed by yellow (8.9%), and orange (8.9%). Across both the descriptive and the cluster analysis consistency is found in the large overlap of shared characteristics between drugs. For the remainder of the paper, for clarity purposes, these cluster groups will be referred to according to their quality, e.g. either as Grade A, Grade B Coloured, Grade B White Drugs, or Grade C Drugs.

Factors that Influence Synthetic Drug Prices

Following the regrouping of variables into clusters, an ANOVA was conducted to examine the influence of the structural variable and the marketing variable (whether the drug was being sold as ecstasy or speed) on the drug's price. First, an ANOVA was conducted on the entire province to provide a comprehensive portrait of price determinants at the provincial level. Following this, a second comparative analysis was conducted using two separate ANOVA tests to compare the determinants of drug prices in Montreal (n=108) to the rest of Quebec (n=153), allowing for insight into geographical variations of price determinants. These two regions were selected based off the data and the number of seizures made in each area required to effect reliable comparisons.

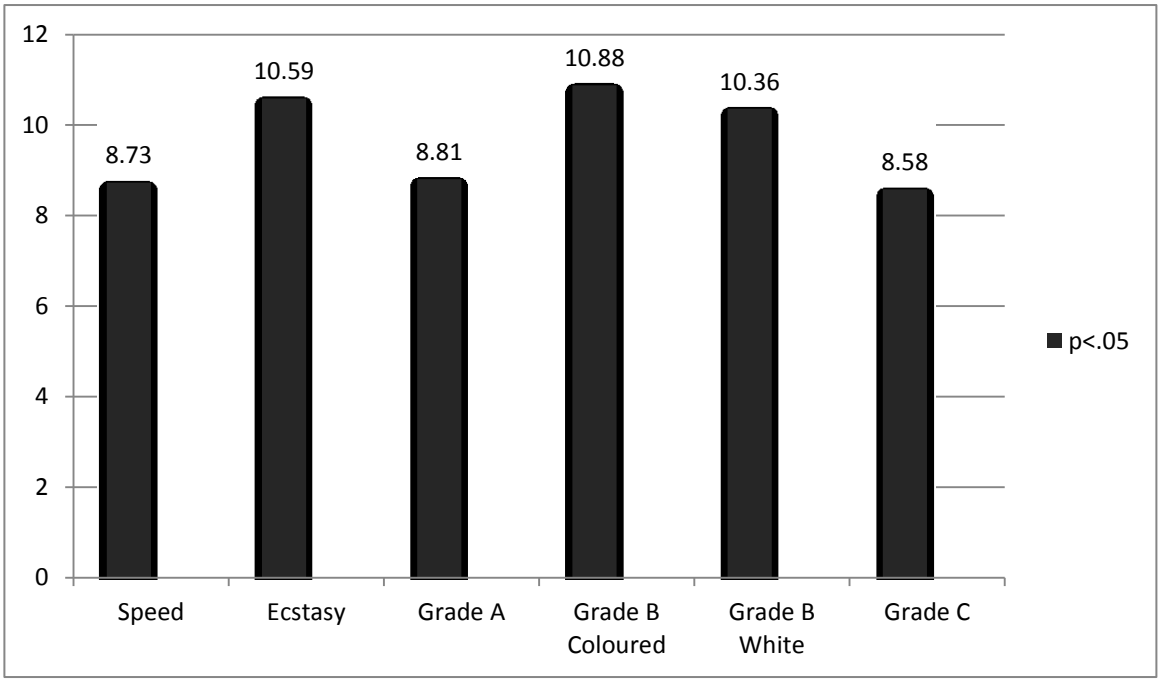
Quebec

Based on the outcome of the ANOVA analysis for Quebec's synthetic drug prices, one can understand that there is a statistically significant difference between prices for both the cluster variable ($p<.05$) and whether it was sold as ecstasy or speed ($p<.01$). Both these variables account for 10% of synthetic drug price variation for the Quebec province. A larger effect resulted in whether it was being sold as ecstasy or speed ($F=8.417$) in comparison to the cluster variable ($F=3.354$). The interaction effect between the cluster and marketing variable was not statistically significant ($p>.05$).

Table 2 below presents the results of the ANOVA analysis. A few unanticipated relationships were borne out of the data for the cluster variable. Grade B Coloured Drugs and Grade B White Drugs were sold for the highest prices; Grade B Coloured Drugs sold on average for $10.88 and Grade B White Drugs sold for $10.36. In contrast, Grade A Drugs were sold for approximately two dollars less ($8.81). In addition, the differential in prices between Grade A and Grade C Drugs were marginal with Grade C Drugs selling for a similar price as Grade A Drugs, at $8.58.

Furthermore, it was also found that drugs which were sold as ecstasy cost approximately two dollars more than if they had been sold as speed (respectively, $10.59 versus $8.73). This may support that drug users are inclined to trust dealers and pay higher prices based on information derived from these players. Supporting this, is the fact that ecstasy is deemed to be a more expensive and better quality drug, involving more elaborate production methods and higher skilled manufacturers.

Table 2: Price Determinants of Synthetic Drugs for the Quebec Province

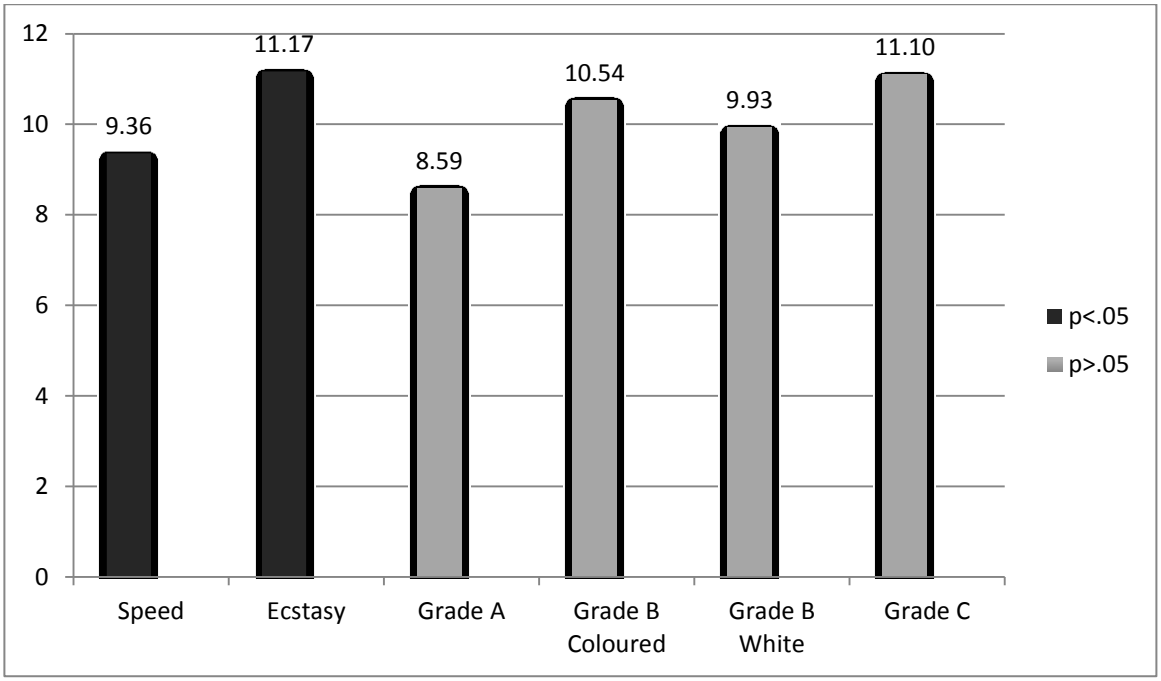


Montreal

ANOVA results for cases within the Montreal region indicated that there was a significant difference between prices depending on whether it was being sold as ecstasy or speed ($F=4.456$, $p<.05$). However, in contrast to ANOVA results for the entire Quebec province, the results sustained that the cluster variable was not statistically significant at the .05 level ($F=1.693$, $p>.05$), as illustrated in Table 3. Thus, the drug's quality did not play a role in influencing the drug's price in Montreal. The marketing variable, whether it was being sold as ecstasy or speed, explained 14.3% of synthetic drug price variation in the Montreal region. Consistent with the ANOVA for the province, ecstasy was sold for a higher price ($11.17) and speed for approximately two dollars less ($9.36). Consequently,

we may also conclude that in Montreal drug users may be more inclined to trust the dealer and pay higher prices based on information derived from these players.

Table 3: Price Determinants of Synthetic Drugs in Montreal

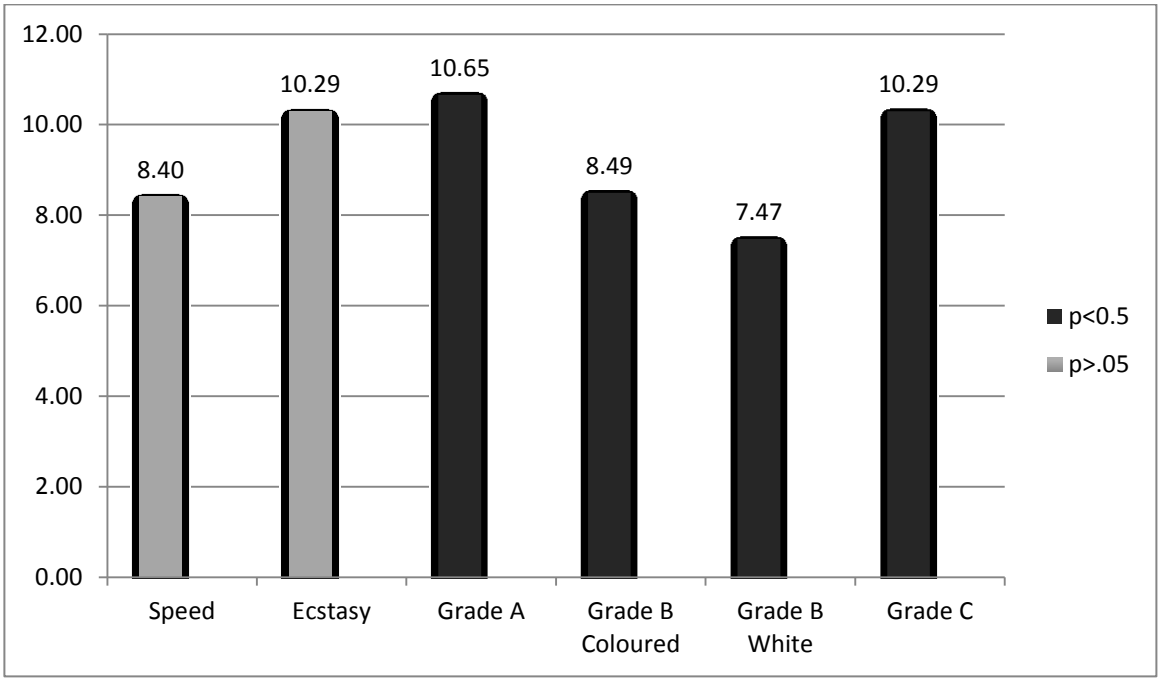


The Province of Quebec outside Montreal

For comparative purposes, an ANOVA was also conducted to examine the determinants of prices for the rest of Quebec outside Montreal. The results of the ANOVA sustained that there was a significant difference, albeit weak, between prices for the cluster variable ($F= 2.708$, $p<.05$), but not for the marketing variable ($F= 2.367$, $p>.05$). In this analysis, the cluster variable explained 10.1% of synthetic drug price variation for the region. In contrast to all of Quebec, Grade A Drugs were the most expensive outside of Montreal ($10.65). Consistent with all of Quebec, Grade A and Grade C Drugs were similar in price, Grade C Drugs being sold on average for thirty-six cents less (at $10.29).

In contrast, Grade B Drugs were sold for the lowest prices; Grade B Coloured Drugs for $8.49 and Grade B White Drugs for $7.47. These results are displayed in Table 4.

Table 4: Price Determinants of Synthetic Drugs for the Quebec Province Outside of Montreal



Discussion

The current study was designed to empirically examine structural features of the synthetic drug market by examining links between seized synthetic drugs and their price determinants. The first analysis demonstrated that a high number of different drugs are present in the market, potentially indicating a high number of manufacturers. The second investigation confirmed that a drug's composition and whether the drug trafficker markets the drug as ecstasy or speed can marginally influence its price, depending on the region. This study obtained divergent results for Montreal in comparison to rest of Quebec; outside

of Montreal prices were only influenced by quality, while prices sold in Montreal were only influenced by whether it was marketed as ecstasy or speed.

Evidence of a Competitive Market

The high density reported from the network analysis represents the high number of profiles that share one or two of the same ingredients. Based on this data, it may be argued that due to the similarities between profiles and higher frequency of some profiles over others (e.g. methamphetamine and caffeine tablets comprise 27.4% of seizures) some manufacturers have a significantly larger market share than others. Although this inference follows from the logic expressed above, the ubiquity of these ingredients and the high number of different combinations of these ingredients in this sample causes us to lean towards an alternative interpretation. First, the most prevalent profile and substances in the sample consists of two very common ingredients, methamphetamine and caffeine. Given the ease with which caffeine can be obtained and that most synthesis procedures aim to produce methamphetamine, it is likely that multiple manufacturers are producing a similar product that contains both these ingredients, indicating multiple synthetic drug producers. In addition, there are a high number of different chemical profiles, eighty in total also suggesting a high number of producers. These findings are further supported by the descriptive analysis, which demonstrated that each region in this sample carried a wide array of tablets with different chemical compositions and physical features. However, due to the small sample sizes per region it is important to emphasize that tablets seized in each region may reflect only a small subset of local production or specific producers.

Further supporting a competitive market, of the drugs that share the same chemical makeup, few of these also possess the same physical characteristics. Very few tablets shared both the same physical and chemical features with another tablet. The largest group of tablets that shared identical physical and chemical attributes consisted only of six tablets. Assuming that the manufacturer consistently presses their tablets with the same logo, this supports the earlier conclusion that there are a high number of drug manufacturers. Previous research suggests that manufacturers may be unlikely to use multiple different logos, as logos may be strategically used to build brand loyalty among their consumer base (Karch, 2011). As consumers begin to associate a logo with a high quality drug it is suggested that they will attempt to obtain drugs with that same logo the following purchase (Karch, 2011).However, concern should be exercised, as logos may be duplicated by others to deceive consumers into believing they have purchased a higher quality product or simply separate actors producing the physical features of the tablet in a post-tabletting phase of production.

It is also important to note a further limitation with these interpretations. As the drug composition data in this sample lacks detailed information only providing us with information on the contents of each tablet and not the respective concentration of each substance, we risk inferring that all tablets that contain both MDMA and caffeine came from the same production batch when in fact each tablet has different quantities of each substance, which would indicate multiple manufacturers. To minimize this possibility all physical and chemical features of the tablet were taken into account when making links between drugs that came from the same origin. Thus, drugs that shared the highest number

of characteristics also had the highest likelihood of originating from the same manufacturer. The data source used in this study is in contrast to research conducted by Esseiva et al (2003), Esseiva et al (2007), and Zingg (2005) who performed highly sophisticated extraction methods that recorded precisely the amount of each substance present in the seized drug, providing more accurate links between drugs with shared characteristics.

In addition to the aforementioned limitation, this study hinges on a few principle assumptions, the primary being the premise that manufacturers consistently use the same recipe and methods. Very little research has explored the synthetic drug market and it has not been established that manufacturers consistently produce the same tablets. Due to this we risk concluding that there are multiple producers operating in the synthetic drug market in cases where there are a large number of distinct profiles present, when in fact it may only be one producer altering his manufacturing process.

Price Analysis Discussion

Moving to the price data, the drug's quality, as determined by the cluster variable, was deemed to have a statistically significant, albeit weak, effect on prices for the province as a whole and for the region outside Montreal. However, this cluster variable exerted a different effect on prices for these two geographical areas. When Montreal was excluded from the analysis drugs of higher quality were sold for higher prices, with the exception of Grade C Drugs (drugs with no active ingredient were more expensive than Grade B Drugs). Although initially counterintuitive that lower quality drugs are more expensive, given research that has demonstrated that cocaine users perceive low prices to be indicative of poor quality (Evrard, Legleye & Cadet-Taïrou, 2010), it is logical that traffickers in efforts

to deceive customers would sell these drugs at elevated prices. However, in contrast, when examining Quebec as a whole, medium quality drugs (Grade B Drugs) are sold for the highest price, followed by high quality (Grade A Drugs), and low quality (Grade C Drugs). It is notable that higher quality is associated with higher prices only in the province of Quebec when Montreal is excluded, and that prices are not correlated with a drug's quality within the Montreal market.

Trafficker-Consumer Relations

This contrast between Montreal and the rest of Quebec may be attributed to two scenarios; the market structure and differential production costs. In regard to the market structure outside of Montreal, prices may be influenced by a drug's quality because of trafficker-consumer relations. Traffickers in attempts to obtain return customers have provided reliable, valuable information about their products to increase trust and future sales. Although it is unlikely that a trafficker will disclose to a user that a drug contains no active ingredient, traffickers may accommodate users by presenting drugs at different prices depending on what they can afford, leaving the decision with the user on whether to purchase a higher or lower quality drug. In contrast, in Montreal, fewer incentives may be in place for traffickers to develop a strong customer base through trusting relationships, as there may be a higher demand for drugs and therefore traffickers may be less inclined to obtain a regular clientele, with new customers always looking to buy the product. Indeed, the notion that 'there's a sucker born every minute' may be more in tune with a dense urban population that makes it more difficult for consumers to keep suppliers in check. However, that drug traffickers in Montreal are more likely to sell to people they don't know is

inconsistent with higher quality drugs being sold for less in this city, which would imply that dealers provide lower prices to individuals they know. This may be explained by the limitations in sample size, which did not find quality to statistically significantly influence price determinants in Montreal, with most drugs sold as Grade B (65%) and only a small fraction as Grade A (25%) and Grade C (10%).

Production Costs

The discrepancy on how the drug's quality influences prices in different regions may also be explained by looking at production costs. Research on illicit drug markets has stated that a drug's quality rarely influences its final price when production costs are insignificant, forming only a fraction of the retail price (Reuter & Caulkins, 2012). For example, in the heroin market, the drug's retail value is marked up by 99% from its wholesale cost in the country of origin (Caulkins & Reuter, 1998). Applying this to the current study, quality may be more inclined to be associated with a drug's cost outside of Montreal because production costs are high (e.g. precursors may be purchased in smaller quantities and thus cost more) and play a larger role in influencing the drug's final price. Thus, synthetic drug manufacturers in the Montreal region may operate out of larger laboratories and therefore acquire precursors in bulk, wholesale quantities, resulting in considerable cost reduction. As supported by the above inferences in regard trafficker-consumer relations, drug demand may be higher in this large metropolitan area, which is reflected in the low accountability between dealers and users. Thus producers, faced with larger demand may be inclined to obtain and produce drugs in large quantities, reducing associated production costs. That large production facilities may be located in a dense

urban city contrasts with what we know of the cannabis market. Large expanses of land are generally required to produce wholesale quantities of cannabis, and thus production facilities are more likely to be located in vast, isolated expanses of land in rural areas. In contrast, synthetic drug production requires relatively little space to produce significant output, allowing for a greater mobility and the opportunity to set up near consumer markets.

Stage of Market Development

That the structure and distinctive features of Montreal's synthetic drug market is different from the rest of Quebec was also supported by the results of the marketing variable. While whether it was being sold as ecstasy or speed influenced the price in Montreal, it did not exert a statistically significant effect for the rest of Quebec. Thus, consumers in Montreal were more likely to rely on what the drug trafficker stated about the drug, than the drug itself. This finding is consistent with other studies on illegal drug markets (cannabis, cocaine) that demonstrate the perceived quality of the drug is dependent on the information that is provided by the drug seller (Lakhdar, 2009; Evrard et al, 2010). This may be indicative of the presence of many first time transactions between dealers and sellers or may reflect the demographics of the consumers, with many new users. Novice consumers have little information (e.g., dealer's reputation, familiarity with the drug) to rely on when making a first purchase and may not be able to distinguish between different "highs", therefore indiscriminately purchasing drugs regardless of the price. As a buyer becomes a regular user and their education about the drug increases they may develop the knowledge for what to look for, who to buy it from, and how the effects should feel. Thus,

these more experienced users may find better quality drugs through the contacts they have made and the repeated use of the drug.

Further supporting this is the "Expected Purity Hypothesis" developed by Caulkins (1994), which states that a key factor that influences drug prices are consumers' perceptions of the drug's potency. Given that drugs are "experience goods" purchasers are often unable to assess their quality until after consumption (Reuter & Caulkins, 2004; Caulkins, 2007). Thus, consumers, unable to evaluate the drug's quality may rely on other factors, such as the drug trafficker's reputation and statements to calculate the quality and hence the price they will pay, during the time of purchase.

However, these analyses are not entirely satisfactory, as the inferences about relationships between suppliers and consumers are based on the assumption that the drug seller knows the true quality of the drug, and is therefore aware that the consumer is being wrongfully manipulated. There is evidence in other drug markets with long distribution chains that suppliers deceive traffickers further down the chain about the drug's quality, to increase their respective profits (Reuter & Caulkins, 2004). In this sense, the retail dealer is likely as misinformed as the consumer in regard to the commodity's quality. A further limitation in this study is that due to the shortcomings of the data it was not possible to examine all price determinants of synthetic drugs. Thus, confounding factors may be at play in setting these prices. Prices may be set according to the relations between a trafficker and consumer; closer relationships justifying a lower price and unknown purchasers a higher price. In addition, a major problem to using price data is that prices fluctuate in regard to quantity discounts, with higher prices associated with smaller purchases and vice

versa (Caulkins & Padman, 1993). The current data did not detail the amount of the drug that was purchased at each sale not allowing us to account for this factor. More research is necessary to confirm the relationships between prices and structural dynamics.

Location of Transactions

We may also make inferences about Quebec's synthetic drug market based on an analysis of the price variation. Generally, retail drug transactions are standardized and are made in rounded dollar amounts. This finding has been documented in illegal drug markets across many countries (Wendel & Curtis, 2000). Standardized drug prices generally result as drug sales are conducted quickly in order to avoid police detection. Producing change prolongs this process and consequently increases the risk of exposure to law enforcement (Reuter & Caulkins, 2012). However, we note that in Quebec's synthetic drug market, many drugs are sold for prices that may require the production of change (e.g. $2.50, $7.50). This allows us to infer that some synthetic drug transactions may be conducted in private locations, where law enforcement detection is diminished and the luxury of making change can be permitted. This finding is also supported by the Gruppo Abele's (2003) research that found many synthetic drug purchases were made in private dwellings.

Conclusion

This study aimed at bridging a knowledge gap about the structural features of the synthetic drug market and factors that influence synthetic drugs prices. The results of the analysis, albeit with limitations, provide support for a competitive perspective of the drug market. These findings closely follows that of earlier research that states illegal crime

groups operate within ephemeral and competitive structures (Block & Chambliss, 1981; Reuter, 1983; Haller, 1990; Potter, 1994), contrary to the claims made at the beginning of this paper in regard to large groups dominating Canada's drug market. What can be cautiously inferred from the data in this study can assist authorities in creating more intelligence led and proactive programs to effectively target drug manufacturers. The detection and arrest of members of drug trafficking groups face many challenges and it has been recognized that in order to effectively accomplish this goal requires that law enforcement officials participate in an information exchange with numerous players, including forensic drug analysts (Esseiva et al, 2007). This is particularly relevant given the lack of research to date on the synthetic drug market and the priority that the Canadian government has accorded to combat the synthetic drug industry. For example, in 2009 the RCMP Synthetic Drug Initiative launched the first ever Canadian drug strategy to focus specifically on tackling synthetic drugs (RCMP, 2009). For resources to be effectively allocated programs should be designed that reflect the reality of the synthetic drug market in the Quebec province, and to take into account variations in market characteristics according to region.

Although the limitations of the available data does not allow for validation of the market structure, it does illustrate the distinct characteristics of this market and the value of applying innovative methodological frameworks. Innovative analyses have been encouraged when assessing illicit markets, which is noted by Caulkins and Reuters (2006):

> Although data presently available does not allow for model validation…nevertheless [it] illustrates the richness of possible behaviours of

> markets for illicit drugs and the value of being open to models built up from the special properties of those markets, rather than merely importing standard analysis and conclusions (p. 2).

In markets where research and data sources are scarce the value of approaching an illicit market from another method enriches our understanding and provides us with new models to validate findings, rather than repeatedly using familiar methods that leave us with the same fragmented conclusions. Triangulating the findings of studies with other sources augment the reliability of our results and provides a comprehensive understanding of illicit markets. To enhance the reliability of the findings in the current study, more detailed information regarding seizures should be obtained, including the concentration of substances in tablets, which can be used to validate links between manufacturers at a more detailed level and provide greater understanding of this market traditionally hidden from the purview of researchers.

Notes

[1] We would like to thank Dr. Louis-Eric Trudeau, Professor in the Department of Pharmacology at Université de Montréal, for his assistance.

Conclusion

Within the limits of the available data, the results of this study infer that the synthetic drug market in the Quebec province may be composed of a high number of small structures with a high number of independent producers, indicating a competitive market. In addition, this study provides further insight into the inner dynamics of the drug market, including the potential influence of production costs and relational features on retail prices based on the economic analysis. However, these inferences are only as good as the data sources and statistical tests used to derive them. To provide accurate interpretations of the findings the below section will provide an in-depth exploration of the study's shortcomings and the implications of the findings within these limitations.

Shortcomings and Advantages of the Analyses

While these results provide us with greater insight into the market, as with any criminological study it is important to take into account both the methodological and practical limitations when interpreting the results. To begin with, the drug composition data in this sample lacks detailed information about the concentration of the individual substances present in the synthetic drug tablets. Only having information about the contents of each tablet and not their respective concentration we risk inferring that all tablets that contain the same ingredients originated from the same production batch when in fact each tablet may have different quantities of the substances, thus potentially coming from different batches and indicating multiple manufacturers. Having information on the percentage of each substance in the tablets would allow for more accurate and reliable appraisals of the market's structure. As this level of detail was unavailable for the current study, this limitation was minimized by taking into account both the physical and chemical

features of the tablet when making links between drugs to determine their origin. Thus, drugs that shared the highest number of characteristics were also determined to have the highest likelihood of originating from the same manufacturer. The data source used in this study is in contrast to research conducted by Esseiva et al (2003), Esseiva et al (2007), and Zingg (2005) who performed highly sophisticated extraction methods that recorded precisely the amount of each substance present in the seized drug, providing more accurate links between drugs with shared characteristics.

Although there is concern that the chemical and physical profiles of synthetic drugs do not reflect the manufacturers that produced them, the tablet form that these drugs were pressed in helps alleviate this fear. Given that all the synthetic drugs in this sample were pressed into a tablet they have a distinct advantage over analyses conducted in other drug markets such as cocaine, as they are more likely to reflect the manufacturer that made them (Palbol, Boyer, Naulet & Chabrillat, 2002). In contrast to drugs in other markets the chemical and physical properties of synthetic drugs are more likely to remain static throughout the distribution chain (from manufacturer to consumer), as traffickers who distribute the drug post-production are unable to alter the composition of the drug by adding cutting agents (Zingg, 2005). Thus, a synthetic drug's profile is more likely to be confined to the manufacturer, which increases the reliability of the inferences made about the structure of the synthetic drug market.

However, a drug's physical profile may not be reflective of the manufacturer who produced it. There are two separate steps involved in production of a synthetic drug tablet, the chemical synthesis of the drug and the compression of the tablet (Baer, 2007).

Consequently an individual other than the manufacturer may compress the tablet, forming its physical properties such as logo, shape, weight, and diameter. Thus, different manufacturers may produce tablets with identical physical profiles, should they all source out to the same individual who compresses the drug into tablet form (Baer, 2007). Problems with the using the colour and logo to make links between drugs has been expressed by other researchers (Milliet, Weyermann & Esseiva, 2009). Despite these issues associated with the physical characteristics of synthetic drugs, including their low reliability, it has been stated that they should still be used as another source of complementary information (Marquis et al, 2008). Although physical profiles should not be used on their own to identify a manufacturer, they can still be used in conjunction with chemical profiles as a supplementary source of data to confirm links between manufacturers.

Additionally, further issues exist with using synthetic drug's physical profiles, including its logo and colour, to identify the structure of the drug market. Manufacturers may duplicate logos due to their popularity or because the logo has become an indicator on the illegal market of a high quality tablet (Bell, Barrett, Burns, Dennis & Speers, 2003). This was demonstrated in a study by Bell et al (2003) who found that almost all of the MDMA tablets they seized had a "Mitsubishi" logo although it was not possible that all these tablets had originated from the same producer. Consequently, drug logos are unreliable physical indicators because many manufacturers use the same logo and therefore they do not necessarily reflect the drug's composition or the manufacturer.

Furthermore, colour is also a poor indicator of a manufacturer because differences are frequently very minor between producers (Zingg, 2005). Different colours may indicate that it was made by a different manufacturer yet this distinguishing characteristic can only be perceived if tablets are directly compared beside one another, which is rarely possible, as even large drug seizures are not representative of all the drugs in the illegal market. In addition, large seizures often require that numerous analysts extract and categorize the physical properties of seized drugs. These analysts are unlikely to obtain consistent and reliable results due to the subjective nature of identifying a drug's colour (Zingg, 2005).

In addition to the aforementioned limitations, this study hinges on a few assumptions, the primary being the premise that manufacturers consistently use the same recipe and methods. Very little research has explored the synthetic drug market and it has not been established that manufacturers consistently produce the same tablets. Due to this we risk concluding that there are multiple producers operating in the synthetic drug market in cases where there are a large number of distinct profiles present, when in fact it may only be one producer altering his manufacturing process. However, based off current research about synthetic drug manufacturers, this risk may be lower for high quality tablets and higher for low quality tablets. Manufacturers who produce high quality tablets may be more likely to consistently use the same recipe and synthesis methods, as not only is it difficult to modify high quality recipes and still obtain proper results, but there is no rationale for a drug producer to change the manufacturing process (Baer, 2007). The risks of changing a drug recipe are high, as not only would it be more challenging and few incentives to sell an inferior quality product, but a minor change in the type, quantity of ingredients or

production methods may be dangerous, resulting in a chemical explosion. In contrast, manufacturers who produce low quality tablets may be more likely to modify their recipes. Drug producers with relatively little experience that primarily produce low quality drugs may modify their recipes in an aim to create a higher quality end product.

Further limitations also exist with the economic analysis. To begin with, the data only allowed us to assess whether the clustering of marketing variables influenced prices. As outlined in the literature review, a multitude of factors influence prices and the current data was unable to conduct a comprehensive analysis of these determinants. Thus, the findings in the price determinant section may be attributed to confounding factors. A major limitation rested with not knowing the quantity of drugs that were purchased during each transaction. Thus, a tablets price may be lower in a specific region not because of distinct traits of this market, but rather because market players purchased the drug in greater quantities. This study was unable to account for this possibility due to the limitations of the data.

An additional shortcoming involves the drug's purity, as we did not have information for the quantity of each substance present in the tablet. Although this was discussed as a shortcoming in the data composition analysis it is equally applicable to the economic analysis. In illicit markets prices may remain stable while the drug's purity fluctuates in response to market changes (Caulkins & Reuter, 1998). Purity varies widely within illicit drug markets (Caulkins & Reuter, 1998) with large fluctuations observed in methamphetamine in the U.S. over the past 15 years (Caulkins et al, 2004). Changes to the drug's purity may be done due to chemical shortages, such as precursor regulation

(Cunningham and Liu, 2003) with producers diluting the drug to increase the drug's volume and stabilize profits. The current study was unable to account for this due to the available data.

A final limitation of the seized drugs in this sample is that it cannot be determined whether they are reflective of the total illegal drug market. Law enforcement officials are estimated to seize only ten percent of all drugs that are circulating in the illegal market (Zingg, 2005). In addition, the tablets in this sample are only a subset of all samples, selected by law enforcement officials to be examined by Health Canada. To reduce this risk and to increase the representativity of results, seizures should be collected from different geographic regions in order to paint a better picture of all drug activity in an area (Zingg, 2005). Both the fact that the drugs have been seized from various regions in Quebec and that our results were supplemented with other data sources, including its price help, at least in part, to overcome this.

Given the shortcomings, this study advances an exploration into the potential causes of these factors, advancing the necessity of more detailed information and research into this hidden market. This study would benefit from a qualitative analysis that assessed production methods and synthetic drug producers' behaviours and practices to provide more reliable interpretations. Due to the limitations, this paper does not advance that this method should be applied in strict criminal identification of manufacturers, but rather as a supplemental source of information to provide a better grasp into the dynamics of an otherwise hidden market. This thesis contributes to the study of the synthetic drug market by providing valuable information about how drug properties can be used to examine the

synthetic drug market, informing us about the possible structure of this market, and raising awareness of the value of recording detailed information about drug seizures to monitor and learn about the market.

Allocation of Resources and Policy Implications

What can be cautiously inferred from the data in this study, in regard to a competitive market structure and unique characteristics according to production costs and distributor-consumer relations, can assist authorities in creating more intelligence led and proactive programs to effectively target drug manufacturers. The detection and arrest of members of drug trafficking groups face many challenges, and it has been recognized that in order to effectively accomplish this goal requires that law enforcement officials participate in an information exchange with numerous players, including forensic drug analysts (Esseiva et al, 2007). This is particularly relevant given the lack of research, to date, on the synthetic drug market and the priority that the Canadian government has accorded to combat the synthetic drug industry. Recently, in 2009, the RCMP Synthetic Drug Initiative launched the first ever Canadian drug strategy to focus specifically on tackling synthetic drugs (RCMP, 2009). In addition, only days after the most recent publication of the UNODC's World Drug Report (2012), that highlighted Canada's purportedly growing role in the global synthetic drug market, it was announced that Canada donated over $800,000 to their Global Synthetics Monitoring: Analyses, Reporting and Trends Programme (SMART), totalling Canada's donation to more than U.S. $1.3 million dollars over the past two years (UNODC, 2012). For resources to be effectively allocated, programs should be designed that reflect the reality of the synthetic drug market in the

Quebec province and take into account variations in market characteristics according to region, rather than attempting to tackle a highly structured organization, which is inconsistent with research.

Additionally, synthetic drug profiles can increase the number of successful criminal prosecutions, as they can be used to provide reliable evidence in the courtroom. To begin with, synthetic drug profiles are considered objective tools to generate information, as different analysts can repeatedly test them and they will consistently obtain the same results (Zingg, 2005). This is in contrast to the testimony of a police officer or witness, which is considered subjective, as it may be influenced by the individual's perspective or situation and cannot always be verified by different sources. Secondly, the chemical and physical properties of synthetic drug profiles generally remain stable and do not alter or significantly undergo degradation over time (Zingg, 2005). Thus, a seized drug profile can be re-examined at different points in times and will continue to reflect the manufacturer who produced them. In addition, synthetic drug profiles may have the ability to demonstrate the extent of a drug trafficker's activity in an organized crime group (Dujourdy et al, 2003). For example if it can be determined that the accused, a drug manufacturer, constantly uses the same recipe and therefore has manufactured tablets that carry the same drug profile it can be demonstrated, at minimum how many tablets he produced, by examining drug seizures. This may influence the severity of a criminal sentence, as it allows us to separate large, wholesale manufacturers from small, one-time producers. Individuals who were heavily involved in the synthetic drug market may receive more punitive sentences, in

contrast to small producers who only participated in the production of drugs a few times over short careers.

The benefits of this highly valued intelligence gathering tool suggest that forensic drug composition analysis should be implemented into law enforcement techniques. As mentioned, the results obtained from analysts of synthetic drug profiles can provide valuable information to law enforcement agencies on the inner workings and overall versatility of these drug trafficking groups to better guide investigation techniques that aim to decrease drug production over the long term. Lastly, if seized synthetic drug profiles are analyzed over long periods it will generate extensive databases that will permit researchers to analyze how the structure of the synthetic drug market changes over time and enable them to observe how or if it transforms in response to police enforcement intervention efforts. Consequently, it provides police with a feedback system to observe whether the programs they have implemented are having an effect on drug trafficking.

Directions for Future Research

This study aimed at bridging a knowledge gap about the structural features of the synthetic drug market and factors that influence synthetic drugs prices. The results of the analysis, albeit with limitations, provide support for a competitive perspective of the drug market. These findings closely follows that of earlier research that claims illegal markets are characterized by competitive structures with many small groups operating in the same market, contrary to the claims made at the beginning of this paper in regard to large groups dominating Canada's drug market. Providing additional information about the distinct features of the synthetic drug market, this study also demonstrated that both the drug's

quality and marketing factors play a marginal role in influencing the drug's final price, depending on the region. In sum, this study suggests that regional differences are a result of different production costs and relations between trafficker and supplier, which may be influenced by the ratio between demand and supply and hence traffickers reliance on the user for repeat business. While inferences can be made about the drug market based on these findings, more extensive research needs to be conducted to further enhance the reliability of the results. The wide ranging benefits of using synthetic drug profiles, including more effective police techniques and an enhanced understanding of market features, make this a method that should be diligently pursued by researchers and enforcement organizations to effectively target and learn more about the intricate processes that underlie the illegal synthetic drug world.

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