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Research paper

Estimating the production, consumption and export of cannabis: The Dutch case

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ABSTRACT

Background: Quantifying an illegal phenomenon like a drug market is inherently complex due to its hidden nature and the limited availability of reliable information. This article presents findings from a recent estimate of the production, consumption and export of Dutch cannabis and discusses the opportunities provided by, and limitations of, mathematical models for estimating the illegal cannabis market.
Methods: The data collection consisted of a comprehensive literature study, secondary analyses on data from available registrations (2012–2014) and previous studies, and expert opinion. The cannabis market was quantified with several mathematical models. The data analysis included a Monte Carlo simulation to come to a 95% interval estimate (IE) and a sensitivity analysis to identify the most influential indicators.
Results: The annual production of Dutch cannabis was estimated to be between 171 and 965 tons (95% IE of 271–613 tons). The consumption was estimated to be between 28 and 119 tons, depending on the inclusion or exclusion of non-residents (95% IE of 51–78 tons or 32–49 tons respectively). The export was estimated to be between 53 and 937 tons (95% IE of 206–549 tons or 231–573 tons, respectively).
Conclusion: Mathematical models are valuable tools for the systematic assessment of the size of illegal markets and determining the uncertainty inherent in the estimates. The estimates required the use of many assumptions and the availability of reliable indicators was limited. This uncertainty is reflected in the wide ranges of the estimates. The estimates are sensitive to 10 of the 45 indicators. These 10 account for 86–93% of the variation found. Further research should focus on improving the variables and the independence of the mathematical models.

Introduction

Up until the 1980s, the Netherlands was importing cannabis, mainly in the form of hashish, from countries such as Morocco, Pakistan, Afghanistan, Lebanon, Columbia and India. The majority of cannabis consumed in Europe originated from the Moroccan Rif Mountains and the border regions of Pakistan, Afghanistan and Iran, where cultivation increased explosively since the 1960s to meet the growing European demand (Afsahi, 2011; Weijenburg, 1993). It wasn't until the 1980s that cannabis cultivation emerged in the Netherlands and this 'import substitution' became a topic of particular interest to Dutch scholars.

The emergence and increase of the cultivation of cannabis in the Netherlands is attributed to several factors, including the development of new cultivation techniques and varieties of cannabis (Decorte & Boekhout van Solinge, 2006; Spapens, Müller, & Van de Bunt, 2014), national and international efforts to counter the smuggling of hashish to the Netherlands (Korf, 2006), and the 'tolerant' Dutch attitude toward the sale of cannabis through coffee shops (Jansen, 1993; Fijnaut, Bovenkerk, Bruinsma, & Van de Bunt, 1998; Spapens et al., 2014). Consequently, the Netherlands has developed into a significant producer of cannabis over the past three decades (Korf, 2011; EMCDDA, 2013).

Though it is clear that the Netherlands has become a large-scale producer of cannabis, questions continuously arise as to the actual size of the illegal Dutch soft drug market, and how much of domestic production is exported. Estimates of the size of the domestic market and the export also play a central role in the current political debate pertaining to the regulation of the cultivation of cannabis for coffee

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shops in the Netherlands. The Minister of Security and Justice in part bases his decision to not allow the regulation of cannabis cultivation for Dutch coffee shops on export estimates, stating that if a lot of the cannabis cultivated in the Netherlands is intended for export, regulating the cultivation for Dutch coffee shops will only have a limited effect on the total cultivation. Furthermore, illegal cultivation would continue to exist and regulated cultivation would be ineffective in combatting organized crime related to the cultivation of cannabis (see for example Tweede Kamer, 2014a, 2014b).

However, the information needed to quantify the cultivation, consumption, and export of Dutch cannabis is limited and uncertain due to the clandestine nature of illegal markets. This article presents findings from a recent estimate of the production, consumption and export of cannabis for the case of the Netherlands and discusses the opportunities provided by, and limitations of, mathematical models for estimating the illegal cannabis market (Van der Giessen, Van Ooyen-Houben, & Moolenaar, 2014).

Data collection

Because limited information is available on the Dutch cannabis market due to its clandestine nature, the models are data driven. Where data for a certain variable were not available, substituting in other variables or combinations of variables approximated the value. Unfortunately, this means that a fairly large number of variables are required for the estimates. To validate the data, we not only searched for the most recent data, we also assessed the uncertainty inherent in the data.

The variable values are based on a comprehensive literature study, secondary analyses on data from previous studies, and available registrations. The registrations used are primarily from 2012–2014. As such, our estimates of the production, consumption, and export do not denote a specific year, but rather a yearly average. Only the most recent and reliable data were considered. Furthermore, when several potential sources were available for specific variables, these sources were combined. When using several different data sources, contradictory results may be indicative of potential uncertainty associated with specific variables. A range was established in which each value of the variable might move according to the available literature to take this uncertainty into account. This range is defined by the minimum and the maximum value found in our sources when several sources are available and by the mean value and its standard deviation when only one source is available.

The data were validated by a panel of experts and subsequently augmented and adjusted where they deemed it necessary. This expert review improved the validity of the variables used when the literature provided insufficient information and served as an additional check of the limitations of the methods.

Data analysis

We recorded the lowest and the highest reported values we could find for each variable. With these, we calculate the lowest and the highest possible outcomes for the production, consumption and export models. These constitute the lower and upper bounds of our interval estimates. Furthermore, we perform a Monte-Carlo simulation (MC) by drawing 100,000 random values between the lowest and highest value of each input variable. This yields a range in which 95% of the estimates lie. This approach significantly differs from the approaches of previous authors who generally varied only a few variables. Though the MC simulation is generally used to determine a 'confidence interval', we chose to label the results as an 'interval estimate' for the current paper to emphasize that the range within which 95% of the estimates fall, is dependent on the models used and their inherent assumptions. Both the upper- and lower bounds of the estimates and the interval estimates are presented here in order to be transparent about the potential estimate outcome ranges.

Furthermore, a sensitivity analysis is performed to determine to what extent the outcomes are sensitive to variations in the individual variables. This is done by changing the value of each variable with 1% (point) and leaving the values of all other variables unaltered. We also investigate which variables have the greatest impact on the estimates.

Modelling the export of Dutch cannabis

The mathematical model to estimate the production, consumption, and export of cannabis developed by Jansen (2012) was used as a starting point and expanded upon with the models used in other state of the art, national and international estimates (Bouchard, 2008; Carpentier, Laniel, & Griffiths, 2012; Hakkarainen, Asmussen, Perälä, & Vibeke Dahl, 2011; Kilmer & Pacula, 2009; Van der Heijden, 2006; Van Laar, Frijns, Trautmann, & Lombi, 2013a; Van Laar, Frijns, Trautmann, & Lombi, 2013b; Van Laar, Cruts, et al., 2013; Van Laar, Trautmann, & Frijns, 2013). This resulted in several alternative models for the production and consumption of Dutch cannabis. Export is modelled by subtracting the estimated consumption from estimated net production. Net production is the production available to the consumption market, which means that cannabis confiscated by the police is not included. These models are similar to the model used by Jansen (2012), but contain more detail and pay more attention to the estimation of the dark numbers and uncertainties inherent in the data.

All models implicitly assume that cannabis sold as 'Dutch cannabis' is in fact produced in The Netherlands. However, cannabis sold as 'Dutch cannabis' may have been produced elsewhere (e.g. Belgium, Germany, Spain, Denmark) using methods and materials typical to the Netherlands. Unfortunately, we have no information on the share of cannabis sold as 'Dutch cannabis' that is grown abroad.

Production models

The medium to large scale indoor production of cannabis requires a considerable amount of electricity (for lighting, heating, etc.), which is likely to be stolen to minimize costs and the risk of discovery. This makes electricity use for cultivation a prime candidate to estimate indoor cannabis production (the primary modus operandi for cultivation in the Netherlands). We estimate the net production of Dutch cannabis (NY) using three production models; two of which are based on the cannabis production using stolen electricity, but differ in the way they account for the cannabis produced without stolen electricity. The third production model estimates the net production by totalling the cannabis from confiscated harvests and adjusting for the capture rate (CR) and confiscated harvests (CH). See Table 1 for the individual variables used in the production models.

In the models based on the cannabis produced using stolen electricity net production is modelled as the cannabis produced at cultivation sites using stolen electricity (Y^{ET}), adjusted for the so-called dark number (DN) and confiscated harvests (CH). In this context, the dark number is the amount of cannabis cultivated without stolen electricity. The dark number can be estimated in various ways, but due to data limitations we were only able to use two methods. Using the first option to approximate the dark number, net production is estimated by calculating the amount of cannabis that could technically be produced using stolen