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Research paper

Filling in the blanks. An estimation of illicit cannabis growers' profits in Belgium

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ABSTRACT

Background: As a result of increased pressure on cannabis cultivation in The Netherlands, the number of confiscated indoor cannabis plantations in Belgium is rising. Although increases are reported for all plantations sizes, half of the seized plantations contain less than 50 plants. In this study, factors and variables that influence costs and benefits of indoor cannabis cultivation are investigated as well as how these costs and benefits vary between different cannabis grower types.
Methods: Real-situation data of four growers were used to perform financial analyses. Costs included fixed and variable material costs, as well as opportunity costs. Gross revenue per grow cycle was calculated based on most recent forensic findings for illicit Belgian cannabis plantations and was adjusted for the risk of getting caught. Finally, gross revenues and return on costs (ROC) were calculated over 1 year (4 cycles).
Findings: Financial analysis shows that in all cases gross revenues as well as ROC are considerable, even after a single growth cycle. Highest profitability was found for large-scale (600 plants, ROC = 6.8) and mid-scale plantations (150 plants, ROC = 6.0). However, industrial plantations (23,000 plants, ROC = 1.4) and micro-scale plantations (5 plants, ROC = 2.8) are also highly remunerative. Shift of police focus away from micro-scale growers, least likely to be involved in criminal gangs, to large-scale and industrial scale plantations would influence costs as a result of changing risks of getting caught. However, sensitivity analysis shows that this does not significantly influence the conclusions on profitability of different types of indoor cannabis growers.
Conclusion: Seizure and confiscation of profits are important elements in the integral and integrated policy approach required for tackling illicit indoor cannabis plantations. The large return of costs evidenced in the present study, underpin the policy relevance of confiscating those illicit profits as part of enforcement.

Introduction

Over the past few years, the Belgian illicit indoor cannabis growing industry has developed into a booming business (De Ruyver, 2006; Decorte, 2010b). Police data show that the number of discovered plantations, with dimensions ranging from 2 to >1000 plants, has risen from 35 in 2003 to 1111 in 2012 (Table 1). Although these figures can be seen as a direct indicator of police efforts in discovering plantations, they may also reflect an increase in the Belgian cannabis supply. In addition to a manifest increase in small-scale plantations, the number of large plantations has been growing as well (source: Belgian Federal Police – Desk Production DJP/Drugs). This trend is most likely stimulated by an increased Dutch involvement in the 'Belgian' producer networks. Indeed, many of the discovered plantations are set up or organized by Dutch criminal entrepreneurs or persons having at least some connection with the Netherlands, whereas most of the materials used are sourced from Dutch growshops (Fijnaut & De Ruyver, 2008; Spapens & Fijnaut, 2005; Van Camp, 2008). The latter indicates a shift of cannabis-growing entrepreneurship from the Netherlands

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Table 1
Discovered active cannabis plantations by scale type in Belgium: 2007–2012.

Grower type	2007	2008	2009	2010	2011	2012
Micro-scale (2–5 plants)	68	136	138	211	190	172
Mini-scale (6–49 plants)	135	219	227	312	376	453
Small-scale (50–249 plants)	50	125	161	165	187	166
Middle-scale (250–499 plants)	37	58	73	94	101	89
Large-scale (500–999 plants)	42	63	67	104	119	142
Industrial scale (>1000 plants)	40	45	71	82	88	83
Total	372	646	737	968	1070	1111

Source: Belgian Federal Police – Desk Production DJP/Drugs.

to Belgium. This can be explained by what police term as 'displacement'. At the end of the 1990s, the Netherlands had started to focus on the so-called backdoor of the coffee shops and cannabis-producing networks (Boekhout van Solinge, 2004; Korf, Van der Woude, Benschop, & Nabben, 2001; van de Bunt, 2006; van Ooyen-Houben, 2006). One of the main drivers was international pressure on the Netherlands as a result of the increasing stream of international drug tourists visiting both coffee shops and other dealing premises. These outlets cause potential public nuisance for local citizens and, according to neighboring countries, draw young people into the Netherlands to purchase illicit drugs (Boekhout van Solinge, 1996; De Ruyver, Surmont, De Moor, & Vandam, 2007; EMCDDA & Europol, 2013; Fijnaut & De Ruyver, 2008; Surmont, 2007).

As a result of their highly dynamic and adaptive character, drug networks found a new operation base in Belgium. The displacement was also opportunity-driven: initially, plantations were not easily discovered by the Belgian police, because they lacked the know-how their Dutch colleagues had acquired after years of seizures (Spapens, van de Bunt, Rastovac, & Miralles Sueiro, 2007) Belgium did not have a long tradition in detecting cannabis plantations and subsequently identifying the networks they operate in (Van Camp, 2008).

Currently, when a plantation has been dismantled by the Belgian police, the prosecutor tries to estimate the financial benefits of the actors involved, based on the confiscated assets and/or calculated financial returns (Vanhove, Surmont, Van Damme, & De Ruyver, 2012). At production level, the prosecution currently uses a fixed price of €3 per g (Van Camp, 2008), without taking plantation type or grower characteristics into consideration. The fixed price is applied to the possible yield of the discovered plantation and possible former yields (in grams): the yield calculation is based on research by Toonen, Ribot, & Thissen (2006) and applied at 28.1 g per plant.

In 2010, an interdisciplinary study, funded by the Belgian Science Policy Office shed more light on agronomic and criminological aspects of Belgian indoor cannabis cultivation. The study found that (i) one cannabis cycle can be completed in 11 weeks so that a grower can theoretically conduct at least 4 cannabis grow cycles in one year; (ii) a reliable yield estimate of an indoor cannabis plantation is 575 g per m^2 of dried cannabis buds; (iii) the Belgian cannabis market chain has a highly complex structure in which unit prices are predominantly determined by transaction sizes, but where a broad range of product-related factors and social mechanisms also have a significant impact on price formation; (iv) Belgian cannabis growers across all scale types (micro-scale to large-scale) receive between €3.00 and €4.25 per g of dry cannabis buds, depending on the relationship of the grower with the wholesaler, transaction size and quality (apart from the scale of the grower). This means that the fixed price of €3.00 per g currently used by the Belgian prosecution is an underestimation of the current prevailing market prices. These results support the conclusion that an illicit Belgian cannabis grower can obtain a gross revenue of between €6900 and €9775 per m^2 per year (€3.00 or €4.25 per g × 575 g per m^2 × 4 cycles per year) (Vanhove, Surmont, et al., 2012; Vanhove, Van Damme, Surmont, Van Puyenbroeck, & De Ruyver, 2012a,b).

Although much is known about wholesale prices and profits in drug markets (EMCDDA, 2012) in general, little is known about precise monetized profit rates of different kinds of cannabis growers. Police and judiciary assume the latter are considerably higher than in legal economic activities, but estimations have never been provided. Here we aim to reveal returns on cost for different types of cannabis growing operations. Currently, the Belgian judiciary makes no distinction in prosecution of cannabis plantations of different scales. However, Decorte (2010a, 2010b) has argued that small-scale cannabis production should be considered as a specific segment of the Belgian cannabis market because small-scale-growers (i) desire a milder and more organic product than the cannabis sold through mainstream coffee shop channels; and (ii) are ideologically oriented growers that cultivate cannabis as part of a subculture and do not want to contribute to profits of criminal networks. As a result, Decorte (2010b) made a case for government-regulated production and trade of cannabis that would limit the possibilities for organized crime in the cannabis distribution chain. Data on profit margins for different plantation sizes would at least allow the development of a more finely tuned and differentiated policy towards containing illicit cannabis growing in Belgium.

However, the findings of Vanhove, Surmont, et al., 2012, do not allow determination of conclusive net profits of illicit cannabis growers in Belgium. Most interviewees at production level could not provide these researchers with adequate information on the type of investment made in growing installations nor other production costs (fertilizers, electricity, etc.) (Surmont, Vander Laenen, & De Ruyver, 2011; Vanhove, Surmont, et al., 2012; Vanhove, Van Damme, et al., 2012). In this paper, we combined findings from real case studies with information from grey literature resources in order to estimate gross revenues and return on costs of different types of Belgian indoor plantations.

Methods

We calculated costs and gross revenues of four separate (Belgian) cannabis growers: three growers (with 5, 150 and 600 plants, respectively) who were interviewed for the study of Vanhove, Surmont, et al. (2012) and one grower with an industrial-size plantation (>1000 plants). The latter was not included in the snowball sample of Vanhove, Surmont, et al. (2012); these types of grower are harder to recruit to scientific studies as they do not wish to compromise their business (Surmont et al., 2011). In interviews, growers were asked about objectively verifiable data such as the number of plants, environmental factors such as temperature and light regime, materials used, etc. In the case of the industrial grower, the latter information was obtained from grey literature and television coverage documenting his plantation at time of seizure.

Several studies have stated that snowball sampling works better with more marginalized groups of drug users than with cannabis smokers and dealers, because the latter belong to more socially

integrated groups (Korf, 2011; Liebregts et al., 2011). Nonetheless, we used a snowball sampling approach because information given to the police by the respondents could be highly biased; and the police may arrest 'stereotypical' groups which in turn may bias any sample taken from within a detention setting (Caulkins, 2007; Surmont et al., 2011; Van Den Broeck, 2001). Our intention to discuss monetary transactions was not realized because respondents feared this information might be used against them at some future point (Surmont et al., 2011). We succeeded in interviewing nine growers with various characteristics and motives for illicit indoor cannabis growing. Using the typology of the Belgian Federal Police, one held a *micro-plantation* (5 or less plants), one held a *mini-plantation* (6–49 plants), three held a *small-scale plantation* (50–249 plants), three others were holding a mid-scale plantation (250–499 plants) and one grower operated a *large-scale plantation* (500–999 plants). The sample thus broadly represented the Belgian indoor cannabis cultivation sector, as confiscation numbers are more or less evenly distributed over the four grower types (Table 1). Three of these nine growers were chosen for more detailed characterization, so that each type was represented in our study. As Vanhove, Surmont, et al. (2012) had used interviews to determine pricing mechanisms at different levels of the cannabis distribution chain, it was not necessary to retrieve detailed information on the growing installations and premises. We selected growers who provided us with the most information on their plantation and business. We compared costs and gross revenues of the aforementioned industrial grower (approximately 23,000 plants, the largest plantation ever discovered in Belgium), a large-scale grower (600 plants), a small-scale grower (150 plants) and a micro-scale hobbyist grower (5 plants).

Data on the four real growing cases were fed into a financial cost-benefit analysis. Eide (2000) distinguishes four different cost components of a criminal activity: (i) psychic costs (guilt, anxiety, fear, dislike of risk), (ii) material costs, (iii) expected punishment costs, and (iv) opportunity costs. Psychic costs were omitted from our analysis, because it was not possible to monetize them. For material costs, we considered fixed costs (investments) as well as variable costs (incurred per grow cycle). Material costs were estimated by using data on the material used in grow cycles performed by Vanhove, Van Damme, et al. (2012) and Vanhove, Van Damme, & Meert (2011). Input prices were obtained from growshop websites or from agricultural supply stores. Expected punishment costs included formal and informal sanctions as well as costs arising from lawsuits. According to Belgian criminal law, cannabis producers risk a fine of between €1000 and €100,000 (Van Cauwenberghe, 2012). However, due to the wide range of fines and the many factors that influence the magnitude of a fine, we did not include the punishment costs in our calculations. Opportunity cost of crime consists of the net revenue (i.e. gross revenue minus costs) of a legal activity foregone while planning, performing and concealing the criminal act (Eide, 2000). We included labour of the industrial grower in the opportunity costs (see below) but did not consider labour costs for the other three growers as they had a legitimate job and thus an income from the legal sector. We did not have any information on the methods, time and number of people involved in plantation set-up or post-harvest trimming activities. Since these can be highly variable (e.g. trimming can be done manually of mechanically), we did not include labour costs for plantation set-up or for post-harvest activities.

In his renowned economic approach to crime and punishment, Becker (1968) showed that the probability of being arrested is an important element in the marginal utility of criminal activities. Rates of return on costs (ROC) of criminal activities, usually defined as net profit (sales minus total costs) divided by total costs, should consequently be adjusted for risk. If the probability of getting caught is π, then the cannabis grower has a probability of $(1-\pi)$ of selling a quantity of cannabis Q at unit price P. Following Easton (2004), the rate of return on costs is then:

$$\mathrm{ROC} = \frac{(1-\pi)PQ - C}{C} \quad (1)$$

in which C is total cost of cannabis growing, and P and Q the price and quantity of cannabis sales respectively. Estimation of the value for π in the case of Belgian cannabis production is difficult due to the rapidly changing situation, both in terms of total plantation numbers as well as in terms of enforcement. Bouchard (2007) reports a π-value of 0.05 in Quebec, Canada, whereas Easton (2004) assumes a good estimate for π in British Columbia, Canada, is 0.16. We have no indication of a good estimate for π in Belgium. As a result, we took the average of the aforementioned π-values reported for Quebec and British Columbia. In our basic calculation on ROC of cannabis growing in Belgium, we thus set π to 0.1. Quantities of commercial cannabis obtained per grow cycle were derived from the overall yield figure determined by Vanhove, Van Damme, et al. (2012) (i.c. 575 g per m^2) that was multiplied by grow surface area. In two cases, lower yield figures were used (see infra for argumentation). The analysis spanned a period of 4 grow cycles, which roughly covered one cannabis cultivation year (Vanhove, Surmont, et al., 2012). Price information was obtained per case from interviews (Vanhove, Surmont, et al., 2012).

Input quantities and price estimations for each case are summarized in Table 2. Where interviews did not yield unambiguous information on inputs used, estimations were made on the basis of extrapolations of input use in grow experiments of Vanhove et al. (2011) and Vanhove, Van Damme, et al. (2012). This was especially the case for fertilizer consumption rates. Investment costs, variable costs and opportunity costs were adjusted for the inflation rate of 6.16% (http://nl.inflation.eu/) that occurred during the period between interviews being conducted (July 2010) and the gathering of cost price information (July 2012), so that all items in (1) were expressed in July 2010 prices.

The first case deals with an industrial-size cannabis plantation (around 23,000 plants) that was discovered in 2009 and had been operational during an unknown number of years. It consisted of 2 large farming sheds, with a total surface of 1532 m^2. Plant pots were not used, as rooted plantlets were planted directly in the soil. The plantation used one 600 W lamp per m^2, resulting in 1532 lamps and accompanying ballasts. The plantation consumed (1532 × 600 W) (lamps) + (25 × 135 W) (ventilators) + (25 × 3000 W) (heaters) + (30 × 550 W) (turbines) = 1014 kW of electricity. The grower concealed electric power consumption from official power suppliers by generating his own electricity through a diesel generator. Annual fuel consumption of the latter was extremely high (estimated at 400,000 l per cycle) and required weekly delivery to the farm. Upon discovery of the plantation, three foreign, illegal workers were found to be working on the plantation. Police reports state (source: newspaper *Het Nieuwsblad* 15 June 2009) they earned €4000 per month. As a result, labour cost per cycle was estimated at €33.000 (3 persons × 2.75 months per cycle × €4000 per month). During cannabis cultivation, the two large sheds could not be used for 'normal' agricultural activities. In order to assess the opportunity cost of this grower, we assumed a rental price of €1500 per month, which corresponds with rental prices for similar farming sheds (http://www.2dehands.be/and http://www.aanbod.be/). We further assumed the farmer was continuously active in cannabis cultivation and therefore missed a monthly net income of €1500 in the legal economy, which is added to the total opportunity costs (€9000 per grow cycle, i.e. 3 months × €3000 per month). Since plant density (8 per m^2) is out of the range of the grow experiments of Vanhove et al. (2011) and Vanhove, Van Damme, et al. (2012) and because of the unusually large scale of the operation under consideration, a conservatively

Table 2
Investments, variable costs and sales prices (1 grow cycle) for 4 real cases of Belgian cannabis growers.

	Unit	Industrial	Large-scale	Small-scale	Micro-scale	Unit price (€)	Price source
Plants	n	23,000	600	150	5		
Surface	m^2	1532	50	20	1		
Investments							
Pots (25 × 25 m)	n	0	600	150	5	0.70	a
Grow tent 1 m^2: Secret Jardin Darkroom DR90	n	0	0	0	1	125.00	b
Lamps Philips Master SON-T PIA Plus E40 (600 W)	n	1532	50	20	1	37.00	b
EB600-SON Electronic Ballasts	n	1532	50	20	1	60.00	c
Carbon filter Wilco 150 cm; 2400 m^3/h	n	30	1	0	0	170.00	b
Carbon filter Can-Light 1500 m^3/h	n	0	0	1	0	125.00	b
Carbon filter Can-Light 150 m^3/h	n	0	0	0	1	38.00	b
Turbine: box silent air (4250 m^3/h)	n	30	1	0	0	295.00	b
Turbine: box silent air (2500 m^3/h)	n	0	0	1	0	250.00	b
Turbine: Ruck RK125L 330 m^3	n	0	0	0	1	75.00	b
Turbine control: Torinsifan (R.I.C.)	n	30	1	1	0	235.00	c
Flexibles	m	350	40	20	0	3.75	b
Reflecting white canvas (2 m wide)	m	0	70	20	0	1.50	b
EUROM EK3301 Heater	n	25	2	1	0	60.00	d
Honeywell NV-1800E ventilator	n	25	2	2	0	30.00	b
1568 kW diesel generator set (380/220 V)	n	1	0	0	0	310,200.00	e
Trimprol automatic cannabis cutter	n	1	0	0	0	1950.00	b
Variable costs							
Rooted plantlets	n	23,000	600	150	5	2.00/10.00	f
Peat soil	l	0	6600	1650	55	6.50	g
Tap water	m^3	0	20	5	0	3.05	h
Well water	m^3	782	0	0	0	1.80	i
Electricity from the net	kWh	0	30,240*	12,096	605	0.24	j
Diesel for power generator	l	285,264	0	0	0	0.77	k
Terra Vega	l	617	17	5	0	6.00	b
Terra Flores	l	3081	81	21	1	4.75	b
Rhizotonic	l	0	27	7	0	18.50	b
Cannazym	l	0	43	11	0	10.00	b
Cannaboost	l	0	46	12	0	35.00	b
Labour	hours	1848	0	0	0	6.00	b
Opportunity costs							
Rent of sheds	months	3	0	0	0	1500	
Income in legal economy	months	3	0	0	0	1500	
Sales price	€/g	3	3.43◦	4	2.25†		

a = ALTCO BVBA, Assenede, Belgium; b = Growcenter-Noord (Amsterdam, NL) (http://www.growcenter-noord.nl/); c = Growshoponline (Heerlen, NL) (https://www.growshoponline.nu/); d = Wehkamp, Zwolle (http://www.wehkamp.nl); e = price (VAT incl.) for a Himoinsa™ generator, model HMW-1785 T5 at Van Daele Machinery, Belgium (http://www.vandaele-machinery.be/, 395 l/h diesel consumption at full power; f = police reports consistently mention €10 per cutting; for the industrial grower, however, quantity discounts are expected and €2 per cutting is used (based on prices offered for cuttings on internet forums such as http://www.jointjedraaien.nl/or http://www.wietforum.nl/); g = AVEVE (http://www.aveve.be); h = Water-Link (http://www.water-link.be/), prices for usage between 15–500 m^3, prices for 2012, incl. VAT; i = cost estimate of well water in Flemish agriculture, including infrastructure depreciated over 10 years and taxes (Messely, Lenders, & Carels, 2008); j = luminus (https://www.luminus.be/), only daytime rate, incl. all taxes, using IMEWO distribution net, incl. VAT; k = Belgian Federal Government. Directorate-general Statistics and Economic information (http://statbel.fgov.be), average 2008 price for fuel oil supplied at quantities >2000 l.

* Electricity not paid for, because tapped before the meter.

◦ Price composed of 30% €3.25 g^{-1} and 70% €3.5 g^{-1}.

† Price composed of 50% €2 g^{-1} and 50% €2. g^{-1}.

estimated yield of only 300 g per m^2 was used in the financial analysis instead of the yield figure (575 g per m^2) determined by Vanhove, Van Damme, et al. (2012). These authors also showed that cannabis prices decrease with increasing transaction sizes and provided a range of €3.00 to €4.25 per g of dry cannabis buds bought at the grower's level. Since cannabis production of the considered grower is estimated at 460 kg per cycle, we used the lower bound of the prices reported by Vanhove, Van Damme, et al. (2012) (€3.00 per g).

The second grower invested in materials to set up a professional large-scale soil-based plantation of 600 plants in his basement in 2009. The equipment was bought via a Dutch growshop, but set up by the respondent himself, following guidelines and recommendations from friends, the growshop, internet and various

grey literature sources. Because the basement had no alternative economic value and because the grower used his free time (with the help of some friends) to manage the plantation, no opportunity costs were taken into account. Electric power costs were avoided by (illegally) tapping electricity before it came to the meter, a common practice in illicit cannabis cultivation (Bovenkerk & Hogewind, 2003; Spapens et al., 2007; Wouters, Korf, & Kroeske, 2007). In fact we could view this grower as having two criminal enterprises: growing cannabis and stealing electricity. In order not to credit profits from stealing electricity as profits from cannabis growing, we repeated our financial analysis (large-scale+ in Tables 3 and 5) by taking the electricity cost into account. In the present case, the grower sold the lower quality buds (around 30%) at €3.25 per g to the growshop where he sourced his cultivation equipment. Good quality buds (70%) were sold to a middleman (also connected to the growshop, claiming to operate on behalf of a coffee shop) at €3.5 per g. A small (negligible) part was auto-consumed or was shared with friends who had helped him with the laborious cutting activities.

The third grower transformed his attic (5 m × 5 m; 20 m^2 occupied by cannabis plants) into a grow room, in 2007. The equipment was installed by an employee of a Dutch growshop, and although the growshop offered him a 'bargain' (grow room was set up without additional cost in return for the first harvest), he was said to have declined this offer and to have paid the full installation costs. Presumably, the latter covered the investment cost (as described for the first two growers), supplemented by transport and labour costs. Unfortunately, no information was given on the exact cost of installation, so we only used the equipment costs. Following the same reasoning for the second grower, no opportunity costs were assumed. The respondent had some friends who also had a plantation, and were familiar with the cannabis business, so he did not have many problems in finding a contact to sell his cannabis harvest to. According to the grower, as a result of his experience (>5 years), he produced high quality buds that he was able to sell at €4 per g. As with the second case, a negligible part was auto-consumed or given to friends who assisted in harvesting and cutting.

The fourth grower purchased a so-called grow tent (0.9 m × 0.9 m × 1.8 m) from a Dutch growshop, to set up a *micro-scale plantation* to grow 5 plants to fulfil his own needs and those of his closest friends. No opportunity costs were assumed because opportunities missed by investing time and infrastructure in cannabis production are negligible. This grower operated out of the range of the grow experiments as performed by Vanhove et al. (2011) and Vanhove, Van Damme, et al. (2012), both in terms of plant density (12–16 per m^2 for the latter authors) and in terms of scale of the plantation (around 200 plants for the latter authors). Furthermore, the interviewed grower claimed to strive for quality, rather than for large quantities. As a result, a conservative yield estimate of 300 g per grow cycle was considered, rather than the yield figure of 575 g per m^2, proposed by Vanhove, Van Damme, et al. (2012). Since profit seeking was not the grower's primary goal, the harvest was sold below the normal market price: €2.5 per g for small quantities (1–10 g) (half of the harvested volume) and only €2 per g for higher transaction sizes.

Given the uncertainties on the precise yield of the industrial grower (first case), a sensitivity analysis was performed in which yield was varied between 200 and 600 g per m^2 with an increment of 100 g per m^2. Growers who operate at a scale similar to those of our case studies might receive different prices because apart from transaction sizes, cannabis price setting depends on many product and socially related aspects Vanhove, Surmont, et al. (2012). As a result, a second sensitivity analysis was performed in which ROC for all considered growers was calculated by varying cannabis prices in the range proposed by Vanhove, Surmont, et al. (2012) (€3.00–€4.25 per g), with an increment of €0.25. An

Table 3
Financial analysis of 4 real cases of Belgian cannabis growers after one year or 4 cycles of cannabis growing. Large-scale+ takes the electrical power costs of the large-scale grower into account.

Grower type	No. of plants	Crop area (m^2)	Fixed costs (€)	Fixed costs per m^2 (€)	Variable costs (€)	Of which power costs (€)	Variable costs per m^2 (€)	Total costs (€)	Total costs per m^2 (€)	Total gross revenue (€)	ROC (1 year)
Industrial	23,000	1532	510,747	333	1,527,233	1,155,173 (76%)	997	2,081,890	1352	4,963,680	1.4
Large-scale	600	50	7727	155	37,477	0	750	45,204	904	354,488	6.8
Large-scale+	600	50	7727	155	64,823	27,346,(42%)	1296	72,550	1451	354,588	3.9
Small-scale	150	20	3391	170	20,431	10,932 (54%)	1022	23,822	1191	165,600	6.0
Micro-scale	5	1	352	352	858	546 (64%)	858	1211	1211	4590	2.8

Table 4
Sensitivity analysis of 1 year of cannabis growing by an industrial grower (profile 1: 23,000 plants on 1532 m^2 of cultivation surface).

Yield (g per m^2)	Total cost (€)	Price per g (€)	Total gross revenue (€)	π	ROC (1 year)
200	2,071,890	3.00	2,309,120	0.1	0.6
300	2,071,890	3.00	4,963,680	0.1	1.4
400	2,071,890	3.00	6,618,240	0.1	2.2
500	2,071,890	3.00	8,272,800	0.1	3.0
600	2,071,890	3.00	9,927,360	0.1	3.8

important uncertainty in our financial analysis was the probability that Belgian cannabis growers get caught (π). Information on π in Belgian or international cannabis cultivation is scarce. Since π-values reported for Quebec and British Columbia (Canada) vary between 0.05 (Easton, 2004) and 0.16 (Bouchard, 2007) respectively, a third sensitivity analysis was conducted in which ROC for all growers was calculated by varying π between 0.00 and 0.20 with an increment of 0.05.

Findings

Total investment cost of the first (industrial) grower needed to cover the 1532 m^2 plantation can be estimated at €510,747 (Table 3). Variable costs per cycle, including purchasing rooted plantlets, and costs of electricity and fertilizers, were estimated at €381,808. Share of electric power costs were considerable (80% of variable costs). Aggregated opportunity costs for the considered grower were €8478 per cycle. When using a yield figure of 300 g per m^2, total yield of one cycle can be estimated to be 459,600 g or around 460 kg. After one production year (4 cycles), total costs are estimated at €2,071,890 whereas total (adjusted) gross revenue (defined by $(1-\pi)$ PQ, see (1)) is €4,963,680 and ROC is 1.4. Sensitivity analysis (Table 4) shows that when the conservative yield estimate of 300 g per m^2 is increased to 600 g per m^2 (slightly higher than the yield figure proposed by Vanhove, Surmont, et al. (2012)) gross revenue of the industrial grower, after 1 year, increases to €9,927,360 and ROC to 3.8.

For the large-scale grower, total investment cost was estimated to be €7727. Variable costs were estimated to be €9369 per cycle. Using the yield figure of 575 g per m^2, this respondent could generate a possible yield of 28,750 g per cycle. Selling 70% of his harvest to a broker at €3.5 per g and 30% to a growshop at €3.25, generated a possible total gross revenue (after one year and adjusted for the chance of getting arrested, π) of €354,488 and an ROC of 6.8. In reality, this would probably be less: a part of the harvest was paid to the cutters in kind. Tapping electricity before the meter considerably reduced his variable costs. If he was paying for electricity, as might be the case with many growers of similar size, €7258 would be added to the variable costs each cycle. However, even in that case, ROC after one year would be high (3.8).

Based on our calculations, total investment cost of the small-scale grower should have been around €3391. This respondent was well-aware of the large profits he would generate. As a result, he did not find it necessary to tap electricity illegally. In contrast to The Netherlands, Belgium has not set up agreements with electricity companies, to alert judicial authorities in case of unusual high consumption of electricity (Van Camp, 2008). For this reason, variable costs per cycle reached €5108 of which €2903 was for electricity. Using the yield figure of 575 g per m^2, the plantation generated 11,500 g of dried cannabis buds per cycle. The respondent strived to produce a high quality product and had a fixed agreement with his buyer to be paid €4 per g. After one year (four cycles), this would generate a total gross revenue (adjusted for the chance of getting arrested, π) of €165,600 and an ROC of 6.0. The small amounts of cannabis consumed by the grower and/or paid to the cutter/friends, were negligible and would not significantly affect total gross revenue.

Following our estimations, initial investment of the micro-scale grower was €352. Variable costs to produce a harvest-ready first cycle were estimated at €215. Using a modest yield estimate of 300 g per m^2, his first cycle supplied him with 300 g of dried buds of cannabis. Not being a profit seeker, he gave some of the harvest to his friends and sold it to other friends, using low retail prices of between €2 and €2.5 per g. Considering that the grower sold all his crop at an average retail price of €2.25 per g, he would generate a total gross revenue of €4590 (adjusted for the chance of getting arrested, π) and an ROC of 2.8 after one year (4 cycles). In reality, the profit was (according to the respondent) €0, because he used part of the crops for self-supply and to share or gave away, selling only a small part (thereby continuously varying the retail price between €0 and €2 per g) to break-even.

Comparison of data with that of findings from elsewhere is difficult due to the scarcity of studies on the subject. Cervantes (2006) estimated the total costs of two real-case Dutch cannabis indoor plantations to be €356 per m^2 for a 12 m^2 plantation and €492 per m^2 for a 24 m^2 plantation. Caulkins (2010) estimated total costs of three typical cannabis plantation sizes in the United States. Cost estimates were €988 per m^2 for a small-scale (2.3 m^2) plantation, between €904 and €1808 per m^2 for a mid-scale plantation (140 m^2), and between €158 and €486 per m^2 for an industrial plantation (4000 m^2) (all prices in this section were converted from US$ using a conversion factor of 0.75). According to Caulkins (2010), the lower costs mentioned by Cervantes (2006) is probably linked to the location of the studied plantations in The Netherlands, where material for cannabis growing infrastructure is more easily available. Contrary to the costs mentioned by Caulkins (2010), in this study no significant economies of scale (i.e. lower costs per m^2 with larger scale of operation) prevailed (Table 3). Lowest fixed costs per m^2 were found for the large-scale grower (€155), whereas fixed cost per m^2 for the industrial and micro-scale grower was more than double that amount (€333 and €352, respectively). Variable costs per m^2 were highest for the small-scale grower (€1022) and for the large-scale grower, taking the electricity cost into account (large-scale+ in Table 3). Electricity costs varied from 42% (large-scale+ grower) to 76% (industrial grower). As a result, stealing electricity by tapping it before the meter, considerably reduces costs of indoor cannabis growing.

Our financial analysis shows that in all considered cases ROC is positive after the first grow cycle, even when assuming that all fixed costs are made before the first cycle. In Belgium, in 2010 mean annual per capita income was €15,598 (Source: Belgian Federal Government. Directorate-general Statistics and Economic information (http://statbel.fgov.be). This study has shown that small-scale, large-scale, large-scale+ and industrial growers generated profits that were far above the domestic average income level. Moreover, ROC values were considerable. Across the four cases, ROC values were lowest for the industrial grower (1.4) and the micro-scale grower (2.8). However, these profit margins were greatly exceeded by ROC values of the large-scale and mid-scale grower, 6.8 and 6.0 respectively. When electricity costs for the large-scale grower were taken into account (large-scale+), ROC reduces to 3.9 (Table 3).

Sensitivity analysis in which sales prices were varied in the range of €3.00 and €4.25 per g of dried cannabis buds, showed that

Table 5
Total gross revenue, total costs and ROC in a sensitivity analysis of 1 year of cannabis growing by 4 grower profiles, using different sale price levels. Large-scale+ takes the electrical power costs of the large-scale grower into account.

Price (€ per g)	Industrial	Large-scale	Large-scale+	Small-scale	Micro-scale
	Total gross revenue (€)[a]				
3.00	1,240,920	77,625	77,625	31.050	810
3.25	1,344,330	84,094	84,094	33,638	878
3.50	1,447,740	90,563	90,563	36,225	945
3.75	1,551,150	97,031	97,031	38,813	1013
4.00	1,654,560	103,500	103,500	41,400	1080
4.25	1,757,970	109,969	109,969	43,988	1148
	Total costs (€)				
All prices	2,081,890	45,204	72,550	23,822	1211
	π				
	0.1	0.1	0.1	0.1	0.1
	ROC				
3.00	1.4	5.9	3.3	4.2	1.7
3.25	1.6	6.4	3.6	4.7	1.9
3.50	1.8	7.0	4.0	5.1	2.1
3.75	2.0	7.6	4.4	5.5	2.4
4.00	2.2	8.2	4.7	6.0	2.6
4.25	2.4	8.7	5.1	6.4	2.8

[a] Gross revenue is adjusted for the probability of getting arrested (π).

Table 6
Total gross revenue, total costs and ROC in a sensitivity analysis of 1 year of cannabis growing by 4 grower profiles, using different levels of π. Large-scale+ takes the electrical power costs of the large-scale grower into account.

π	Industrial	Large-scale	Large-scale+	Small-scale	Micro-scale
	Price per g (€)				
	3.00	3.43	3.43	4.00	4.25
	Total gross revenue (€)[a]				
0.00	1,378,800	98,469	98,469	46,000	1275
0.05	1,309,860	93,545	93,545	43,700	1211
0.10	1,240,920	88,622	88,622	41,400	1148
0.15	1,171,980	83,698	83,698	39,100	1084
0.20	1,103,040	78,775	78,775	36,800	1020
	Total costs (€)				
All π-values	2,081,890	45,204	72,550	23,822	1211
	ROC				
0.00	1.7	7.7	4.4	6.7	3.2
0.05	1.5	7.3	4.2	6.3	3.0
0.10	1.4	6.8	3.9	6.0	2.8
0.15	1.3	6.4	3.6	5.6	2.6
0.20	1.1	6.0	3.3	5.2	2.4

[a] Gross revenue is adjusted for the probability of getting arrested (π).

the divide between the large- and small-scale growers with very high profit margins on the one hand, and the industrial and micro-scale growers with smaller, though still considerable ROC values, on the other hand, was maintained in the considered price range (Table 5). The micro-scale grower nevertheless differed from the other cases because the respondent claimed to seek no profit from his growing operations, a typical characteristic of small-scale growers, according to Decorte (2010a). Nonetheless, results showed that even with this kind of micro-scale plantation, high profits can be generated. The grower in this case can be considered to be both a grower and a retail seller. In our recent study on yield and prices of cannabis in Belgium (Vanhove, Surmont, et al. 2012; Vanhove, Van Damme, et al. 2012), retail prices for 1 g of cannabis ranged between €7 and €8. If this grower with 5 plants sought to make a profit and sold all harvested cannabis at retail prices, it would be possible to create a profit ranging between €7560 (ROC 5.2) and €8640 (ROC 6.1) over one year. The latter ROC values are in the range of ROC values for the large- and the small-scale grower in the sensitivity analysis.

The probability of getting arrested as a cannabis grower (π) is uncertain in the present study and proves to be significantly influencing ROC values, as shown by the sensitivity analysis in which π is varied in the range of 0 (no chance of getting arrested) to 0.2 (20% chance of getting arrested (Table 6). However, even at high values for π (0.2), ROC for the large-scale, large-scale+ and the small-scale farmers remained high (6.0, 3.3 and 5.2, respectively) and still >1 for the industrial (1.1) and the micro-scale grower (2.4).

Conclusion

The financial analysis spans only one year but clearly shows that returns on costs for all scales of indoor cannabis cultivation are considerable and are generated very quickly (apart from the industrial case, ROC is >1 already after a first growth cycle of 11 weeks). If we extended the timeframe of our analysis to two or four years, returns on costs would be even greater, because most investments (e.g. lamps) cannot be amortized over just one year. The sensitivity analysis shows that our conclusions are robust and can be generalized for all cases of indoor cannabis cultivation in Belgium.

Decorte (2010a) states that micro-scale growers represent mostly non-profit seeking hobby growers. Potter (2010), however, found that even hobby-growers can be profit-driven and might eventually increase their scale of operation and become involved in profit making activity. If police would shift their focus away from the micro-scale growers and intensify efforts to confiscate large-scale and industrial scale plantations, π-values would be reduced for the micro-scale growers and increased for the larger

scale growers. Our sensitivity analysis shows that even in the case of such differentiated police efforts, large- and small-scale plantations remain the most profitable. However, the consistency in total costs per m^2 across growers (Table 3) indicates that differences in ROC between large- and small-scale plantations on the one hand, and micro- and industrial scale plantations on the other hand, are predominantly linked with variation in yield and price, rather than with cost per unit area.

Because of the criminal networks that are often behind small- to industrial scale plantations, addressing professional (industrial) cannabis cultivation is a high-listed priority in the security policies of Belgium and the Netherlands. The profit perspective is the driving force behind the illicit drug economy. The profits are, as shown in this article, determined by market-bound factors (sales prices), production costs and methods. Criminal organizations that control cannabis production can be tackled successfully only when their profits can be seized and confiscated. The large return of costs evidenced in the present study, underpin the relevance of confiscating those illicit profits. Production is the first and thus most important link in the cannabis supply chain. The European Monitoring Centre on Drugs and Drug Addiction (EMCDDA) tries, at European level, to develop reliable indicators to monitor the supply side, as they currently do for the demand side. Findings presented here provide an important qualitative and quantitative set of tools to evaluate the reliability of any indicators. These insights form the cornerstones of an integral and integrated approach of the drug phenomenon, as urged at a European level and implemented in a large number of European countries (Muscat & Pike, 2012).

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Conflict of interest

None declared.

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