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Understanding the illegal drug supply chain structure: a value chain analysis of the supply of hashish to Europe

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Despite the social, health, law enforcement, and economic importance of illegal drug supply, the lack of information and understanding regarding these supply chains stands out. This paper carries out a disaggregated analysis of the structure of the hashish supply chain from Morocco to Europe to explain the value contributions at each level, the end-price formation, and the supply chain management practices. The methodology adopted is based on a mixed method of data collection where the primary data are gathered from field interviews with cannabis producers and dealers and secondary information is obtained from official statistics, research papers, informational reports, and documentaries. We review supply and value chain frameworks through the lens of cost-benefit analysis. Our main findings show an unequal contribution on the part of the different levels of distribution, with end-user prices increasing by 7000% of the cost of production during the supply chain. The chain also has high variable costs but limited fixed ones, exacerbating the lack of stability and fostering continuous adaptation. We also detect a reluctance to raise end-user prices but a great propensity to change quality. This research may have implications for several stakeholders. In the case of dealers, we find that they have created a supply-push system thanks to their dominant power, leaning on information sharing as a source of resilience. In the case of law enforcement, we delve into the operational functioning of the drug chain and the reasons for its survival. For financial investigation operations, unknown or unrealized economic parameters are quantified. For development agencies, the need to implement alternative development programs for producers is evidenced. Finally, for health authorities, we highlight the consequences of seizures and prohibitions of hashish trafficking on the deterioration of the quality of hashish and the subsequently added health hazards for end-users.

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Introduction

The main goal of this article is to understand how the illicit supply chain structure of cannabis resin¹ or hashish produced in Morocco and exported to Europe, is organized and also to estimate hashish price formation along the different stages of the supply chain. Recently, academics are showing interest in using the knowledge derived from illegal drug marketing networks to understand the success of legal cannabis marketing (Krause and Pullman, 2021). Indeed, it has been argued that most research on drug dealing is focused on the USA and is concerned with retail or ‘street level’ dealing (Pearson and Hobbs, 2001), and there is a lack of understanding of the hashish world and the economic behaviors of each agent, and their associated risks (Chouvy, 2016). Specifically, this study aims to estimate the value contributed by each member/level to understand the operations, profitability, and risks assumed. The supply chain management concerns itself with the design and coordination of various stakeholders to optimize the flow of information, product, and finance throughout the entire supply chain (Mentzer et al., 2001). The unique objectives of the hashish supply chain, its actors, and how processes are arranged may require a specific study.

Regardless of the continual disruptive events in the cannabis supply chain due to police seizure (see seizure data in Europe in EMCDDA (2019), or in UNODC (2022) at the global level), as with any product, the ultimate success of a business depends on management’s ability to coordinate and integrate a network of individual businesses (Lambert and Enz, 2017). In the case of cannabis, a product whose illegal nature renders its distribution from production to consumption particularly complex, the supply chain network structure (SCNS) is configured according to its complex nature. A primary aspect of SCNS is identifying how actors partake within the various market flows (Lambert and Cooper, 2000). Further, existing literature about drug pricing in illicit markets shows the prominence of the economic approach based on the associated risks and uncertainty due to law enforcement efforts (Ritter, 2006), and the role of the institutional context (Moeller and Sandberg, 2019). Considering the relevance of price for consumer decisions (Zhu et al., 2021), research has mainly focused on explaining end-consumer prices, which show a great variation from country to country (Munksgaard and Tzanetakis, 2022). However, product characteristics and quality are also very relevant attributes for cannabis purchase decisions (Zhu et al., 2021). The modification of production and supply alternatives with the increase of European indoor production and production for self-consumption, together with the illegality of hashish, the social image, and the disruption risks associated with police seizure, are key determinants of the current hashish supply chain management and are becoming differentiating drivers with respect to other drugs. By analyzing the supply chain structure, we aim to estimate the value contribution at the different levels of the network of suppliers, dealers, and customers that participate in the hashish supply chain to assess the risks assumed by each actor.

The present study can be justified for several reasons. First, from an economic point of view, transnational drug trafficking creates significant negative externalities, which are little understood (Leong et al., 2022). According to UNODC (2022), the size of the illicit cannabis market has not stopped growing, showing an upward trend for the period 2010–2019, with an estimation of more than 209.22 million users in the world. In the case of Europe, 27.4% of the population aged 15–64 (that is, 91.2 million individuals) are estimated to have tried cannabis at least once in their lifetime, and it is used twice as much by young adults (15–34) than by adults (15–64). Indeed, trade in cannabis accounts for around 38% of the retail market for illicit drugs in

the European Union (EMCDDA, 2019). Also, it is estimated that Europeans spend more than 9 B€ on cannabis every year, making its illicit market the largest of its kind in the European Union (EU) (Europol, 2021)².

Second, the study of the supply chain is very relevant given the diversity of actions that are carried out, both at the production and distribution levels, to maintain stable conditions in drug consumer markets (Mejia and Restrepo, 2016). Morocco, as the largest foreign source for the European market, is also considered to be a strategic area in the trade of cannabis (El País, 2021; EMCDDA, 2021b; Blickman, 2017). According to counter-narcotics police services in Spain—the main entry gate to Europe, Moroccan hashish seizure ranked highest among all drugs with about 461,020 kg in 2020 (CITCO, 2021). Cannabis from Morocco is the most consumed drug in Europe, accounting for an estimated 38% of the retail market (EMCDDA, 2016).

Third, from a production point of view, widespread knowledge concerning cannabis production has facilitated domestic and home production (Weinberger et al., 2019), significantly increasing the supply in the market and stimulating the ‘Green Avalanche’ in cannabis production and commercialization (Decorte, 2010), not without an environmental impact (Klassen and Anthony, 2022), and in the absence of a clear social position concerning hashish decriminalization (Mann et al., 2022). Consequently, the European cannabis market size has increased, and we are facing a more complex supply chain configuration and management.

Fourth, every drug supply chain has specific characteristics. Very different sourcing structures from one country to another make it difficult to generalize the homogeneity of channel theories (Taylor and Potter, 2013). Risks and resilience are key factors in illegal drugs supply chains, where changing dynamics feature prominently due to internal management issues (e.g., limited management skills, conflicts), or external actions (e.g., security policies), making changes inevitable and continuous, and distribution channels more complex (phenomena known as “metamorphose”, according to Curtis and Wendel, 2000, p. 126). Information sharing is a key resource for chain adaptation (Scholten et al., 2020). Drug supply chains are based on long channels, with distribution hubs, wholesalers, and retailers, although transformations and adaptations are continuous at the retail level to exploit new markets (Coomber and Moyle, 2018), or to nurture a rapid adaptation to changing attitudes toward herbal cannabis or local cultivation (Weinberger et al., 2019). Finally, despite the relevance of disruption risks in the cannabis supply chain and the resilience and ability to adapt to different contexts, the literature has dismissed these types of vulnerabilities in supply chain management (cf. Xu et al., 2020).

Previous studies focusing on the commercialization of hashish are scarce and mainly concern the final retail stage and consumption patterns (see Table 1 for a review). There are, however, a lack of contributions analyzing the international drug supply chains, and their consequences for security and health programs (cf. Jahre et al., 2012). Previous contributions about drug distribution have focused on the organization patterns in the country of destination, detecting a high degree of complexity and identifying the existence of four levels of distribution, these being, importation, wholesale, middle market, and retail-level dealing (May and Hough, 2004; Pearson and Hobbs, 2001). It has also become clear that alongside the economic principles of the functioning of a market, there are also specific cultural and social values, in which the prevailing interest of the market is “to maximize supply options to militate against risks of disruption to supply” (Taylor and Potter, 2013, p. 394).

Table 1 Selected publications on cannabis commercialization issues.

Article	Setting	Main findings
Pearson and Hobbs (2001)	UK	Middle-market drug distribution consists of interconnected layers of intermediaries carrying out transactions
May and Hough (2004)	UK	Classification of drug retail markets
Desroches (2007) Murji (2007)	USA, UK, Canada, The Netherlands UK, USA	The behavior of higher-level drug traffickers (dealers) Drug distribution mode (hierarchies, markets, and networks). Role of Ethnicity/race in drug distribution
Sifaneck et al. (2007)	New York (USA)	Differences between marijuana retailing, designer, and commercial markets.
Caulkins and Bond (2012)	Mexico-USA	Legalized marijuana production undercut marijuana prices.
Jahre et al. (2012)	Uganda	Complexity as a cause of drug-supply chain stock shortages. Logistic processes redesign to improve drug access and health.
Belackova and Vaccaro (2013)	Florida (USA)	The role of friendship for networks of marijuana retailers.
Taylor and Potter (2013)	Rivertown (UK)	Social supply values of friendship and trust as the key elements to relationships with suppliers and customers.
Chouvy and Afsahi (2014)	Morocco	A decline in traditional cannabis seed cultivation was due to a massive ongoing shift towards hybrid cultivation with higher THC.
Fernández-Steinko (2016)	Spain	Cannabis value-added chain in Spain.
Berg et al. (2017) Berg et al. (2018)	Denver (USA) Seattle (USA)	Assessing recreational marijuana retailers. Examining the retail environment of recreational marijuana retailers' point-of-sale.
Červený and van Ours (2019)	Australia, Belgium, Brazil, Cambodia, Canada, Czech Rep, France, Germany, India, Netherlands, Portugal, Slovakia, South Africa, Spain, Switzerland, Thailand, UK, and the USA	The behavior of prices of cannabis sold over the Internet marketplace
Thompson and Jeffords (2019)	USA	An increase in arrests does not decrease retail drug margins. Some patterns of relationships between drug retail margins.
Conklin et al. (2020)	Denver and Colorado (USA)	The legalization of retail marijuana increases neighboring house value.
Mahamad et al., (2020)	Canada	After cannabis legalization, illegal cannabis was less expensive, with higher potency content than legal cannabis.
Donnan et al. (2022) Mann et al. (2022)	Literature review USA	Factors influencing cannabis purchasing. Public debate regarding opinion about cannabis decriminalization is more focused on social implications than on consumption-related factors.

Information about illicit market operations is limited and basic (Holt, 2017), despite the literature showing an interest in understanding the economics of cannabis markets, (Caulkins and Nicosia, 2010). Concerning the first issue, despite the importance of the international supply network of hashish, the limitation of transnational studies is noticeable, as is the scarcity of contributions regarding the transfer of the product between countries. Extant illicit distribution and supply chain literature has brought to light the possible differential effect of the chain level regarding the allocation of law enforcement resources (Ritter, 2006). Also, Desroches (2007) identifies multiple actors for distributing drugs at the wholesale and retail levels in the consumption country, and Murji (2007) analyses the place of ethnicity and race in the different organizational modes of drug distribution. Caulkins et al. (2016) describe the cocaine market in Italy as a set of ordered layers that make up a network. Concerning chain logistics, Caulkins and Bond (2012) provide estimations of the smuggling costs of Marijuana in the USA, and Basu (2013, 2014) discusses the critical role of multiple and novel resources devoted to transnational smuggling operations from source to the destination markets, with unique transaction costs arising from concealment and corruption. Further, Holt (2017) raises the emerging role of online markets. But, undoubtedly, contributions to the hashish value chain have mainly targeted the retail market, its management, and its operations (Pearson and Hobbs, 2001).

Galenianos and Gavazza (2017) analyze how retailers' moral hazard behavior can affect the quality and consumption of drugs, concluding that the legalization of drugs would improve their quality. Leong et al. (2022) analyze price bargaining between local dealers (pushers) and transnational gangs, concluding that changes in local dealers influence final consumption conditions more than changes in transnational gangs.

Existing studies on drug end-price formation are very limited, and mainly focused on the retail market. In the first instance, estimates of cannabis prices in Europe can be found, particularly at the retail level and, some, at the wholesale level (Pearson and Hobbs, 2001). As the case of other markets, in Canada for example, prior to legalization, cannabis prices had been around \$6.80/g to \$7.69/g, with prices rising by around 51% after legalization, according to Mahamad et al. (2020). Indeed, in relation to the explanation of price formation in upstream and downstream markets, contributions have mainly focused on hard drugs in the case of cocaine markets. In this vein, Caulkins et al. (2016) estimate the amount received by international suppliers to be 30–40% of the end price offered by retail sellers and local dealers. Concerning the demand-price behavior, Mejia and Restrepo (2016) find an inelastic pattern of consumer demand for cocaine, though the drug at its origin is elastic due to the possibility of substitution by other sources. Leong et al. (2022) find that prices at upstream levels of the chain move in parallel to the quantities

available, but without affecting the final quantity supplied to end-consumers. This conclusion is consistent with Thompson and Jeffords’s retail level analysis (2019), which finds some correlation patterns between retail prices and margins of different drugs, without margins being affected by the increase in arrests. However, drug scarcity due to interdiction policies leads to significant negative spillovers in the form of more violence at the intermediate levels of the chain (Castillo et al., 2020). Finally, Leong et al. (2022) and Mejia and Restrepo (2016) agree on the ineffectiveness of police measures at higher levels of the chain when compared to policies targeted at lower stages. Thus, there is a need for further research to expand the knowledge of the practices and dynamics in the network structure of drug supply chains, which, in turn, would facilitate the understanding of operations, price formation, and the implications for distribution organization.

Hashish: product and market. Hashish (also locally named *chira*) is the basis for various by-products. A primary product of cannabis is marijuana, made from the leaves (buds) of the female plants which are picked when they are ripe and dried. It contains between 5% and 10% THC (the main psychoactive compound) (see Fig. 1).

Hashish is the resin from the buds of female plants. When it is produced, it acquires a brown color that is sold in blocks and contains, approximately, 25% THC. *Kif*, traditionally consumed in production areas, is made with small crystals that form at the



Fig. 1 Cannabis plant from the fields of the Rif mountains.

tip of the buds. Other derivatives from cannabis are the ‘hashish oil’, with a high proportion of THC that can reach up to 60%, edibles, or concentrated extracts of cannabis. However, the consumption of these latter products is comparatively marginal (EMCDDA, 2021). Cannabis is the most widely used drug in Europe (see Fig. 2), with a similar distribution of prevalence between herb and resin (EMCDDA, 2017, 2021a).

In terms of illicit income generated, cannabis occupies third place after oil and the pharmacological sector and it is a natural substance that has been perfected over the past century, constantly changing its production and distribution techniques to adapt to increasingly difficult illicit markets (UNODC, 2010). Nevertheless, this product continues to find a way to spread throughout Europe, entering through Spain, which has become the main gateway, only comparable to the Netherlands (UNODC, 2019). Cultivation of cannabis is undergoing an expansion all over the world, both in outdoor and, especially, indoor cultivation (Weinberger et al., 2019). Indeed, today cannabis is produced in 151 countries, covering 97% of the population (UNODC, 2019). In the case of Europe, according to UNODC (2005, 2022), it appears that Morocco has been the main supplier to markets in Western and Central Europe, with most of the Moroccan cannabis resin (hashish) destined for countries in Europe, being shipped to Spain and then on to France (which is also the leading consumer country in Europe), the Netherlands and other countries in the region.

Theoretical underpinnings. As conceptual bases, we adopt several theoretical frameworks. First, drug markets can be conceived as vertical production chains where all members involved are price takers (Mejia and Restrepo, 2016). Second, due to the critical role of interrelationships between the several levels of the supply chain, we applied the framework for supply chain management developed by Lambert and Cooper (2000) and Lambert and Enz (2017). This approach consists of three closely inter-related elements: the supply chain network structure, the supply chain business processes, and the supply chain management components. In this paper, we focus on the first element (cf., chain structure), though considering aspects of the other subsystems to account for links between them. This framework leads to a unique method for a comprehensive chain analysis. Finally, we use the value chain approach (Koc and Bozdog, 2017; Stabell and Fjeldstad, 1998), as a method for breaking down the chain into strategically important activities, given that the overall value-

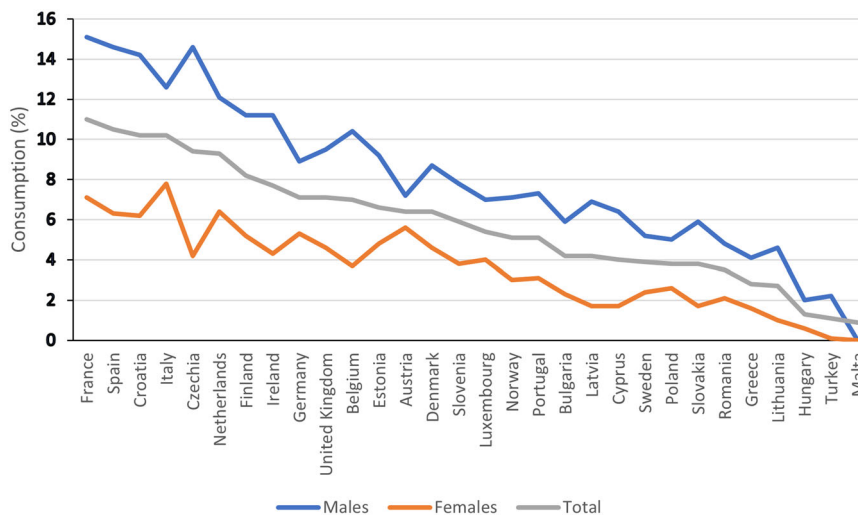


Fig. 2 Prevalence of consumption of cannabis among 15–64 years population in Europe by gender (%).

creating logic of the value chain with its generic activity categories is valid for all industries. A business value chain envisions a system made up of subsystems which each have inputs, transformation processes, and outputs that deliver value (Porter, 1985). Its emphasis on (i) the complex linkages and inter-relationships, and (ii) identifying the source of competitiveness, are particularly interesting for supply chain analysis. To apply this approach to the supply chain structure of the Moroccan hashish exported to Europe, we focused on accounting data for cost and revenues (Hergert and Morris, 1989). Activities and processes are classified as primary (i.e., directly related to the distribution of hashish), and secondary (i.e., contributing to the efficiency of primary activities).

Supply chain structure includes all agents interacting directly or indirectly through their suppliers or customers, from the point of origin to the point of consumption, performing a range of activities (both primary and supporting) along the network (Lambert and Cooper, 2000). In the case of the illegal cannabis industry, (as Desroches (2007) points out, “drug trafficking is an activity that involves the importation, manufacturing, cultivation, distribution, and/or sale of illicit drugs”), this is a hierarchical system, where drugs “are moved from smugglers, growers, or manufacturers to wholesalers who pass the product down through the chain of distribution to retailers and eventually to the consumer or drug user.” (p. 827). In the case of illicit hashish trafficking, the value chain is a set of closed markets, whose distribution system maintains a clear structure, and the tasks of each agent are clearly differentiated (May and Hough, 2004). Among the specific features of the distribution channels, we can list the following: their length, their highly customized nature, the role of third parties, and issues relating to the fact that the final consumer does not fully understand the origin of the product or the smuggling process. In the material delivering path, sell-in represents the product inflow to drug dealers, and a sell-out is the product outflow to consumers. The configuration of the channel and exchanges is clearly determined by the risks of seizure, which can vary.

Methodology

In the context of the limited information available, a mixed-method approach to gathering data was adopted, following other related studies in this field (e.g., Chouvy and Afsahi, 2014). First, a literature review was carried out focusing on hashish and drug distribution. Besides academic literature, we reviewed reports, official statistics, and information appearing in several media.

Participants and sampling. The dataset for this research has been compiled from different sources of information. As the setting is a transnational study, with a long, multi-layered supply chain (Caulkins et al., 2016), and different actors. The study was conducted considering the downstream processes of the hashish supply chain.

First, the economic information of the production stage was elaborated (this information is detailed in the Supplementary material). The sources of hashish production are in the Rif region of Morocco, in a context where economic alternatives are very limited. For this purpose, farming families from the towns of Ketama, Douar Aachouche Tahetani, Takarkouret, Akchour, Beni Hadifa, Tlata Ketama, Bab Taza, Bab Berred, Bni Razine, Targuist, Mensora, Taounate, and Ghafsai (see a cannabis field in the Ketama region of Morocco in Fig. 3).

Two types of information sources were used: family farmers (13) and agricultural technicians. Considering the level of danger inherent to the environment and the reluctance to provide information, we adopt an emic approach to understand the



Fig. 3 Cannabis fields in the Ketama region of the Rif mountains.

context, with two different types of informants, these being producers, and dealers. In the case of the former, these are farming families whose interviews were conducted over friendly free-flowing discussions and open-ended questions to allow the interviewer to explore inductively emerging themes about production and operation practices (Tracy, 2013). Farmers described the production process, income, costs, time spent on each activity, and materials used. Thus, they were asked for the necessary data in order to estimate production costs, applying the principles of cost accounting, such as cultivation tools (e.g., irrigation pump, pipelines, sickles, plastics), seeds, materials, or fertilizers used to enhance the growth and yield of plants. In cases where farmers did not know the value of any of the inputs used, an agricultural technician provided us with the market value of that good. With these data, cost information was compiled for the inbound logistics and operations stages. Specifically, there were depreciation costs (Supplementary Tables S1 and S4), labor costs (Supplementary Tables S2 and S6), production costs (Supplementary Tables S3 and S8), annual amortization (Supplementary Table S4), raw material costs (Supplementary Table S5), packaging (Supplementary Table S7). Additionally, farmers provided information on the revenues, distinguishing between those provided by the hashish of the traditional variety (beldiya) and an average of those obtained by the transgenic varieties (Supplementary Tables S11, S12a, and S12b). There was a diversity of crop variety among the different families. Productivity data were calculated by dividing income by the amount of resin obtained. The data in the tables are average data. Additionally, and based on the information obtained, the authors carried out a profitability analysis of the production activity, distinguishing between production derived from the traditional variety and that derived from transgenic varieties, which are more productive than the former (Supplementary Tables S13–S16)³.

To obtain data on the costs deriving from the outbound logistics stages from the production areas to the coasts of Spain (mainly) and Portugal, primary and secondary sources were used. Regarding the former, two people obtained data on the transport stage from the production areas to the Moroccan coast, and another 10 people located in Guat el Marssa, Oued Laou, and Sidi Abdeslam (Moroccan coast) on the entry and distribution of hashish in Europe. These people are known locally as “juriri juriri” (Moreno-Oliver, 2021). The information obtained from this group of people was collected by applying a snowballing process in which contacts and relationships had to be used. They provided a description of how hashish was smuggled into southern Spain and Portugal, focusing on operations activities and prices at the intermediate and final stages of the value chain. Regarding secondary sources, to gather incomplete information or to cross-check the data obtained, economic data on the smuggling phase into Europe were collected from the analysis of

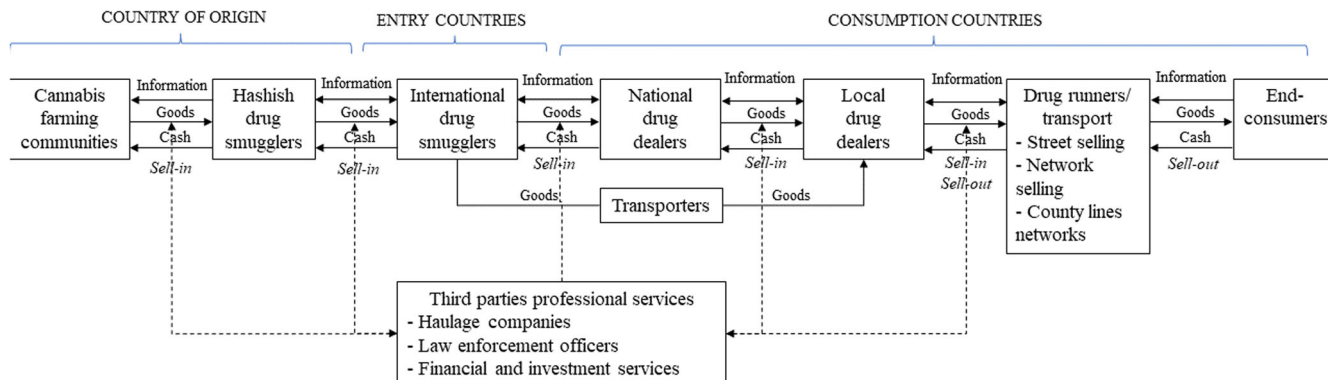


Fig. 4 Moroccan hashish supply chain: actors, flows, and processes.

investigative newspaper articles and TV documentaries on hashish trafficking in the Strait of Gibraltar (García-Ferreras, 2018), and the El País, El País report (2020). In addition, economic information on distribution across Europe was taken into account for data obtained from the research program published in DocumaniaTV (2019). Finally, to assure external validity, the obtained data were cross-checked with existing secondary sources of information on Morocco-Spain drug trafficking (e.g., CITCO, 2021; El País, 2021; Fernández-Steinko, 2016; Moreno-Oliver, 2021; Nader, 2019; Noguera-Gracias, 2018). Retail prices were checked on EMCDDA’s report (2021b), the website Weedindex (<http://weedindex.io/>), and Červený and van Ours’s price study (2019).

As groups involved in this study are difficult-to-access and marginalized populations, the recruitment was carried out through snowball sampling methods (Noy, 2008). This is a typical sampling method in drug dealer studies, with hard-to-reach and potentially low-number populations (e.g., Nelson, 2023). Interview sessions lasted between 15 and 30 min and took place following a mix of pedagogical and responsive interviewing (Tracy, 2013). Due to the nature of the context, notes were written after each interview, and data were cross-checked to ensure accuracy. The interviews were conducted by one of the researchers of the study, who is a connoisseur of the language, culture, and habits (Nelson, 2023).

Results

The Moroccan hashish supply chain structure

Configuration: actors and information flows. The Moroccan hashish supply chain can be conceptualized as being composed of up to seven main actors. It is organized as a long channel, with several actors taking part in different types of countries (see Fig. 4). Primary activities are involved in the physical creation of the product, its sale and transfer to the buyer, as well as any required assistance (Koc and Bozdag, 2017). They consist of the following: inbound logistics, operations, outbound logistics, marketing, and sales and service. Besides the drug and financial flows, information flows which enable buyers and sellers to get updated information about each shipment can be difficult to manage but are critical to smuggling the drug between different countries and ensuring delivery in a timely manner, and avoiding police surveillance. In other words, information flows are critical for the resilience and survival capacity of the supply chain.

Value chain activities. The supply chain process starts from the production of cannabis, from planting to packaging, comprising a series of techniques with a lower degree of complexity than other drugs such as cocaine. *Inbound logistics* are activities associated



Fig. 5 Harvesting cannabis in the Rif mountains.

with receiving, storing, and distribution inputs to the product, such as material handling, warehousing, inventory control, vehicle scheduling, and returns to suppliers (Koc and Bozdag, 2017). These activities relate to the cannabis farming stage. In this phase we can distinguish two main activities, sowing the seed and harvesting and drying.

Cannabis cultivation in Morocco is in the geographical area of the Rif Mountains, which includes the provinces of Chefchaouen, Taounate, Al Hoceima, Tetouan, and Larache. The introduction of modern agricultural practices and modern hashish production techniques has accelerated in the last 20 years, producing more potent and varied cannabis derivatives to the detriment of quality (Chouvy and Macfarlane, 2018).

Focussing on cannabis production, it is known that many farmers are dedicated to its cultivation. Nowadays six main varieties of cannabis are grown in Morocco. The traditional variety is beldiya, which is only cultivated in the Rif mountains (Morocco Latest News, 2021). In recent years, new hybrid seeds have been introduced (e.g., *khardala* or *pakistana*), and even transgenic modified ones (e.g., *gaouriya*, *kush*) and these are gaining greater acceptance among farmers for their productivity and because of pressure from intermediaries (Afsahi, 2017). This change has allowed farmers to increase the production of resin, increasing the profitability of the plant with a high THC potential, albeit with a different quality. Moreover, these new seeds have enabled the creation of a new portfolio of products for the market, thus satisfying the demand in the various destination countries. The second activity of the inbound logistics is the harvesting and drying of the buds collected between the months of September and the beginning of October (see Fig. 5).

Operations consist of activities associated with transforming inputs into the final product form, such as machining, packaging, assembly, equipment maintenance, testing, printing, and facility operations (Koc and Bozdog, 2017). In the case of the hashish value chain operational activities would be related to the processing and packaging stage of hashish. In the processing phase, we can identify two main activities, dry sieving, and filtration. The second stage of the operational activities is packing production where two main processes can be identified, packaging and storage. During packaging, the pollen is pressed into cellophane bags, forming resin blocks of different shapes and weights, depending on the order and the method of transport. Subsequently, the resin blocks are stored for a short time in hidden warehouses in the mountains until they are sold. Regarding transformers, we can point out that there are a small number of transformers that offer large volumes of merchandise ready for sale to drug traffickers. At a different stage, the process known as the sieving technique allows processors to produce different products with different levels of resin quality, increasing the variety of products offered to the hashish consumer.

The supply chain process continues with the *outbound logistics*. Hashish shipments to the Iberian Peninsula are produced from specific locations in the North Coast of Morocco (e.g., Guat el Marssa, Oued Laou, Sidi Abdeslam), to some coastal towns of Spain (e.g., La Linea in Cadiz). Several steps are involved in the study of the outbound logistics network (see Fig. 6). This network is made up of a group of interconnected activities such as transportation, distribution, storage, inventory levels, packaging, and materials handling, to guarantee the efficiency of the distribution of finished products to customers (Mentzer et al., 2001).

Secondary activities are mainly related to transportation and storing and hiding the drug. They include physically moving products from their place of production to where they are needed, adding value to each shipment in terms of bulk breaking, place, and time (Lambert et al., 1998). Transportation is the most significant area of logistics, as well as having a major impact on the level of customer service and cost structure (Chopra et al., 2007), especially due to the risk of seizure by the police (EuropaPress, 2021; El País, 2021). Transport plays a critical role, connecting producers with drug dealers in consumer markets and ensuring hashish reaches its destination, aiming at minimizing seizing risks and costs.

Concerning *transportation*, hashish crosses many routes inside and outside Moroccan territory to reach its destination and it is transported in different ways. Overland transport is a feature of the two main hashish markets, North Africa, and Europe. In North Africa, the product is transported in large trucks across the Merzouga desert, where it is loaded into off-road vehicles to cross

the border between Morocco and Algeria. From this point, it is distributed to Tunisia and Libya. In Europe, this is carried out by freight trucks, which leave loaded from the port of Tangier or Nador to reach the ports of southern Spain or France (see Fig. 7), and there the merchandise is stored in cottages, warehouses, or hidden places known to drug traffickers as “kindergartens” or “nurseries” until being delivered all over Europe.

The second option is by sea, this being the most traditional and common route. This is carried out mainly by speedboats, carrying up to 3 t (metric ton) in each boat, but other types of ships may be used as well, such as merchant ships, vessels, or fishing boats. These boats are often loaded with large amounts of hashish off the coast of northern Morocco, or they wait for the drug from motherships in the middle of the Alboran Sea. These vessels unload their merchandise at ports in Spain, France, and Italy. High-speed motorboats are also used to transport smaller quantities. For this last route, hashish usually has numerous common departure points, which are found between the beaches of Ceuta and Tangier, crossing the maritime Strait of Gibraltar to the Spanish coast. A third option is by air, with pirate planes that drop the drug from the air to isolated areas at night. These planes are an increasingly common way to transport the drug to European territories avoiding border controls, cameras, or radar surveillance systems. Finally, it is also worth noting the number of people who transport the product in their luggage (body packing), or even ingested it in the form of acorns, attached to the body, or inserted inside the body “mules” (body stuffing).

Finally, concerning *supporting activities*, the collaboration of professional third parties is particularly relevant, these collaborate in exchange for bribes and may be haulage companies (i.e., transport, port services), law enforcement officers (who can reveal police seizure plans), or financial and investment services (money laundering).

Performance analysis of the hashish value chain

Primary activities. In the cultivation stage of the value chain, the production costs confronting the farmer are analyzed depending on the type of seed, either *beldiya*—the original plant and exclusive to the Rif Mountains—or transgenic seed, per cultivated hectare. We will analyze fixed and variable production costs of the inbound logistics stage.

The fixed costs of the *inbound logistics* stage focus on the depreciation cost of materials that the farmer uses, these being common for any type of seed. We can see the annual amortization rate of the materials used in the various agricultural tasks is mainly related to cultivation (see Supplementary Table S1⁴). The variable costs of the inbound logistics stage are determined by the costs that arise in the tasks of tillage, planting,



Fig. 6 Transporting to smuggling hashish from Morocco to Spain by speedboats.



Fig. 7 Bales of hashish transported in a truck.

cultivation, and storage. First, tillage can be carried out in a traditional way, using mules or donkeys, or tractors with disc harrows that are usually rented (\$64.80 per ha). With regard to sowing, it is not usual for farmers to buy seeds, since cultivation generates seeds. Furthermore, in the case of transgenic seed, the transformers provide it free of charge to the farmers to underline their commitment to acquiring the harvest. Regarding the cultivation stage, the cost is associated with the irrigation activity required by the crop (\$397.48 per ha), the use of mineral fertilizers (\$280.80 per ha), and phytosanitary products such as home-made insecticides or repellents (\$16.20 per ha).

After harvesting, drying takes place, the cut plants are spread out in the sun hanging by ropes. Once dry, they are gathered into bundles of one kilo (called '*machmoum*') and stored. Thus, the cost that the farmer has in this task comes from drying (\$27.00 per ha), chemical rodenticides (\$10.80 per ha), and labor (\$2932.20 per ha) (see Supplementary Table S2 for the cost of labor). The total costs assumed by the farmer at this stage per cultivated hectare amount to about \$2932.20. Supplementary Table S3 includes the set of fixed and variable costs of the inbound logistics stage (production).

Operations include the production costs that the transformer must face when processing *double zero* hashish from the two types of seed. We analyze the formation of fixed, variable, and total costs in this operations stage. The fixed costs of the operations stage (processing and packaging) relate to the amortization costs of the materials needed to perform the tasks at this stage, sieving (\$54.00 per ha) and packaging (\$97.00 per ha), as well as the energy cost of the installations and pressing machines (\$388.80 per ha). Details of the amortization costs of the equipment used are provided in Supplementary Table S4 of the Supplementary material. The level of variable operation costs is determined by the costs derived from the seed, raw hashish, transport, repairs and maintenance, storage, workforce, and packaging. The cost of seed that is given to the farmer (\$242.14 per ha), the raw hashish is the main raw material for the transformer (\$6912.00 per ha), and as we have mentioned before, the latter buys 80% of the entire harvest from the farmer (Supplementary Table S5 contains the costs of raw material). The processor has transportation costs from the farmers' warehouses to the processing establishments and after which the product is stored until it is sold (\$540 per ha).

In relation to the costs of repairs and maintenance, the former is frequently carried out by the transformers themselves. In addition, since the cultivation of hashish is an illegal activity, maintenance activities are carried out unofficially or eschewing official services, and there is no proof of cost. Regarding storage, the necessary costs are related to the chemical rodenticides (\$10.8 per ha) and workforce (\$302.40 per ha). Supplementary Table S6 shows the labor costs of the operations stage for each type of seed. Additionally, most of the Ketama processors pack the hashish in the same way, using practically the same materials (\$32.62 per ha). Supplementary Table S7 shows the costs of the different materials. The total costs assumed by the transformer amount to about \$8579.96 per ha (see the detail of fixed and variable costs in Supplementary Table S8).

Outbound logistics include all logistic and commercialization operations until the product reaches the end consumer. Strait drug traffickers (*'besnas'*) are organizations that are mainly dedicated to the transport of merchandise from the coves of Morocco to the South Coast of Spain. They acquire hashish at an average cost of \$270 per kg. The costs of transporting the hashish from Morocco to Spanish territory, during which the drug trafficker needs to count on an external gang located in Morocco to facilitate the transport of the drug are detailed in Supplementary Table S9. This gang is made up of three actors, these being

drivers, muleteers, and porters who will work intermittently. Also, narco-wholesalers can perform wholesale functions. They may be the *besnas* themselves—who buy the drug in Morocco, or organized clans from different countries who acquire the drug in large quantities from the Moroccan processors and wait for the drug traffickers to deliver it to them. Sometimes, these clans also buy the drug directly from the drug trafficker. The hashish is acquired by the *Besnas* at an average price of \$370 per kg (\$370,000 per operation of 1000 kg). The drug is then carried across to Spain and other European territories. A considerable number of people take part in unloading the hashish, performing surveillance tasks, and storing the hashish. This last function is usually carried out by professional importers, who have specialized vehicles (*'caletas'*). The cost of transport increases from \$51,840 in the Spanish market to \$103,680 in the French market and to \$188,956.80 for the rest of the European market. These figures have been determined through direct fieldwork.

Drug gangs, located in every European market, are dedicated to the commercialization and distribution within a well-structured network of the resin they have acquired from wholesalers, and they usually control certain points of sale within various neighborhoods of the cities. These gangs acquire hashish at \$1920 per kg (\$1,920,000 for 1000 kg). These organizations also take charge of storage, transport, and management expenses, since the retailer organizes the deliveries of the hashish to retailers through various freelance employees and makes sure that the payment is made correctly before or after the sale, guaranteeing thus a good outlay. Based initially on Reuter and Trautmann (2009), we estimate the total cost of managing the merchandise to be \$216,000, including storage costs at various points in town, distribution, and the security of the drug stash.

Retailing, the final stage of the commercialization process, is performed by the drug runners (also known as 'street dealers' or '*pushers*'), who perform the retail functions. These salespeople work for the retailer for a fixed economic benefit for each kilo sold. Their function is to sell the merchandise in small quantities to the final consumer in the assigned geographical area. However, many of their customers buy hashish from them to sell to their own individual customers. The drug runner acquires hashish at the Narco retail at an average of \$5400 per kg, and sells it to his or her customers. This purchase does not usually exceed an amount of 1 kg, this being the only cost and one that supposes a financial outlay of \$5400 per kg. This amount is sold in 1 or 2 g plastic bags, setting a price that varies depending on the market. Specifically, in Spain hashish has been sold at an average price of \$11,420 per kg, in France \$13,240 per kg, and in the rest of Europe at an average of \$20,000 per kg (see Table 2). In general terms, there has been a price increase in retail pricing since 2018 due to police pressure and the reduction in the number of street dealers brought about by COVID.

Support activities. In addition to the main activities, according to the value chain model, there is a set of support activities that contribute to improving the efficiency of the chain. Drug trafficking groups are organizations whose operations require different travel expenses, such as vehicles, fuel, computers, or communications (e.g., narco-radars) (see Supplementary Table S10). Additionally, some human resource management costs are inherent to the activity. These consist of activities concerning the hiring and remuneration of all types of personnel. Bribes paid to law enforcement officers, and financial and haulage service employees to guarantee that the shipment is sent without setbacks should also be included.

Revenues and contributions margin: value chain analysis. Our analysis of the production areas reveals that about 80% of the raw

Table 2 Revenues and contribution margin per operation (1000 kg) in the commercialization stage (\$).

Drug smugglers (<i>besnas</i>) (strait drug trafficker from Morocco to Spain and Portugal)		Wholesaler drug smugglers (distributes throughout Spain, Portugal, France, and Europe)		Retailing drug dealers (distributes at the national level)		Retail selling (drug runners) (Individual points of sale)			
						Spain	France	Other European markets	
<i>Revenues</i>						Spain, France, and the rest of the European markets	Spain	France	Other European markets
Sale price (1 kg)	370.00	1920.00			5400.00	11,420.00	13,240.00	20,000.00	
<i>Contribution margin</i>									
		Spanish market	French market	Rest of the Europe market	Spanish, French, and the rest of the Europe market	Spanish market	French market	Rest of the Europe market	
Income	370.00	1920.00		5400.00		11,420.00	13,240.00	20,000.00	
Hashish cost	270.00	370.00		1920.00		5400.00			
Internal organization transport expenses	39.380	51.84	103.68	188.957	216.00	-	-	-	
External organization transport expenses	15.35	-	-	-	-	-	-	-	
Net income	45.27	1498.16	1446.32	3291.04	3264.00	6020.00	7840.00	14,600.00	
Earnings (%)	12.24	78.03	75.33	60.95	60.44	52.71	59.21	73.00	

production is sold to the processor, while farmers reserve the remaining 20%, 10% being for their own consumption and, finally, the remaining 10% for processing and sale (see details by ha in Table S11). Incomes are much higher for *beldiya* seed (traditional variety) than other varieties (\$324.00 vs. \$61.69) (see Supplementary Tables S12a and S12b). However, due to differences in productivity, transgenic cannabis seeds yielded a higher profitability per ha at the time of the analysis (see details in Supplementary Table S13).

At the transformation stage, transgenic seeds are beginning to dominate, and they now represent the larger share of the product. This leads to higher income from transgenic hashish than from *beldiya* hashish (see Supplementary Table S14). Then, considering that 80% of cannabis produced is purchased and transformed into resin, we estimate an income per kg of \$756 (for *beldiya* seed), and \$270 for transgenic (see Supplementary Table S15). Hashish elaboration from transgenic is also less costly than that produced from *beldiya*, yielding higher profitability (see Supplementary Table S16).

Beyond production, the commercialization stages account for most of the final cost of the hashish (see details in Table 2). The first level includes the drug smugglers in charge of transporting the drug from Morocco to Spain and Portugal, with estimated earnings of about 12%.

Afterward, in the wholesale distribution to Europe, evidence reveals that Spain and France are intermediate markets (besides being consumers). At this level, wholesale gangs exert their power of control arising from the concentration of the hashish shipments, albeit while running increasing risks due to police persecution. These two factors result in a remarkable increase in margins of up to more than 70%. Additionally, some distribution tasks in destination markets are performed before the final sale is made. This level accounts for a very significant quota of the final cost, with estimated earnings of about 60%.

From a global point of view and based on the data obtained, we have drawn up a model of the hashish value chain from Morocco to Europe, in which the existence of a high number of levels and actors is verified, especially from southern Europe (see Fig. 8). Significant profits from hashish are present in the production stage, but this is minor compared to the profitability obtained by drug dealers in the final stages of commercialization. There is a

big jump once the drug enters European territory, up to 78.03% for wholesalers that operate in Spain and France. Price formation is determined, to a large extent, by the margins of these intermediaries and leads to the multiplying of the initial production cost by up to 7000%.

Conclusions, discussion, and limitations

The paper analyzes the case of the illicit supply chain, production, and operation activities of the hashish being channeled from Morocco to the European markets. The cannabis/hashish value chain exists more as a framework for stakeholders’ interactions and system operations than as a tangible reality. The police persecution of hashish trafficking between Morocco and Europe, together with the importance of this drug in the European market, has generated a supply chain with a highly dynamic organization and led to considerable opacity in operations and economics as well. This study contributes to mitigating the lack of knowledge about hashish distribution (Chouvy, 2016) by analyzing the structure of the hashish supply chain exported to Europe from Morocco. Based on supply chain management and organizational literature, we adopt a hierarchical structure-financial approach oriented to (i) characterizing the relevance of each actor in the success of the value chain and its specificities (efficacy of the chain structure), and (ii) identifying the impact of each actor in the value chain, and in price formation (efficiency analysis). The former has made it possible to explain the structure of the supply chain and the activities carried out by each actor, while the latter makes it possible to understand the value chain, with the contributions and earnings made at each level.

The hashish supply chain shows a continuous adaptation pattern of supply strategies and structures to new conditions in both production and consumption markets. It is a case of the exercise of coercive power by dealers, capable of conditioning the entire chain from production to retailing (Cox, 1999). As an example, hashish grown from traditional *baldiya* seeds is progressively being replaced by hashish grown from transgenic ones, increasing earnings by more than 20%. Additionally, production is becoming more internationally oriented by offering new varieties with higher THC levels, while increasing the sales portfolio. Outbound logistics are constantly adapting and updating to evade

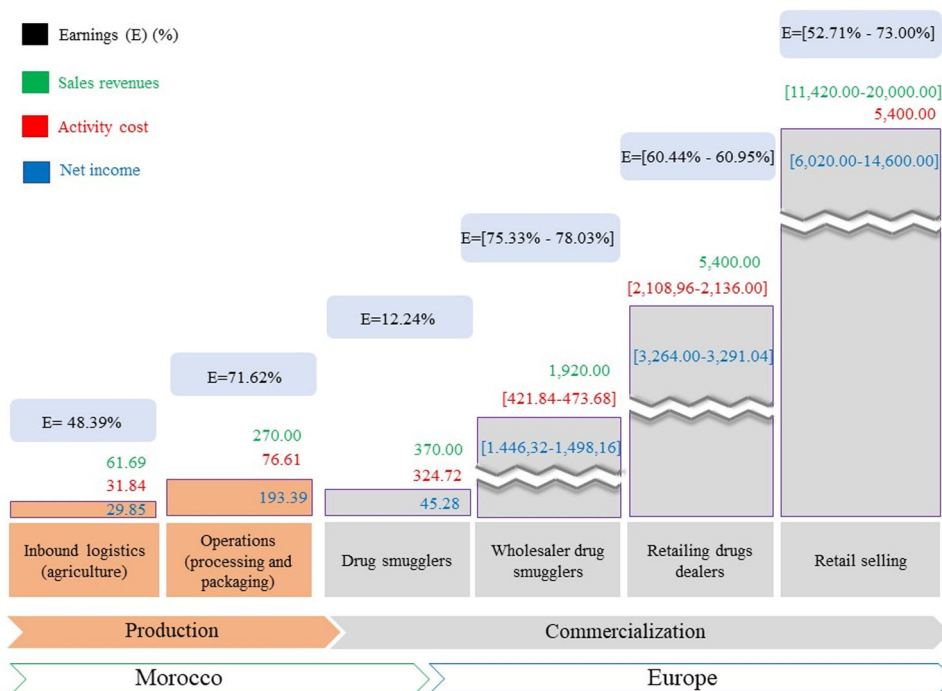


Fig. 8 Value chain assessment of revenues and expenses: implications for risk-taking.

police operations. New routes are mapped out in North Africa with different means for crossing the Mediterranean Sea and store shipments until arrival at the final markets. It is worth mentioning the use of fast transport by speedboat between Morocco to the Campo of Gibraltar region in Spain; a journey which takes 30 min and can transport up to 2000 kg. This is a critical but risky logistic activity, attractive to many unemployed people from the South of Spain (El País, 2021).

Another sign of the coercive power of dealers, as revealed by the value chain analysis, is that farmers perform most of the operational activities, with a high level of variable costs and limited fixed costs. Due to the importance of risk avoidance—of greater importance than cost efficiency, hashish channels are long, with a high number of participants, requiring high-efficiency levels to be able to reach markets at the cost of reductions in distribution efficiency. Indeed, hashish prices in entry markets include a high share of product and logistics costs. However, as hashish is transported to Central and Northern Europe, prices increase progressively due to the notable increase in the number of people involved and units of transport means required. Most costs correspond to the margin of additional intermediaries due to risk assumption and to self-consumption. Only a minor part of total costs corresponds to logistics costs. This pattern is consistent with that observed in countries such as Spain (Fernández-Steinko, 2016).

The hashish supply chain strategy should be understood not just in terms of operational efficiency, but as the need to control the drug flow. Hashish drug smugglers and international drug dealers were able to create a supply-push system because they had a dominant power relationship with their customers, which allowed them to force their product attributes (i.e., quality and price) onto the end-user. In this vein, Thompson and Jeffords (2019) find some patterns of correlations between retail prices and margins of different drugs, with margins unaffected by increased arrests. Thus, a relevant pattern observed along the supply chain is a disinclination to raise prices compared to a greater willingness to change quality (Fig. 9).

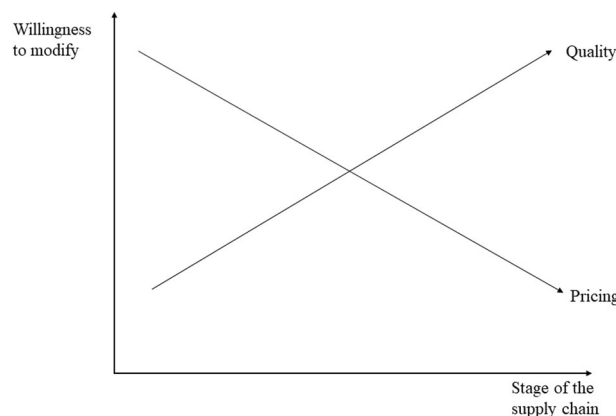


Fig. 9 The willingness of drug dealers to modify hashish pricing and quality along the supply chain.

Concerning profitability, given that margins increase dramatically once the drug arrives in the Iberian Peninsula for distribution to Europe (from 12% to 75%, approximately), this suggests the existence of a relationship pattern between seizure risk and the margin of each level of the value chain. Another related finding is the exponential increase in pricing downstream of the chain. This conclusion deserves further research to assess its consistency with the mainstream thinking of price inelasticity (Donnan et al., 2022), and with the fact that margins are not affected by the increase in arrests (Thompson and Jeffords, 2019). In real terms, this could imply a reduction in hashish quality in the context of product scarcity or when there is an increase in demand.

Practical and social implications. Due to the illegal character of drug supply chains, information, and knowledge is very limited and unclear. However, the flexibility and adaptability of this type

of supply chain may explain its intensity and its survival. Thus, understanding the chain performance through costs and profitability at its different stages introduces new mechanisms of chain resilience, and illustrates the relevance of operations efficacy over efficiency, and the use of coercive power as a core relationship mechanism.

Despite the social, health, law enforcement, and economic relevance of illegal supply chains, there is a profound lack of knowledge about their operation, agents, and processes. For managers, tax agencies, and public bodies, it is useful to know the mechanisms and magnitudes involved in order to be able to identify and control practices. Also, it highlights the ‘funnel’ generated and the economic conditions of the hashish-producing areas that need development alternatives. Finally, we highlight the consequences of seizures and bans on hashish trafficking on the deterioration of hashish quality and the added health risks for the end-user. Health authorities may consider launching communication programs aimed at raising awareness of the quality of hashish consumed, as it can be an additional health risk.

Future research and limitations. Regarding management and social interests, several research lines emerge. As stated before, although illegal supply chains are extremely relevant with regard to social, health, law enforcement, and economic affairs, knowledge about their operation, agents, and processes is extremely scant. For managers, tax agencies, and public bodies, it would be useful to understand the mechanisms and magnitudes of the hashish supply chain in order to identify practices that could be useful in the marketing of legal cannabis (Krause and Pullman, 2021). First, it is interesting to define the hashish business model that could help to assess strategies and the value provided by each actor (Casadesus-Masanell and Ricart, 2010). Second, it would be interesting to analyze the implications of information systems in the resilience of drug channels (Scholten et al., 2020), and its distribution (e.g., based on Larke et al., 2018). Third, a strategic assessment should be made of the alternatives used to ensure that legal channels remain competitive. With the great increase in indoor and outdoor cannabis small-scale production in various European countries (Alvarez et al., 2016; EMCDDA, 2021a), viability problems can occur in hashish imported from Morocco, not only for economic reasons but also due to security and risk levels. Additionally, it is necessary to highlight the ‘funnel’ generated, with asymmetrical performances, and the limited economic conditions of hashish production areas. Also, it should be investigated whether and how the risk of seizure and concentration of dealers affect end prices and product quality.

Finally, the limitations of this study derive from the lack of transparency and reluctance of key informants to provide information, as is often the case in a black market. We experienced limitations in generalizing the income values in the intermediate stages, as well as the difficulty of ascertaining with a degree of certainty the expenses associated with bribery, a significant cost for third-party actors. Specifically, the snowball sampling method used has limitations linked to the randomness of the sample, dependence between the subjects in the sample (in particular, on referrals of the respondents first accessed), and the willingness of the research subjects to participate, limiting the accuracy of generalizing from the data provided.

Data availability

All data generated or analyzed during this study are included in this published article and its supplementary information file. Additionally, data transcription from interviews with cannabis

producers is held at the public University of Almería’s repository [<http://hdl.handle.net/10835/14121>].

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Notes

- 1 The other main product coming from cannabis is the herb, but in this case, there are other origins and provenances, including local production.
- 2 There is some controversy regarding the evolution of the production of Moroccan cannabis resin. The European Union reports (EMCDDA, 2017) state that there has been a decline in Moroccan hashish production and that more herb than resin is being consumed in Europe, though the quantity of resin seized far outweighs herb. Other analyses consider that hashish production has not declined and that estimation methods should be adjusted to understand the new reality of production and consumption (Chouvy and Afsahib, 2014).
- 3 Variables and data collected of production and operations stages are contained in the Supplementary material. The data contained in the tables are average data.
- 4 The Supplementary material includes Tables S1–S16 with disaggregated and detailed information of production and operations for each stage in the chain and depending on the nature of different types of costs and profitability and considering two different types of seed varieties.

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Competing interests

The authors declare no competing interests.

Ethical approval

The study was approved by the head of the research group Marketing and Strategy: Research and Innovation, at the University of Almería, which serves in lieu of an ethics committee. This group complies with the Code of Good Research Practices of the University of Almería [https://www.ual.es/download_file/view/61968/91398], which is adhered to the main international codes of research practice for safeguarding good research practice.

Informed consent

The research project and study purpose were explained at the beginning of the interview to all potential recruits. They were all told that the information obtained would be fully anonymous and that it would only be used for academic purposes. They were given assurance that the interviews would be confidential, and responses would be anonymized. Verbal consent was provided.

Additional information

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