PEN-CP
Pan-European Network of Customs Practitioners

Estimating the Illicit Goods Market

Innovative Methods for Customs Administrations

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Credits

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1 Challenges in estimating the size of illicit goods markets

One of the primary responsibilities of any customs administration is to safeguard the economy and citizens from the harmful effects of illicit cross-border trade and trafficking. To achieve this, customs officers monitor international trade flows to detect and seize a broad variety of illegal goods. However, a key challenge of customs enforcement is the lack of comprehensive data to assess the overall effectiveness of these control efforts—specifically, how much illicit goods customs agencies can intercept. While most customs systematically document seizures and gather related data, these records do not capture the illicit goods that evade detection and pass customs controls undetected.

1.1 Understanding illicit markets and trade

Illicit markets and illicit trade are related but distinct concepts around illegal economic activities. Illicit markets refer to the broader system or environment where illegal goods and services are bought and sold, encompassing the entire ecosystem of demand, supply, distribution channels, and transactions for illicit goods. On the other hand, illicit trade in goods refers to the exchange or movement of products that are banned or restricted by law, making their production, distribution, or sale illegal (OECD 2016). Illicit trade is a critical component of illicit markets, enabling the flow of illegal goods within these underground economies.

As frontline border control authorities, customs administrations play a vital role in combating cross-border trade in illicit goods that sustain and fuel local black markets. Illicit trade covers various sectors, and in this study, illicit goods are classified into three general types of contraband:

- **Prohibited goods**: Items that are entirely banned from export or import due to legal prohibitions. Examples include heroin, stolen goods, and counterfeits.
- **Restricted goods**: Items that can only be exported or imported with the necessary authorizations, which may include sanctions, quotas, or licensing requirements. Examples include firearms, pharmaceuticals, and waste.
- **Fiscal contraband**: Goods that are imported or exported while evading indirect border taxes, such as duties, VAT, and excise rules. Examples of fiscal contraband include cigarettes, fuels, and alcohol.

Illicit markets operate in secrecy, with participants using various strategies to evade detection by law enforcement. This obscure nature makes it difficult to gather accurate data on the scale and scope of these market. Actors in the illicit drug trade, for example, actively conceal their activities through methods such as encrypted communications (Jaspers 2020), hidden compartments in vehicles for smuggling (WCO 2023), and front businesses to launder money (INTERPOL 2024).

Traditional data collection methods, such as surveys and official statistics, fall short in capturing the full range of illegal activities. Quantitative crime data is scarce, especially outside developed nations, and internationally comparable statistics are limited and often conflicting (Alvazzi del Frate 2010). Moreover, individuals involved in illicit trade may withhold information due to fear of legal consequences or retaliation, making self-reported data incomplete and unreliable (Harrison and

Hughes 1997). For this reason, law enforcement and researchers rely heavily on indirect methods like seizure data, arrest records, and intelligence reports, which underestimate the market by only reflecting detected incidents. And as a result, estimates of illicit trade and illicit markets are often rough approximations based on incomplete data[1].

1.2 Leveraging illicit market data to enhance customs enforcement

High-level statistics suggest that illicit markets are a significant global phenomenon, with illicit trade fueling their growth[2]. Illicit goods are typically produced in one region, trafficked across multiple borders, and consumed or sold in another. This cross-border dynamic places customs administrations at the forefront of the battle against trafficking of illicit goods.

Modern customs enforcement builds on a delicate balance between trade facilitation and border control. On the one hand, customs are committed to facilitate the movement of legitimate goods, thereby supporting economic growth and international trade. On the other hand, they have the responsibility of controlling cross-border traffic to intercept illicit goods and ensure that all imported products comply with national regulations. In recent decades, customs authorities have shifted to risk-based border controls to balance trade facilitation with enforcement, responding to challenges posed by growing trade, limited resources, and increased demand for smoother trade.

Customs enforcement benefits from accurate intelligence about the volumes, types, and origins of illicit goods. This data enables customs to prioritize specific illicit goods, identify high-risk border crossings needing increased enforcement, and assess the technical capabilities required to combat illicit trade effectively. Customs authorities maintain reliable statistics on their control operations, tracking both successful interceptions of illegal goods and instances where resources were wasted on controlling legitimate goods, resulting in false positives. However, while successful controls and seizure records offer valuable insights into illicit trade, they only reveal part of the overall picture. The more critical area of interest lies in missed targets, or false negatives, which could provide key insights into how illegal goods evade detection and enter domestic markets, shedding light on the actual inflow of illicit imports. The image and bullet points below outline the key performance indicators relevant to customs for monitoring both illicit and legal trade flows:

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[1] The debate over the size of illicit trade underscores the challenges in producing reliable estimates. For example, Naim (2009) warns that advancements in technology and globalization have led to new illegal trades, such as synthetic drugs and human organ trafficking, while free trade reforms have expanded both legal and illegal markets. He notes that criminals exploit increased cross-border mobility, but international law enforcement remains hampered by national borders. On the other hand, Naylor (2007) argues that there is no evidence the illicit trade is growing faster than legitimate commerce. He claims that the share of illicit traffic in total cross-border trade is decreasing due to greater transparency and relaxed regulations. He suggests that the best indicator of illicit trade is the amount of dirty money in the financial system.

[2] High-level estimates indicate that various illicit markets represent a significant portion of the global economy. The United Nations Office on Drugs and Crime (UNODC), based on a multi-study meta-analysis, estimates that proceeds from drug trafficking and organized crime accounted for between 2.3% and 5.5% of global GDP in 2009 (UNODC 2011). Concerning black markets for specific commodities, consensus estimates indicate that around 10% of global cigarette consumption is illicit, meaning one in ten cigarettes smoked worldwide is illegal (Petit 2016). The counterfeit and pirated goods trade was valued at $464 billion in 2019, or 2.5% of global trade (OECD and EUIPO 2021).

- **Missed targets** refer to the portion of illicit trade that slips through customs undetected because it is not selected for control. These are false negatives, where illegal goods evade inspection.
- **Successful controls** represent the portion of illicit traffic that customs accurately identify, select, and intercept at the border, resulting in seizures. These are true positives in customs enforcement.
- **The smooth trade** quadrant represents a trade facilitation scenario where customs allow legitimate goods to pass without intervention. In this case, legal consignments are not selected for inspection, corresponding to true negatives.
- **Irrelevant controls** involve the selection of legitimate goods for unnecessary inspection. These are false positives, which can be costly to customs, as they divert resources and slow down legitimate trade flows.

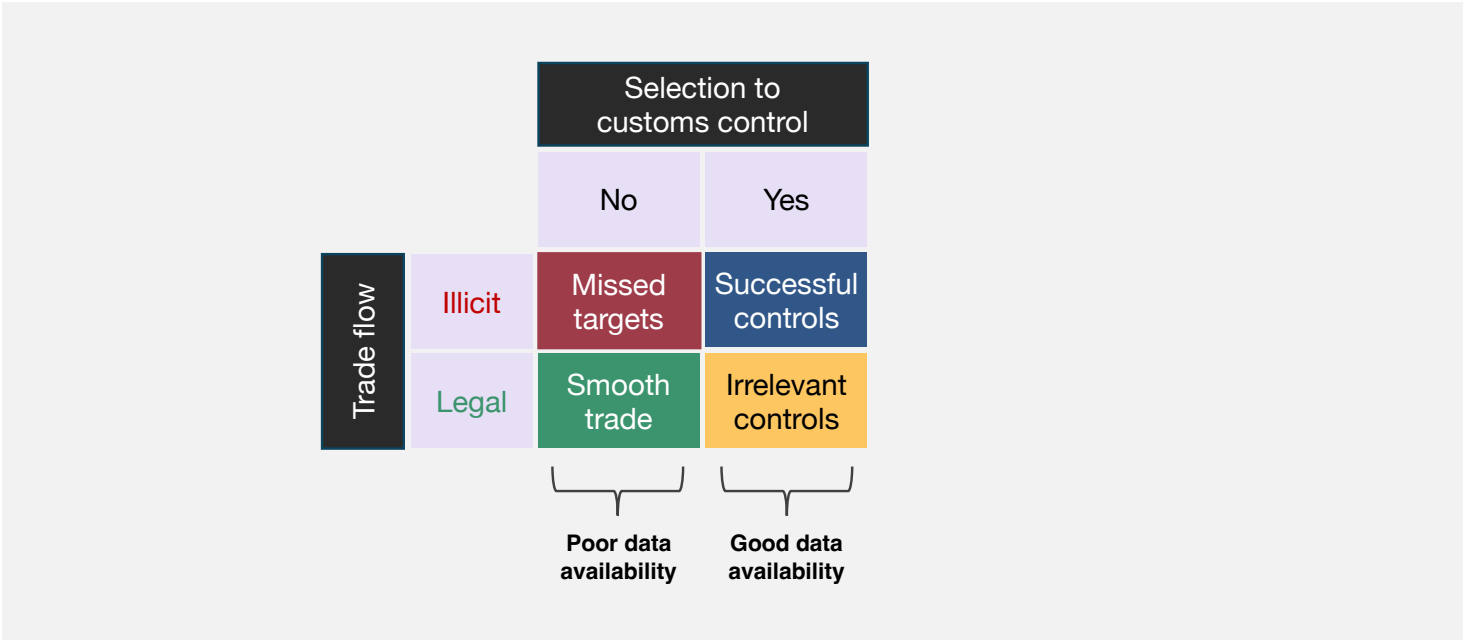

Figure 1 Performance metrics for customs enforcement (adapted from Labare and Migeotte 2020)

The obvious challenge is that data on missed targets is unavailable due to the covert nature of illicit trade—traffickers do not report the volume of goods they successfully smuggle across borders. Even so, customs can use certain techniques to gain better insight into what may be slipping through their controls. One approach is to sample a representative portion of the traffic and conduct 100% inspections on that sample. Under certain assumptions, the results from this full inspection can be extrapolated to estimate the broader traffic. Another option is to perform random inspections on a significant portion of the overall traffic, providing a general sense of the volume and nature of illegal goods within the total flow. However, the downside of these methods is that they are costly, time-consuming, and can disrupt the flow of legitimate trade.

Fortunately, there are also alternative, indirect methods for estimating the actual volume of illicit cross-border traffic. For instance, analyzing local drug consumption patterns can offer insights into the flow of illegal drugs through customs, with several techniques available to estimate consumption. Wastewater analysis detects drug residues to calculate per capita drug use, while syringe collection helps gauge the prevalence of intravenous drug use and assess drug purity in the local market (Lefrançois et al. 2018). Interviews with drug users, dealers, social workers, and law enforcement provide qualitative insights into the scale and dynamics of drug markets. By combining these methods, authorities can form a more comprehensive understanding of local drug consumption and the volumes of drugs that enter the domestic market from abroad.

To estimate cigarette consumption, several techniques can be employed. One approach compares documented, tax-paid sales with self-reported consumption to identify discrepancies between official sales records and consumption patterns. Another method involves analyzing trade balances, where inconsistencies in multi-country trade flows of cigarettes or raw materials like tobacco leaves and filters can indicate illicit activity (Männistö et al. 2021). Additionally, empty pack surveys examine discarded cigarette packs to assess the proportion that are illicit, offering insights into the scale of the illegal cigarette market.

As a third example, a more innovative approach can be applied to tackling the illegal ivory trade. Park surveillance using rangers, drones, spotter planes, and satellites, along with GPS trackers, can help monitor and trace ivory trafficking routes. Additionally, the Elephant Trade Information System (ETIS) plays a key role in tracking illicit trade in elephant products and documenting illegal killings of elephants. By combining these surveillance technologies with data from ETIS, authorities can gain deeper insights into the patterns and networks of ivory trafficking (CITES 2024).

1.3 About this study

This study outlines techniques that provide insights into cross-border volumes of illicit goods, offering a more complete picture than seizure records alone. By leveraging additional sources of evidence, often from unexpected angles, customs administrations can better understand the true scale and scope of illicit trade. This enables customs decision-makers to develop more effective policies and tactics to combat fraud and smuggling. With improved information, customs can reassess threat priorities, refine targeting algorithms, and allocate resources where they are most needed. The insights presented here may also be valuable to policymakers in areas such as national security, health, environment, transportation, and trade.

The next chapter presents a conceptual framework designed to estimate the sizes of illicit markets and the associated cross-border flows of illicit goods. This framework outlines key primary data sources and evidence, detailing various data collection techniques that can be employed to gather relevant information. It also highlights existing databases that can be leveraged for deeper insights into illicit trade activities. Furthermore, the chapter explores quantitative models that can refine the collected data into meaningful statistics and operational insights. By systematically integrating these components, the framework aims to enhance our understanding of illicit markets, enabling customs authorities to make informed decisions in their efforts to combat illegal trade.

The following chapters present case studies on innovative indirect methods for estimating local markets for two types of illicit goods: cocaine and contraband cigarettes. The first case study provides an in-depth exploration of wastewater analysis in Norway as a technique for tracking cocaine use across various municipalities. Following this, Chapter 4 details a multi-method analysis aimed at approximating cocaine markets in Switzerland. Finally, Chapter 5 focuses on measuring cigarette consumption using methodologies such as Empty Pack Surveys and "pack-in-hand" surveys conducted in Estonia, Lithuania, and Ireland.

The final chapter of the study summarizes the key findings and offers recommendations for customs administrations on generating more accurate data regarding illicit trade flows. It also discusses strategies for effectively utilizing this data to enhance customs enforcement efforts.

2 Conceptual framework for estimating illicit market size

The ability to leverage diverse sources of evidence can offer customs decision-makers a more comprehensive view of illicit markets and trade flows. A range of techniques—some of which may be unconventional—can be used to estimate the size of illicit markets. These approaches not only improve the accuracy of estimates but also provide a more comprehensive understanding of the scope and nature of illicit activities. Figure 1 presents a conceptual framework for estimating the size of illicit markets, built around four key components:

1. **Primary data sources**: These include primary data, such as seizure records, trade data, and market surveillance, which are essential for further analysis and estimations.
2. **Data collection techniques**: This encompasses the various technological and methodological approaches, such as web monitoring, sensor-based tracking, and advanced image analysis, that facilitate the collection of data relevant to estimating illicit market sizes.
3. **Databases**: Identifying and accessing databases is important for accurate estimation. These repositories include forensic lab data, trade statistics, and stolen goods databases, all which feed into the process of building accurate models of illicit market activity.
4. **Quantitative models**: These models integrate data from the primary sources, collection techniques, and databases to generate actionable insights. By applying statistical and mathematical tools, these models produce estimates of illicit market sizes, guiding strategic decision-making for customs administrations.

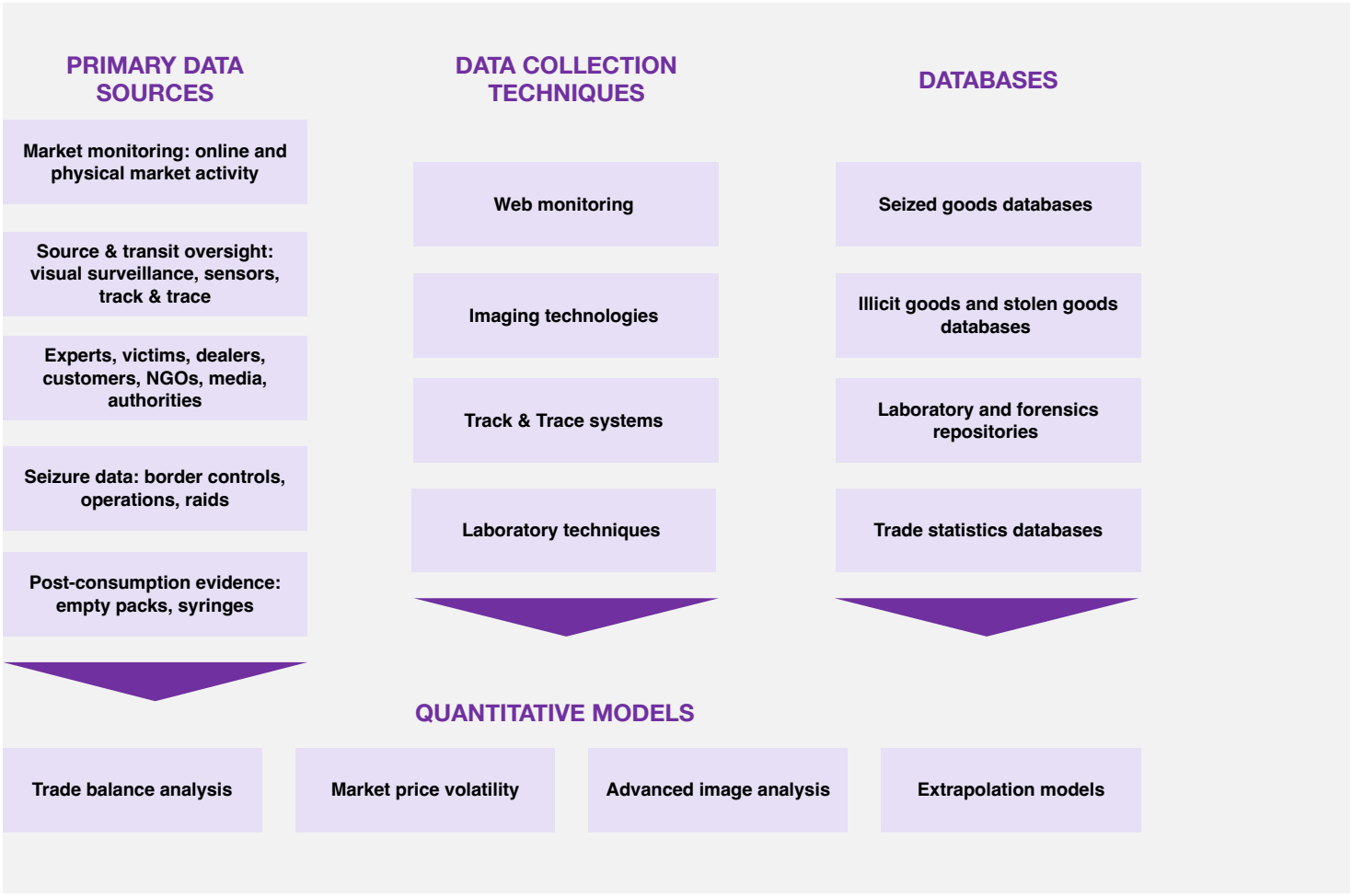

Figure 2 Conceptual framework for estimating the true size of illicit markets

2.1 Primary data sources

The accuracy of estimates for the size of illicit markets is heavily dependent on the availability of reliable and accurate raw data. Without credible data sources, any analysis or projection risks being incomplete or misleading. To ensure comprehensive coverage, these raw, primary data sources can be categorized into five main areas:

- **Market monitoring**: This involves tracking both physical and online markets to gather detailed information on the types, quantities, and prices of illicit goods being traded. Market monitoring also provides insights into the key players involved, such as traders, middlemen, and customers. For example, markets for firearms or cultural artifacts can be monitored to reveal patterns of trade, pricing trends, and the scale of operations within underground markets.
- **Source and transit oversight**: By focusing on the sourcing, production, and movement of illicit goods, this category captures data on trafficking routes and supply chain dynamics. Monitoring the transit of illicit goods—whether within national borders or across regions—can provide

valuable insights into how illicit goods move through trafficking routes, helping to understand the points of vulnerability in criminal networks.

- **Seizure data**: This source includes data from both border control and inland law enforcement operations, offering concrete information on the volume and type of illicit goods intercepted. Seizure data not only reflects the dynamics of cross-border trade but also highlights trends in enforcement and the effectiveness of law enforcement actions.
- **Post-consumption evidence**: This technique provides evidence of illicit goods after they have been consumed, offering an indirect but valuable measure of market activity. For example, the analysis of empty cigarette packs, used syringes, or other discarded items can provide insights into consumption patterns and demand for various illegal products. Such evidence helps to estimate the reach and impact of illicit goods within communities.
- **Interviews and surveys**: These methods gather qualitative data from individuals directly or indirectly involved in illicit markets. Information can be obtained from criminals, victims, and consumers, as well as experts who have specialized knowledge of illicit economies. Surveys and interviews also provide valuable context, offering perspectives on the social, economic, and cultural factors driving illicit trade.

2.2 Data collection techniques

Various data collection techniques can be employed to gather primary data essential for estimating illicit market sizes. These techniques span a range of methods and technologies, offering comprehensive insights into different facets of illicit activities. There are four main categories of data collection techniques:

- **Web monitoring** helps authorities track activity in online marketplaces, including both the surface web and the dark web. By monitoring transactions and interactions in these digital spaces, enforcement agencies can gather intelligence on the trade of illegal goods, including drugs, counterfeit products, and weapons. Web monitoring can reveal not only the types and quantities of goods being traded but also provide insight into the actors involved in these illicit markets[3].
- **Imaging technologies**—such as those installed on satellites, drones, or spotter planes—offer another powerful tool for gathering data. These technologies are used to monitor large geographic areas and can detect criminal activities that are difficult to observe through traditional means. For instance, they allow authorities to monitor the growth of illicit crops (for example, opium poppies or coca plants), identify signs of illegal logging, detect unauthorized excavations at archaeological sites, and track illegal border crossings by irregular migrants. These methods provide high-resolution, real-time data that can be used to identify patterns, spot illegal activities, and allocate enforcement resources more effectively.

[3] For instance, the EMCDDA and Europol have employed web crawlers to gather drug market intelligence from dark web marketplaces (EMCDDA and Europol 2019).

- **Laboratory analysis** also plays a critical role in the collection of data. Samples seized by customs and other law enforcement agencies can be analyzed to determine the presence, quantity and purity of drugs, trace the origin of wood and timber products, or verify the authenticity and provenance of cultural artifacts, for example. In addition to confirming the illegal nature of goods, laboratory tests can provide valuable information about the production process, origin, and distribution networks, enabling authorities to disrupt supply chains more effectively.
- **Track & Trace technologies** are often employed in controlled deliveries, where enforcement agencies allow illicit goods to continue moving to its intended destination under close surveillance to gather intelligence on the broader trafficking network. Track-and-trace systems can provide real-time data on the movements of illicit goods, revealing the routes, methods of transportation, and the individuals involved. This information can be crucial in identifying key actors in criminal operations and mapping out entire trafficking networks.

2.3 Databases

Primary data and effective data collection techniques form the basis for building databases that are essential in accurately estimating the true size of specific illicit markets. These databases, built with reliable and comprehensive data, can provide a useful resource for analyzing market trends, identifying patterns of illicit activities, and understanding the full scope of illegal trade. In turn, this helps inform policy decisions, law enforcement strategies, and international cooperation efforts aimed at combating these markets.

- **Seized goods databases** at national levels serve as a primary source of raw data for estimating the size and dynamics of illicit markets within a country. These databases capture detailed information about confiscated items, ranging from illegal drugs and firearms to counterfeit goods and illicit cigarettes. Globally, the World Customs Organization (WCO) collects seizure data through its Customs Enforcement Network (CEN) as part of its efforts to combat illicit trade and enhance international customs cooperation (WCO 2024). However, access to these valuable datasets is often highly restricted, with only limited portions of the information being made available to external parties, such as academic researchers and analysts outside of the law enforcement community.
- **Illicit goods databases** are repositories of information on specific illegal products. In the case of stolen cultural artifacts, INTERPOL's Stolen Works of Art database (INTERPOL 2024) and the Italian Carabinieri's Protection of Cultural Heritage (TPC) Database (Carabinieri 2023) contain thousands of entries that help track the illicit trade of cultural goods such as paintings, archaeological artefacts, and collectibles. Similarly, privately-owned databases like the Art Loss Register are regularly used by experts to verify the provenance of items on the market and ensure they are not linked to theft or fraud. Beyond cultural artifacts, INTERPOL also manages the Illicit Arms Records and Tracing Management System (iARMS), which holds over a million records on illicit firearms, aiding authorities in tracking illegal weapons across borders (INTERPOL 2024).

- **Trade statistics databases** are more general resources that provide insights into global trade flows. The United Nations Comtrade database (UN 2024), for instance, offers comprehensive global trade statistics, broken down by product and trading partner, and is freely accessible to governments, research institutes, and businesses. Also, twenty-nine countries publish detailed data on exports and imports, comparable to the level found in actual customs declarations. This in-depth information individual export, transit, and import transactions enables public and private entities globally to gain critical insights into legal and illicit trade flows in and out of these nations (Männistö et al. 2021).
- **Forensics databases** support investigations, which may bring light into the scale and scope of illicit markets. For example, INTERPOL has databases to detect fraudulent use of travel and official documents at border points. INTERPOL's SLTD database tracks stolen or lost travel and identity documents, while the SAD database records stolen administrative documents like vehicle registrations. FIELDS provides visual markers to identify counterfeit documents (INTERPOL 2024).

2.4 Quantitative models

Primary data, data collection techniques, and databases all contribute to quantitative models that contextualize and refine raw information into meaningful insights about illicit markets. The variables and relationships within these models produce evidence-based metrics that quantify various aspects of illicit markets, such as market dynamics, trends, and the scope of illegal activities.

- **Trade balance monitoring** offers valuable insights into the reported volumes of cross-border trade between countries and regions. Often referred to as mirror statistics, these quantitative models are designed to detect discrepancies between the export and import figures reported by two countries or trade blocs over the same period. The underlying principle is that if Country A reports exporting significantly more to Country B than Country B reports importing from Country A, it may indicate that some of the trade volumes are being diverted into black markets or unreported channels.
- **Market price volatility** models offer valuable insights into the supply and demand dynamics of illicit commodities. These models are grounded in the fundamental principles of economics—supply and demand—but also incorporate a range of variables that can influence market fluctuations. Factors like law enforcement crackdowns, availability of substitute or competing products, shifts in consumer preferences, and even geopolitical changes can all impact the pricing and availability of these illegal goods. For example, an increase in law enforcement seizures may reduce supply, driving up prices, while the emergence of new synthetic drugs or counterfeit brands may shift demand, affecting market stability.
- **Advanced image analysis** captures electromagnetic radiation for various analytical purposes. Numerous types of cameras and sensors can record wavelengths ranging from X-rays and ultraviolet to infrared frequencies. These devices can be mounted on satellites, drones, fixed structures, and other platforms. Thanks to increasing availability, lower costs, and improved quality, satellite imaging has become a viable data collection technique for law enforcement.

Government agencies, particularly those with access to governmental satellite resources or the means to purchase commercial services, can greatly benefit from the capabilities of high-performance satellite technologies.

- **Extrapolation models** serve as valuable tools for estimating the true market size based on limited evidence samples. For instance, collections of empty cigarette packs can offer localized insights into the prevalence of illicit cigarettes in a city or neighborhood; this information must then be extrapolated to generate a realistic estimate of the total illicit cigarette market. Similarly, wastewater analyses and syringe collection programs can provide geographically specific data on illicit drug consumption, following the same logic of extrapolation to assess broader trends.

3 Case: tracing drug use through wastewater in Norway

The first case study delves into wastewater analysis in Norway as a method for tracking cocaine use across municipalities. This innovative technique measures drug residues in sewage to provide real-time, localized estimates of cocaine consumption. The case highlights the effectiveness of this approach in uncovering drug use patterns and its potential to inform not only public health but also customs enforcement efforts.

3.1 How to estimate drug consumption through wastewater analysis

Assessing drug consumption to measure the illicit market is difficult due to the hidden and stigmatized nature of drug use. However, gathering demand-side data remains essential for effective oversight and law enforcement. Traditional methods like national surveys, drug seizures, and clinical data are often resource-intensive, slow, and prone to biases such as reporting errors, low response rates, and difficulty tracking rapid market changes (EMCDDA 2016, Löve et al. 2018).

In recent years, wastewater-based epidemiology (WBE) has emerged as a more efficient alternative for estimating drug consumption. By analyzing communal wastewater, researchers can assess drug use at the community level across cities and regions. This interdisciplinary method—drawing on chemistry, physiology, sewage engineering, and epidemiology—has proven effective for tracking geographical and temporal trends in illicit drug use in real time (EUDA 2024).

WBE works by measuring specific markers in wastewater that result from the body metabolizing drugs, providing a direct estimate of community drug consumption. This involves sampling sewage from wastewater treatment plants and analyzing the levels of illicit drugs and their metabolites excreted in urine. To ensure accuracy, samples are collected over extended periods, and a standardized protocol is followed to allow comparison of drug loads over time. When repeated annually, this approach helps identify trends in drug use. Best-practice guidelines for sample collection, storage, and chemical analysis have been developed to support consistent and reliable results (EMCDDA 2016).

WBE offers a dynamic and scalable method for monitoring drug consumption, delivering more timely and accurate insights than traditional approaches. To estimate cocaine use from wastewater, researchers follow a six-step process to identify and quantify drug residues, then calculate the amount of cocaine consumed by the population served by sewage treatment plants. The steps are outlined below:

1. **Sample collection**: Composite samples of untreated wastewater are collected from a defined geographical area.
2. **Residue analysis**: The samples are analyzed to determine the concentrations of cocaine and its metabolites.
3. **Sewer load calculation**: Daily sewer loads of the target drug residues (in grams per day) are calculated.

4. **Back-calculation of use**: Cocaine use is estimated by multiplying the concentration of drug residues (nanograms per liter) by the daily sewage flow (liters per day).
5. **Correction factor**: A correction factor is applied to account for variations in drug metabolism and excretion rates.
6. **Population adjustment**: The result is divided by the population served by the wastewater treatment plant, giving the estimated amount of cocaine consumed per day per 1,000 inhabitants. Population estimates are derived from biological parameters, census data, or infrastructure metrics, though these estimates can vary significantly.

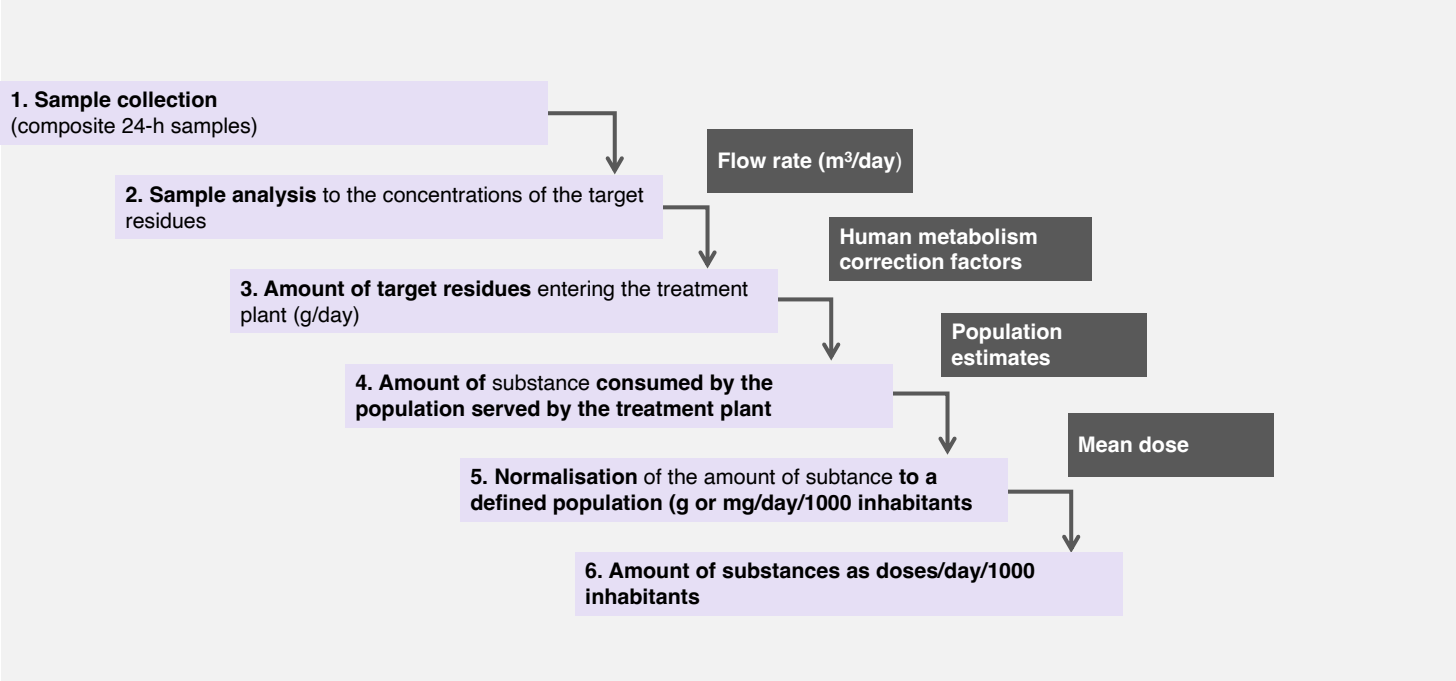

Figure 3. Six steps of wastewater analysis (EUDA 2024)

3.2 Implementing wastewater analysis for customs enforcement

Norwegian customs have previously used wastewater analysis over a one-year period to collect detailed, continuous data on drug consumption. The primary goal was to build a comprehensive time-series database to support operational planning and enhance interdiction and seizure strategies. The focus was on leveraging the data for immediate, short-term operational insights rather than long-term strategic policy development. The main operational objectives were:

1. **Predicting consumption peaks**: Identifying periods of heightened drug use (e.g., weekends, holidays) to optimize the timing and focus of law enforcement efforts.
2. **Adjusting resource allocation**: Allocating personnel and financial resources more efficiently based on observed consumption trends.

3. **Informing seizure strategies**: Analyzing data from small and large seizures to better understand and anticipate drug distribution and usage patterns.

To measure the size of the illicit drug market, the Norwegian Customs Administration incorporates various sources alongside wastewater analysis data, including:

- **Scientific literature reviews**: Both qualitative and quantitative studies on drug consumption are analyzed.
- **Surveys**: Data is collected from surveys assessing the frequency of drug use.
- **Collaboration with partner organizations**: Working with groups that engage with drug users helps gain insights into consumption patterns.

The Norwegian Customs Administration obtained wastewater data through a partnership with the private company responsible for water supply in Oslo. This company was already conducting regular water quality tests, allowing the customs agency to procure its services as a commercial transaction. Given the substantial cost of acquiring this data, customs opted for a one-year period to evaluate its alignment with existing information and estimates.

The collected samples were analyzed by the water supply company's laboratory to detect the presence and concentration of various drug-related chemical compounds. However, when the initial laboratory closed, the agency had to turn to more expensive foreign laboratories for analysis.

Daily wastewater samples were collected over the course of one year to identify the presence and concentration of drug-related chemical compounds. Data collection was limited to the Oslo region, based on the assumption that it is representative of the entire country. To account for population variations, particularly in Oslo, the sewage data was normalized according to the number of inhabitants. This data enabled the analysis of drug consumption patterns, revealing weekly and seasonal variations. Notable trends included increased cocaine use during weekends and holidays.

Additionally, the Norwegian Customs Administration utilizes data and insights from the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) for various strategic purposes. However, this information is not used for operational decisions, as it is aggregated data that does not reflect changes occurring within days, weeks, or months. Instead, customs focus on real-time data to enhance their responsiveness and increase seizure efforts.

Norway aimed to correlate wastewater data with drug seizure data to gain a deeper understanding of the drug market and enhance seizure strategies. Two key ideas were developed:

- **Modeling seizures and demand**: The first approach involved creating a model to establish a relationship between increased seizures and drug demand, addressing the existing data gaps.
- **Estimating drug use from small seizures**: The second idea focused on utilizing data from small seizures conducted by police and customs to estimate overall drug use. By combining this information with wastewater data, customs could predict larger seizures. Given that small seizures often occur with the assistance of detection dogs, customs sought to answer the question: Based on small seizure data, have we missed significant larger seizures?

Norwegian customs aimed to develop Bayesian estimation models to correlate small seizures with larger ones, with the goal of predicting future drug consumption and informing seizure strategies. However, these attempts to establish a relationship using Bayesian methods were inconclusive due to the limited data available. In discussions with an expert from Norwegian customs, several potential benefits and applications of wastewater data for customs operations were identified:

- **Operational use:** Utilizing predictive models to guide law enforcement operations based on anticipated peaks in drug consumption while enhancing resource allocation by pinpointing high-risk periods and locations.
- **Strategic insights:** Assessing the effectiveness of drug interdiction efforts by comparing consumption trends with seizure data and gaining a deeper understanding of drug market dynamics, including changes in supply routes and distribution methods.

Several significant challenges and limitations have been identified in the application of wastewater analysis within this context. First, data insufficiency posed a problem, as one year of data proved inadequate for establishing reliable trends and correlations; a longer data collection period of three to four years is considered essential for accurate modeling. Second, high costs became an issue, as the expense associated with acquiring sewage analysis from the private company was substantial, making it difficult to sustain extended studies without additional funding. Finally, geographical limitations arose because the data primarily represented Oslo, which does not accurately reflect drug consumption patterns across the entire country.

To address these limitations, a potential solution is to pursue multi-agency collaboration among customs, police, health, and environmental agencies to pool resources for acquiring more comprehensive wastewater data over an extended period. Additionally, like COVID-19 data, making drug consumption data publicly available could enhance its utility for various stakeholders, including public health and law enforcement agencies.

4 Case: Multi-method estimation of cocaine market in Switzerland

This chapter presents a case study from a project conducted in Switzerland, focused on estimating the size of the country's cocaine market. The study enhances understanding of the illicit cocaine trade by incorporating additional data sources to identify drug types, volumes, prices, and overall market value.

4.1 How to estimate the size of illicit cocaine market

Estimating the scale of illicit drug markets, such as cocaine, is inherently challenging due to the clandestine nature of the trade. Authorities typically use multiple data collection techniques to assess key market variables—volumes, prices, types of drugs, and trends. They also integrate data from diverse sources, such as seizure records, surveys, and reports, to refine their estimates. Despite the availability of these data points, accurately gauging the size of illicit drug markets remains a difficult task.

The size of an illicit market can be estimated using either supply-side or demand-side methods. The supply-side approach estimates the size of an illicit market by analyzing factors such as production levels, drug seizures, and retail prices. This method has been applied in reports like the World Drug Reports by UNODC. Alternatively, the demand-side approach relies on data from user surveys to estimate the quantity of drugs consumed and the total expenditure by calculating consumption levels and prices. Since supply-side estimates are often more challenging to determine in illicit markets, the demand-side approach is more commonly used (EMCDDA 2019).

In 2016, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) and Europol released the first market size estimates for cannabis, cocaine, MDMA, amphetamines, and heroin. The second version, published in 2019, applied a demand-side approach using a basic model outlined as follows:

Table 1 Demand-side formulas for calculating drug use (EMCDDA 2019)

Total annual consumption = Σ {(Number of last year users)$_U$ * (Amount used per year)$_U$},
where U denotes different types of users according to the type of drugs and country.
Market value (per year) = Total annual consumption * Price

The formulas are simple, but obtaining accurate data on the number of users, amounts used, and prices is challenging due to the secretive nature of illicit markets. For its estimates, the 2019 EMCDDA report relied on general population surveys, the European Web Survey on Drugs, and the

EMCDDA's annual data collection. However, in cases where data was unavailable, the report used complementary data from other sources, such as the EMCDDA's problem drug use indicator, the treatment demand indicator, and data on people receiving opioid substitution treatment, among others.

The work conducted by the EMCDDA represents one approach to estimating the size of the illicit drug market. However, additional data sources, collection methods, and analysis techniques can further enhance these estimates. In Switzerland, the project 'Structure and Products of the Drug Market' (MARSTUP) emerged from a collaborative effort between three Lausanne-based research institutes with long-standing expertise in drug-related issues: Addiction Suisse, the School of Criminal Sciences at the University of Lausanne, and Unisanté. The MARSTUP project was carried out between 2017 and 2020 in the Vaud region, aiming to understand the opioid, stimulant, and cannabinoid markets (Unisanté n.d.).

Although the MARSTUP project was not primarily intended for customs administration, its findings can contribute to the development of more effective enforcement strategies and address the challenges of measuring clandestine markets. This, in turn, supports more informed and data-driven decision-making. This project calculated the drug illicit market size based on four dimensions: products, volume, structure, and value (Zobel et al. 2017 and Zobel et al. 2018):

- **The products:** A comprehensive understanding of the cocaine market involves examining the illicit consumer goods in detail. This includes identifying the active substances, the cutting agents used, purity levels, dosage forms, and the quantities available. Additionally, it is important to analyze packaging types, quantities, market prices, and price variations. Compiling this information allows for an accurate description of what is being sold, in what form, and at what price.
- **The volume:** Understanding the market requires estimating the quantity of products in circulation. Given the lack of legal supply data, such as import statistics, the project estimated consumption quantities based on user data and amounts seized by law enforcement. This approach helps to clarify the market's size and significance.
- **Structure and organization:** Knowing the products and market size is not sufficient to fully understand its operation. It is equally important to know market participants and their practices, from importation and local production to sales and purchases, including all stages of storage and distribution. Understanding these factors clarifies the routines of market organization, the roles of different actors, and the value creation at each level of drug distribution (for example, margins and product cutting).
- **The value:** Finally, the project evaluated the market's monetary value and the income it generates at different levels of drug distribution. This analysis offers insights into its economic significance, attractiveness, and overall impact on the economy. By integrating assessments of available products, volumes in circulation, commercial practices, and revenues and expenses, the project has attained a comprehensive understanding of the drug market for the first time.

The table below shows a summary of key data sources that were used in the MARSTUP project to determine the products, volumes, market structures, and value of this market.

Table 2 Key data sources in the MARSTUP project

DATA SOURCE AND DATA POINTS	PRODUCT	VOLUME	STRUCTURE	VALUE
Police seizures: Details on products sold, their purity and cutting agents, and estimated volumes that would have entered the market if not intercepted.	✓	✓		
Substitution treatment statistics: Number of individuals receiving treatment for drug dependence.		✓		
User surveys: Patterns of drug abuse, types and prices of drugs used by consumers.	✓	✓		✓
Denunciations: Insights into market and distribution networks, emerging trends, and identification of key players.	✓		✓	
Expert observations: Analysis of market and distribution structures, prevailing trends, and identification of key players.	✓		✓	✓
Legal case archives: Information on market participants, drug values, and seized volumes.	✓		✓	✓
Wastewater analysis: Detection of drug types, presence, and quantities in wastewater, allowing for estimates of overall consumption and drug volumes in communities.	✓	✓		
Used syringes: Information on products sold, their purity, cutting agents, and estimated market volumes based on syringes used.	✓			
EU Web Survey on Drugs: Data on average drug consumption volumes, quantities purchased by users, prices paid, and frequency of use.		✓	✓	

The product

The MARSTUP study used various data sources to estimate the product dimension of the cocaine market, including laboratory analysis of police seizures, wastewater samples, surveys, and interviews. Police seizures were analyzed to assess cocaine purity, composition, and packaging types (for example, larger "fingers" for bulk shipments and smaller "pellets" for street-level sales).

Laboratory tests determined the chemical composition, purity levels, and cutting agents (adulterants and diluents), providing insights into how cocaine is modified before reaching users. Wastewater samples helped estimate regional cocaine consumption by measuring cocaine metabolites, cross-validating consumption estimates from other sources. Interviews with users and law enforcement officers provided qualitative data on consumption patterns, pricing, and market structure, supplemented by survey data categorizing user types (occasional, regular, socially integrated, or marginalized).

The data revealed that purity varied depending on the stage of seizure. Larger "fingers," used for importation, typically had higher purity (around 50%), while smaller "pellets" intended for street sales had lower purity (around 40%). This indicated that cocaine was often diluted with cutting agents after entering Switzerland, which directly impacted pricing based on purity levels.

The volume

Three methods were used to estimate the total volume of cocaine consumed: demand-based estimation, wastewater analysis, and seizure data.

Demand-based estimation involved calculating the number of cocaine users in the population and their average consumption levels. Users were classified into three categories—occasional, regular, and socially marginalized—because consumption patterns vary significantly across these groups. For instance, marginalized users (often former or current heroin users) tend to consume more, while occasional users, though more numerous, consume smaller amounts. Estimates for each group's daily or weekly consumption were based on surveys, interviews, and data from addiction treatment centers. By multiplying the number of users by their average consumption, researchers produced a total demand-based estimate of cocaine consumption. The study found that socially marginalized users consumed much larger quantities than occasional users, despite their smaller population size.

Wastewater analysis measured cocaine metabolites (mainly benzoylecgonine) in the sewage system to estimate cocaine use. Samples were collected from wastewater treatment plants in several municipalities within the canton of Vaud over different days (weekdays vs. weekends) to account for variations in usage. These samples were analyzed to detect and quantify cocaine metabolites, providing a real-time measure of cocaine consumption. The concentration of metabolites, adjusted for population size and wastewater flow rates, was used to back-calculate the total amount of pure cocaine consumed. This method revealed clear consumption patterns, such as higher cocaine use during weekends, which aligned with user-reported trends.

Seizure data helped estimate the total volume of cocaine in circulation. Cocaine seizures accounted for about 8–9% of the total market. By adding the volume seized to the consumption estimates, the study arrived at a total estimate of 416 to 500 kilograms of cocaine in circulation annually.

The structure and organization

This dimension was analyzed to understand the actors, roles, and processes in the cocaine trade, from production and importation to distribution and retail sales. The study used several data sources:

- Police Reports and Seizure Data: Provided insights into trafficking routes, transportation methods, and key players in the local market.
- Interviews with Law Enforcement: Gathered firsthand information from officers involved in narcotics operations on the market's organizational structure.
- Interviews with Users and Dealers: Helped identify how cocaine was distributed and sold at the street level, revealing organizational roles within the market.
- Judicial Records: Reviewed to understand the legal and operational aspects of the cocaine trade through trafficking cases.

The study found that cocaine primarily originates from South America, with the Netherlands and Spain serving as key transit countries where cocaine is often diluted before reaching Switzerland. Cocaine importation typically involved "mules," often recruited from West Africa or South America, while larger shipments arrived via maritime containers or vehicles, entering Switzerland through ports like Rotterdam and Antwerp.

Once in Switzerland, the drug was stored in safehouses or distributed by local semi-wholesalers, who cut the cocaine with adulterants (e.g., baby powder) to increase profits. The purity of cocaine decreased as it moved through the supply chain. At the retail level, cocaine was sold through street dealers (catering to marginalized users), phone-based delivery services (for wealthier or socially integrated users), and the darknet.

The study also identified the involvement of specific ethnic groups in the cocaine trade, notably Nigerian networks that played a key role in importation and street-level distribution. These networks organized mule-based transportation and maintained distribution and retail sales channels. Other West African and South American nationals were involved in various aspects of transport, distribution, and retail sales.

The Value

The value of the cocaine market in the canton of Vaud was calculated by estimating total revenue from cocaine sales and distributing this value across actors in the supply chain. This involved analyzing wholesale and retail prices, the quantities in circulation, and costs related to production and distribution.

Data on cocaine prices at various supply chain stages (e.g., wholesale vs. retail) were gathered from police reports, user surveys, and interviews with law enforcement and dealers. Wholesale cocaine, with higher purity (around 50%), was sold at Fr. 200 to Fr. 250 per gram of pure cocaine to semi-wholesalers, who typically diluted it before street sales. Street-level cocaine, with about 40% purity, was priced at around Fr. 100 per gram, though prices could vary significantly, with some users paying up to Fr. 1,500 per gram for purer cocaine in specific situations.

To estimate total revenue, the study multiplied the total volume of cocaine in circulation by the selling price. With an estimated 450 kilograms of cocaine sold at Fr. 200 per gram, wholesale revenue was projected at Fr. 90 million. At the retail level, using the same volume and a price of Fr. 100 per gram, the revenue was estimated at Fr. 45 million.

The study also factored in costs related to cocaine production, transportation, importation, distribution, cutting/dilution, and labor. By subtracting these from total revenue, the net income or profit for actors in the canton of Vaud's cocaine trade was estimated to range from Fr. 28 million to Fr. 39 million annually.

4.2 Applying multi-method estimates for customs enforcement

Comprehensive drug market studies, such as those from the MARSTUP project, provide valuable insights for both customs administrations and law enforcement in multiple ways. At the policy level, estimating the monetary value of the cocaine market helps justify law enforcement budgets and resource allocation, strengthening efforts against drug trafficking. Detailed market analysis also informs the development of data-driven, targeted policies and interventions.

At the operational level, methods like wastewater analysis and demand data help estimate cocaine consumption, allowing authorities to forecast drug flows and allocate resources more efficiently by focusing on local consumption hotspots and seasonal patterns. Additionally, by analyzing the structure of cocaine trafficking networks—including key routes through European transit countries, entry ports, and the involvement of criminal groups—customs officials can better target source and transit nations, as well as high-risk cross-border traders. Further, examining cocaine purity and pricing at different stages, from importation to street-level sales, enables authorities to track changes in drug quality, identify new cutting agents or delivery methods, and detect spikes in trafficking activity. These insights enhance drug seizures and support forensic investigations.

In conclusion, estimating the scale of the illicit drug market requires a multi-faceted approach that integrates various data sources and methodologies. Projects like MARSTUP highlight the importance of combining data from police seizures, wastewater analysis, and user surveys to improve our understanding of drug markets, including their products, volumes, structures, and value. This integrated approach enables customs and law enforcement agencies to make more informed strategic decisions, underscoring the importance of a holistic, data-driven strategy in combating the illicit drug trade.

5 Case: Estimating illicit tobacco markets through cigarette packs

This case study introduces two indirect methods for understanding local illicit cigarette markets: empty pack surveys and “pack in hand” studies. These techniques offer valuable complementary data on the size of the illicit tobacco trade, where information is often limited due to the illegal nature of the activity and lack of reliable records.

5.1 How to estimate illicit cigarette markets through empty packs

The Empty Pack Survey (EPS) is a research method widely used in the tobacco industry to estimate market share, evaluate brand performance, and track the prevalence of illicit tobacco products. By collecting and analyzing discarded cigarette packs, EPS provides valuable data on consumer smoking habits, brand preferences, and the presence of counterfeit or smuggled cigarettes. This case study will focus specifically on the role of EPS in detecting illicit trade, helping to identify and quantify illegal, counterfeit, smuggled, or untaxed cigarettes, thus offering key insights into the illegal tobacco market. The primary objectives of using EPS for detecting illicit goods include:

- **Quantifying illicit trade**: Estimating the scope and prevalence of illegal tobacco products in the market.
- **Identifying counterfeit products**: Detecting counterfeit cigarettes that mimic legitimate brands.
- **Tracking smuggled cigarettes**: Identifying packs smuggled into a region without paying the required taxes.
- **Supporting regulatory enforcement**: Assisting authorities in ensuring compliance with tobacco regulations and tax laws.

In the Empty Pack Survey, target locations are carefully selected based on factors like high foot traffic, areas with known smuggling activity, and regions representing diverse socioeconomic backgrounds. Typical sites include urban centers, border towns, and public spaces such as parks and bus stops. The surveys are conducted periodically, often on a quarterly or annual basis, to track changes and trends in illicit tobacco trade over time.

After selecting the target locations, field workers gather discarded cigarette packs from public waste bins, streets, and other open spaces. Each pack is recorded with details of the collection site, along with the date and time, allowing for analysis of geographic and temporal patterns in illicit trade. Once collected, the packs undergo a detailed analysis. They are sorted by brand, variant, and manufacturer, which helps in identifying counterfeit versions of popular brands. The packs are then examined for signs of illicit activity, including:

- **Missing or counterfeit tax stamps**: Genuine packs should feature official tax stamps; the absence or presence of fake stamps suggests illicit products.

- **Non-compliant health warnings**: Packs with health warnings that do not meet local regulatory standards.
- **Unusual packaging**: Packaging that deviates from standard designs, such as incorrect logos, misspellings, or irregular features.
- **Foreign labels**: Packs displaying labels from other countries, indicating potential smuggling.

Once the cigarette packs are sorted and identified, forensic analysis is conducted. Advanced techniques, such as chemical analysis, can be used to detect counterfeit products by examining the composition of the tobacco.

The data gathered from the EPS is then aggregated to create a comprehensive overview of the market, including the scope of illicit trade by geographic area. Statistical methods help identify trends, correlations, and patterns in the presence of illicit goods. These findings provide valuable insights to companies, stakeholders, and regulatory authorities, enabling them to make informed decisions. EPS is a powerful tool for directly detecting illicit trade through the physical examination of cigarette packs. Regular surveys offer up-to-date information on the prevalence and trends of illegal activity, providing actionable insights that help authorities and companies take targeted measures to combat illicit trade.

However, EPS has certain limitations. As with many research methods, the sample may not fully represent the entire population. The accuracy of findings relies on meticulous documentation and analysis of the collected packs, and the data offers only a snapshot in time, which may not reflect long-term trends. Continuous refinement of the methodology and expansion of survey coverage will enhance the accuracy and comprehensiveness of the data, ultimately contributing to more effective efforts to combat illicit tobacco trade.

5.2 Using empty pack surveys for customs enforcement in Estonia and Lithuania

The Empty Pack Survey (EPS) has become a crucial tool for understanding the scale of illicit cigarette consumption. In Estonia and Lithuania, EPS data—primarily gathered by external firms like KPMG and Nielsen—has been instrumental in shaping strategic and operational decisions to combat tobacco smuggling.

Country example: EPS as a trend monitoring tool in Estonia

In Estonia, the Empty Pack Survey (EPS) has been conducted for over a decade on a quarterly basis, funded by the Estonian Tobacco Manufacturers Association and Philip Morris International. Data collection is managed by Nielsen, with findings shared with the Estonian Tax and Customs Board to complement their intelligence and data on cigarette smuggling. Key uses of EPS data in Estonia include:

- **Monitoring illicit trade trends**: EPS data offers insights into illicit cigarette consumption, helping Estonian customs identify smuggling hotspots, particularly in regions near the Russian border.

- **Validating customs data**: EPS findings are cross-referenced with customs data from cigarette seizures and intelligence reports, validating trends and providing a comprehensive view of the smuggling landscape.
- **Regional trend analysis**: EPS helps authorities understand consumption patterns across Estonia's cities, pinpointing regional variations and identifying areas with higher illicit trade activity.
- **Strategic planning**: While not the sole decision-making tool, EPS data informs resource allocation, especially at ports and border crossings, helping target areas where smuggling activity is rising, particularly from neighboring countries.
- **Collaboration and intelligence sharing**: EPS data facilitates cooperation with neighboring countries like Finland and Latvia, allowing Estonian customs to compare trends and gain a regional perspective on the illicit tobacco market.
- **Identifying emerging trends**[4]: EPS helps detect new patterns in the tobacco market, such as shifts in illicit cigarette consumption in specific cities or regions, enabling customs to adjust their strategies accordingly.

Country example: use of EPS for strategic planning in Lithuania

In Lithuania, the EPS began with local institutions around 2010–2012 but was soon outsourced to external firms due to their ability to provide more accurate data. Today, Lithuania no longer conducts its own EPS, relying instead on the reports generated by private companies. Lithuanian authorities, particularly customs and border guards, contribute seizure data to help validate EPS results. Key applications of EPS data in Lithuania include:

- **Strategic and operational planning**: EPS data enables Lithuanian customs to assess the scale of the illicit cigarette market, particularly smuggling from Belarus, which accounts for 90% of the illegal trade. This helps focus efforts on critical border points and optimize resource allocation.
- **Resource allocation**: Insights from EPS allow customs to direct personnel and equipment to high-risk areas, such as key border crossings, improving their ability to intercept illicit cigarettes.
- **Policy formulation**: EPS findings inform policy decisions aimed at reducing illicit trade. For instance, knowing that domestic illicit cigarette production is minimal (about 1%) allows authorities to concentrate on cross-border smuggling.
- **Investment in technology**: EPS data can justify investments in advanced detection technologies, such as X-ray scanners at Belarusian border crossings, to enhance smuggling prevention.

[4] One of the main challenges faced by Estonian customs is the delay in receiving EPS data, which can be up to three months old, reducing its immediacy for operational decisions. Furthermore, fluctuations in illicit cigarette rates between quarters make it difficult to rely on EPS data as a sole indicator of the market's state.

- **International collaboration**: EPS data supports cooperation with neighboring countries like Poland, enabling shared intelligence and coordinated efforts to monitor and target smuggling routes more effectively.

5.3 Using 'pack-in-hand' surveys for customs enforcement in Ireland

In Ireland, the government employs a distinct methodology to assess the scale of illegal cigarette consumption. Instead of relying solely on empty pack studies, this approach utilizes a multi-method strategy that combines interviews with "pack-in-hand" observations. Since 2009, Revenue and the HSE's National Tobacco Control Office have annually commissioned independent research among smokers to assess the source of their cigarettes. The goal is to estimate the volume of non-Irish duty-paid cigarettes consumed in Ireland. The research follows a three-step methodology, outlined below (Revenue Commissioners, n.d.):

- **Sampling**: The cigarette survey targets nationally representative samples: 500 Irish smokers and 300 Central/Eastern European nationals living in Ireland. A separate survey for roll-your-own (RYO) tobacco involves 200 Irish RYO smokers. All participants are adults aged 18 or older. Fieldworkers visit participants at home until the pre-determined sample quota is met. The sample is stratified by region, with Ireland divided into 3,440 Electoral Divisions, covering urban and rural areas, which serve as the primary sampling points. Fieldworkers follow random routes within assigned areas, meeting quotas based on age, gender, and socio-economic group.
- **Interviews**: Fieldworkers conduct face-to-face interviews over a two-month period, each lasting around 5 minutes. A standard questionnaire is used. Respondents must present a cigarette pack or RYO pouch to participate. Information from the pack/pouch is recorded, and respondents are asked to provide it for further analysis. An incentive (a scratchcard) is offered, ensuring high response rates (over 80%).
- **Analysis**: Data from all fieldworkers are collated for analysis. Tobacco experts examine the packs/pouches to determine legality, based on the tax stamp, health warnings, and the declared source. Legal non-Irish duty-paid packs are also identified. Population estimates, smoking prevalence, and consumption rates are used to estimate total cigarette consumption in Ireland. Data from Irish smokers are weighted using Healthy Ireland research, while data from other nationalities are weighted using Central Statistics Office figures. The RYO survey is weighted using NTCO Smoking Prevalence research.

The 2023 cigarette survey found that 19% of packs were classified as illegal, while 15% were legal but non-Irish duty paid. Of the illegal packs, 99% were contraband—commercial cigarette brands bought duty-paid or duty-free abroad and smuggled into Ireland. Only 1% were illicit whites, cigarettes produced solely for smuggling into other markets, and 0% were counterfeit, meaning no cigarettes were found to be fake or made without authorization to deceive consumers. The estimated revenue loss to the Irish Exchequer from 32.9 million illegal cigarette packs is approximately €422 million.

To target contraband smuggling routes, customs should intensify surveillance at key entry points such as airports, ports, and land borders, particularly those linked to countries with lower tobacco

taxes or duty-free zones. This effort should include increasing random inspections and deploying advanced scanning technologies to detect illicit goods. Strengthening collaboration with neighboring countries like Northern Ireland and the UK is essential to monitor cross-border movements, where tax and price disparities drive smuggling. Additionally, utilizing risk-profiling software to flag passengers, cargo, and vehicles from high-risk regions or with suspicious travel and trade patterns will enhance detection capabilities.

In terms of duty-free purchases, since many contraband cigarettes are legally bought abroad but smuggled into Ireland, customs must tighten controls on personal allowances for duty-free tobacco. This can involve deploying mobile enforcement units at airports and ferry terminals to check travelers' compliance with tobacco import limits, introducing automated systems to detect passengers carrying excessive amounts of cigarettes, and coordinating with airlines, ferry operators, and travel agencies to raise awareness about Ireland’s duty-free tobacco regulations.

With the bulk of illegal cigarettes classified as contraband, customs enforcement should prioritize dismantling organized smuggling networks. This requires close collaboration with international law enforcement agencies such as Europol and Interpol to share intelligence on large-scale tobacco smuggling rings. Undercover investigations should be conducted into supply chains linked to high-traffic contraband sources, focusing on monitoring shipping records, freight forwarding companies, and other logistical operations. Strengthening data-sharing agreements with other customs agencies is essential for tracking cross-border cigarette movements and identifying suspect suppliers or buyers, ensuring a coordinated and effective response to illicit cigarette trade in Ireland.

6 Leveraging illicit markets data for customs enforcement

This final chapter offers insights into how customs can more effectively measure illicit markets and trade flows, and how to use this data to enhance enforcement strategies against illicit trade.

6.1 Customs can use several techniques for estimating illicit markets

The hidden nature of illicit markets makes it difficult to accurately measure the scale of the shadow economy, as reliable data is not readily available. However, there are several innovative and complementary techniques available for estimating illicit markets and the flow of illegal goods.

Operational data from customs activities

Operational data from customs activities can certainly be used in estimation models, but relying solely on them introduces potential biases. Seizure records offer a limited view of illicit trade flows, providing some insights into the types, origins, and volumes of illegal goods. They reflect what customs intercept but provide no insight into what goes undetected. Besides, seizure volumes may fluctuate due to the intensity of law enforcement efforts, changes in smuggling techniques, and seasonal patterns that are unrelated to the underlying supply and demand of illicit goods.

Random inspections or conducting 100% checks on a portion of traffic can provide representative data points that help estimate the proportion of illicit goods within overall trade. However, given the massive scale of today's international trade and the limited resources available to customs authorities, it is not always feasible to consistently generate statistically meaningful sample sizes through these methods alone. For this reason, to gain a clearer understanding of illicit activities, customs should extend their focus beyond operational data and seek complementary information that offers alternative perspectives on illegal activities.

Demand and supply side estimation methods

By concentrating on the demand side of illicit markets and examining the consumers of illegal goods, customs can gain valuable insights into the types and volumes of illicit products being consumed within their domestic market. The amounts of specific illicit goods over time provide some evidence of how much of these products come from other countries and go undetected by customs[5]. Demand-side estimation techniques for drug markets include street price analyses[6], drug residue analysis in wastewater, user surveys, treatment admissions, drug-related deaths, and syringe collection data. In cigarette black markets, demand indicators can be gathered through Empty Pack Surveys and "pack-in-hand" surveys.

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[5] The amount consumed on the domestic market is also influenced by factors such as shifts in consumer demand, the volume of domestic production, and the levels of product exports.

[6] Market price fluctuations often serve as clear indicators of disruptions in illicit goods markets. According to the economic principles of supply and demand, a decline in consumer demand typically results in lower prices. Conversely, an increase in demand usually causes street prices to rise significantly.

Turning attention to supply-side estimation techniques, customs can get a better understanding of volumes and types and origins of illicit goods. Trends and changes in supply patterns offer valuable insights into the volume, timing, and origins of illicit goods attempting to cross borders into domestic markets. They also help estimate the total quantity of imported illicit goods entering a country. Supply-side estimation techniques encompass a range of methods, including street price analyses[7], trade balance monitoring[8], e-commerce and darknet surveillance, and satellite monitoring of illegal crop cultivation.

Creative and unconventional estimation methods

In addition to traditional estimation techniques, emerging technologies and new forms of cooperation enhance the accuracy of estimates for illicit markets. For instance, law enforcement agencies can monitor e-commerce platforms and darknet marketplaces to analyze trends in the types, volumes and availability of illicit goods. Additionally, utilizing sentiment analysis tools to examine discussion forums and social media can provide further insights into the evolution of specific illicit markets.

Another valuable source of intelligence comes from ongoing criminal investigations, which can help backtrack seizures and assess the broader smuggling network. By comparing actual seizures with investigative data—such as criminal organizations' accounting books, delivery capacities, clientele and other relevant factors—customs can estimate how much contraband likely passed through undetected. For instance, in cigarette smuggling cases, traceback investigations can lead to illicit cigarette factories and pinpoint where legitimate goods are diverted into illegal markets (Männistö et al. 2021). Also, by partnering with police and intelligence agencies that intercept communications of criminal organizations, customs can acquire valuable complementary information about the supply side of illegal trade.

Satellite technology equipped with advanced optics and sensors is highly effective for analyzing the supply-side activities of illicit trade. Law enforcement agencies have long used satellites to locate fields of illegal crops, such as opium poppies and coca leaves, as well as to calculate crop yields. Furthermore, this technology can be leveraged to identify illegal logging sites and monitor unauthorized dumping of hazardous waste.

Tracking technologies offer an interesting yet hypothetical approach to assessing how many illegal goods pass through customs undetected. Under a formal cooperation agreement, law enforcement

[7] Fluctuations in market prices often signal disruptions in illicit goods markets. According to the economic principles of supply and demand, a disruption in supply typically leads to higher prices. Conversely, an increase in supply usually results in lower street prices, if demand remains constant.

[8] Trade balance monitoring provides customs with insights into cross-border trading volumes. For instance, discrepancies in bilateral trade data—such as higher exports from Country A to Country B compared to imports—can indicate potential smuggling. Analyzing these trade flows can reveal how legitimate products from one country end up as illicit goods in another, effectively estimating smuggling of items like cigarettes and uncertified timber.

authorities could send controlled samples—such as replica elephant tusks[9] or drug simulants—to various countries to evaluate how many of these items evade detection at the border. In this "red team" testing strategy, authorities would know the total number of incoming targets, allowing for an accurate assessment of detection rates that could be applied to the entire trade flow under certain assumptions.

6.2 Ways to improve quality of illicit markets data

Estimating the scale of illicit markets and the shadow economy is challenging due to the lack of reliable data. Customs authorities use various methods, including seizure data analysis, surveys, expert opinions, institutional data, and modeling techniques. However, each method has inherent limitations and biases, and therefore combining multiple approaches is critical for validating information and supporting more informed decision-making.

Cross-border and interagency cooperation

While data sources are essential, the quality of data collection and analysis is even more important. There is an urgent need for standardized datasets, performance metrics, and analytical models within the customs community. Developing uniform international techniques for data collection and analysis can produce comparable data and enable meaningful benchmarking among customs agencies across different countries.

The international dimension is vital in data collection efforts, as illegal markets operate on a global scale. This transnational nature complicates accurate measurement due to differing jurisdictions, each with varying levels of data availability and reliability. Coordinating data collection and analysis across borders poses significant logistical and methodological challenges.

Collaboration among multiple authorities is equally important for gathering comprehensive data on illicit markets. Various government agencies have access to unique datasets that are invaluable for estimation. For instance, police agencies hold information on criminal networks, environmental authorities monitor environmental crimes, and healthcare authorities track admissions and fatalities related to drug use. Additionally, private sector entities, such as cigarette companies, possess insights into the illicit aspects of their markets. By leveraging these diverse sources of information, customs can achieve a more holistic understanding of illicit trade dynamics.

Regular and targeted estimates grounded in statistical principles

There is a pressing need for systematic and regular updates of data on illicit markets. These markets are highly adaptive and dynamic, evolving swiftly in response to law enforcement actions, regulatory changes, and shifts in consumer demand. Additionally, economic and social factors such as unemployment, poverty, and changing social norms can significantly influence these

[9] Investigative journalists have used fake elephant tusks equipped with hidden GPS trackers to trace the trafficking routes of illegal ivory through international smuggling networks (Christy 2015).

markets. As these factors fluctuate, they affect the size and dynamics of illicit goods, making it difficult to obtain a consistent and accurate snapshot of the market at any given moment.

Another important consideration is the granularity of data. High-level estimates of illicit markets are useful, but operational customs enforcement strive for more detailed data about illegal activities in a specific geographical area or demographic group. This information helps customs to devise best control strategies at specific border posts.

Finally, it is crucial for both data collection techniques and estimation models to adhere to statistical principles. Implementing proper sampling methods, confidence intervals, and other statistical standards is essential for obtaining reliable and accurate information on illicit markets.

6.3 Benefits of better estimation techniques for customs

In conclusion, this study emphasizes the advantages of customs having the capability to accurately estimate the scale of illicit markets and trade flows. By enhancing the understanding of customs experts and policymakers regarding the total volumes of illicit trade, more precise estimates empower authorities to make informed decisions about border control strategies. These evidence-based choices can have a significant impact on various aspects of customs operations, including:

- **Threat prioritization and resource allocation:** These factors are crucial in determining customs' capacity to protect society from the adverse effects of illicit trade. Effective customs control activities save lives, defend tax revenues, protect the environment, and shield domestic industries from unfair foreign competition, among other critical contributions. Improved estimates of illicit trade enable customs to identify non-seizure rates within harmful trade flows, allowing for more efficient allocation of limited control resources.
- **Performance monitoring:** Effectiveness of customs enforcement increases when authorities have a clearer understanding of the volume of illicit goods slipping through undetected. Currently, many customs agencies gather feedback on targeting and inspection outcomes. However, this feedback often only provides hit rates or true positives — instances where customs inspections correctly identify illicit goods or activities. The feedback also determines the rate of false positives, which refer to instances when customs control a legitimate shipment. Importantly, accurate estimates of total illicit market volumes can shed light into the important blind spot of false negatives (the ratio of illicit shipments that go undetected to the total volume of traffic).
- **Cooperation with other law enforcement agencies:** Cooperation with police, border guards and other authorities has become a critical element of effective customs operations. In the face of transnational criminal networks, a single customs administration has limited resources and legal authority to combat cross-border crime. However, it can sometimes be difficult for customs to persuade other law enforcement agencies to support their operations. By providing more accurate estimates of the true scale of illicit trade, customs could potentially create a sense of urgency within the broader law enforcement community, thereby mobilizing resources beyond their own capabilities.

- **Providing decision support data to policymakers:** Specific ministerial or parliamentary committees and working groups may develop an interest in new types of illicit market size estimations. Civil servants and politicians involved in policies, regulations, and budgeting across sectors like national security, health, environment, transport, and trade—especially where there are links to trafficking and illicit trade—could find such data valuable in informing their discussions and decision-making processes.

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