Working Paper

# Considering the Harms: Drug Supply Indicators

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## Preface

This working paper has been commissioned by the Western Hemisphere Drug Policy Commission, a Congressionally established body mandated to evaluate U.S. drug policies and programs in the Western Hemisphere with the aim of making recommendations to the President and Congress on the future of counter narcotics policies. The topic discussed in this manuscript deals with matters of drug supply-oriented policies and interventions with a particular focus on available supply-side indicators used to inform contemporary drug policy, the limits of those indicators, the future challenges of drug policy, and how to improve indicators such that they appropriately incorporate harms.

## Justice Policy Program

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**Considering the Harms: Drug Supply Indicators**[1]

## 1. Introduction

Physicians have long sought to abide by the precept "first do no harm." As others have asserted (e.g., Reuter 2009), policymakers, practitioners, and scholars concerned with designing and implementing supply-oriented drug policy might benefit from doing the same.[2] Critics of U.S. drug policy have pointed to its many excesses (e.g., Nadelman, 1989) and unintended consequences (e.g., Chouvy, 2013). Yet beyond these criticisms is the truth that U.S. drug policy is largely reactive, implemented without full understanding or appreciation of the nature of the phenomenon it seeks to affect. In part, this is inherent to the illegality of drug markets, which, by implication, cannot be studied openly and often require inference on limited data. But, more to the point, policy responses are often made during a period of political urgency to do something about a growing problem or perceived crisis and, at times, involve a sense of collective panic. The public's concerns today over rising overdose deaths from synthetic opioids or, in the 1980s, over marketplace violence from retail distribution of crack-cocaine are important examples of conditions that have prioritized immediate action. Under these circumstances, drug policy tends to default to easily observable measures to show that something is being done.

Yet, how do we know when a policy is succeeding or warranted? To better understand outcomes and shape future drug policies, scholars, policymakers, and practitioners have developed indicators to gauge trends in the drug-related phenomenon. For example, behavioral surveys give us a sense of the demand for drugs (e.g., drug use prevalence rates in a population), and data on drug production and seizures offer insight into availability. These are measures of market activity that might inform a broad understanding of the quantities of illegal drugs that change hands and sometimes at what purity or prices. From these measures, we can evaluate the direction and magnitude of the problem. A growing user population and greater availability of drugs borne out in the data would suggest a worsening problem.[3]

It makes sense that drug policy indicators focus on market parameters, like quantities, prices, and purities, as illegal drugs are sold in markets, even if illegal, and generally abide by the laws of supply and demand (e.g., Paoli et al., 2009). However, that narrow focus risks missing the bigger picture, potentially misinforming policy design and implementation. An alternative approach that incorporates harms may be more helpful for thinking beyond the extent of an activity, market or otherwise, to consider its consequences. Moreover, it might account not just for the harms of the activity, but also for those of policy responses and, in this case, the drugs, themselves.[4]

Most would agree that the production, distribution, and use of psychoactive drugs can generate harms to individuals (e.g., substance use disorder, the transmission of diseases, victimization, and overdose) and

[1] I am indebted to Victoria Greenfield for many of her helpful comments and feedback.

[2] Harm and its reduction have long been serious considerations in areas of drug policy involving the immediate harms related to use of drugs (e.g., needle exchange programs).

[3] There are other programmatic indicators that policymakers and practitioners sometimes point to, such as the number of customs officials trained in drug detection or the number of dollars allocated to alternative development. These are not included in this white paper, as they are indicators of programmatic implementation rather than measures of drug market activity that dominate drug policy.

[4] Researchers also mention the potential importance of accounting for any benefits (MacCoun and Reuter, 2001). We have omitted any discussion of benefits from use (e.g., pleasure) and production (e.g., income) of drugs to keep the analysis on harms of supply-side indicators.

society (e.g., drug-related crime and violence, corruption, lost productivity, pollution, and disorder). However, harms vary by time, place, individual, policy environment, and drug. For example, prescription analgesics may generate fewer harms if taken as medically indicated for acute post-surgery pain in a hospital setting than if consumed by a teenager experimenting at a party.

Drug policy aims to reduce (the risk of) harms implicitly and indirectly through the manipulation of market forces. Scholars and practitioners have divided drug policy into three overarching pillars: 1) supply oriented, oftentimes framed as "supply reduction," which typically seeks to reduce availability and raise prices of illegal substances, either directly, e.g., through seizures and eradication, or indirectly, e.g., through alternative development; 2) demand oriented, oftentimes framed as "demand reduction," which aims to deter initiation through prevention or to promote desistence among those who use substances, e.g., through treatment; and 3) harm reduction, which aims to mitigate the negative impacts from using (and sometimes distributing) drugs (Babor et al., 2010; HRI, 2020). Relatedly, a well-designed policy should, as best as possible, recognize and balance competing aims and tradeoffs that may generate harms of their own. For example, efforts to deter drug use, such as prohibitions on needle exchange programs, may elevate risk of transmission of blood borne diseases; aggressive law enforcement may encourage violence; and raising prices of drugs sold in illegal retail markets through supply disruption may generate more acquisitive crime or engender contamination (Silverman and Spruill, 1977; Caulkins and Reuter, 1998; Broadhead et al., 1999; Werb et al., 2011).

At least as much as any other contemporary policy domain, supply-oriented drug policy has been criticized for its limited successes, shortcomings, and unintended consequences. This is true of the criticisms and challenges related to international supply reduction, which includes source-country efforts, like crop eradication and alternative development, as well as interdicting drugs in transit. This is not to say that supply-oriented drug policy is useless or that governments should end such efforts entirely; rather, at times, they have disrupted markets or the flow of drugs in socially beneficial ways. Yet the unintended consequences of supply reduction efforts (e.g., displacement of production in remote and ecologically protected areas) and the ability of suppliers to adapt over time to their effects limit the effectiveness of successes, perhaps especially when the efforts occur absent policies aimed at reducing demand. Cognizant of such limitations, a more suitable goal would be to determine how supply reduction can be done more efficiently and less harmfully. A shift away from prioritizing traditional supply-oriented indicators, such as the quantity of seizures or number of hectares eradicated, and toward a focus on harms associated with the production and trafficking of drugs might help.

At the request of the Western Hemisphere Drug Policy Commission, this white paper discusses commonly used drug supply-oriented indicators and explores ideas for improving them by focusing on harms, particularly those related to the impacts of policies aimed at the international production and trafficking of drugs. It draws on a small but emerging literature on assessing and accounting for supply-related harms (e.g., Greenfield and Paoli 2012 and 2013, and Paoli et al. 2013). Here, the focus is on the Americas and drug supply policy and indicators, as established by the Commission's statutory mandate. In that vein, this paper primarily considers heroin, cocaine, and methamphetamine which are produced and smuggled in the region. It generally excludes supply reduction efforts aimed at prescription analgesics and cannabis, though it does touch upon future challenges of emerging drugs.

The second section of this paper provides a high-level review of well-known drug supply disruption cases cited by scholars. Supply disruption cases are often temporary. This section also reviews some of the

evidence on the effectiveness of broader supply reduction policies aimed at reducing illegal drug production or diminishing the flow of illegal drugs on their way to the United States. The third section provides a discussion and framework for thinking about supply indicators, especially how available measures inform drug policy as well as the inherent limits of these measures. The fourth section offers some thoughts on future challenges and how existing indicators might fail to provide adequate insights into emerging drug problems. This is followed by a section on accounting for harms in drug-supply indicators. In theory, indicators that aim to incorporate a broader understanding of harms might alleviate some of the unintended consequences of supply-oriented drug policy and the related international discord among countries in the Americas. The paper concludes with a short section on future considerations for the Commission.

## 2. Drug supply reduction efforts

In the Western Hemisphere two plant-based drugs—cocaine and heroin—have historically been the primary focus of drug control efforts.[5] Coca has been produced almost entirely in the Andean region, with shifts in production across Bolivia, Peru, and Colombia. Today, Colombia is the primary producer of the world's cocaine (UNODC, 2019). Peru and Bolivia were major producers for cocaine consumed in the U.S. up through the 1990s. It is difficult to determine if there was a single event or intervention that resulted in a displacement of coca production to Colombia, although shifts in production efforts may be attributable to counter narcotics efforts as well as business decisions by drug trafficking organizations (Friesendorf, 2005; Thoumi, 2002).[6]

Most of the heroin consumed in the United States originates in the Americas, with illicit opium poppy cultivation taking place in Mexico and Colombia. Until the early 2010s, Colombia supplied much of the powder heroin found east of the Mississippi river, with Mexican black and brown tar favored out west (DEA, 2018). However, Colombia opium poppy cultivation has largely been eradicated for reasons not entirely well understood.[7] Mexico is now the largest source of opium poppy used in the manufacture for heroin destined to the United States. Today, estimates in that country suggest that there are some 40,000 hectares of illegal poppy (ONDCP, 2019).

Supply disruption efforts may have shaped shifting patterns in illegal crop cultivation. But the longstanding view that supply reduction physically constrains the quantity of drugs available for use is not entirely accurate. Under this notion, a kilogram of cocaine seized amounts to one kilogram not consumed. To this day, law enforcement will make such assertions in the press after making large seizures. Rather, supply disruption efforts aimed at illegal drugs affect the costs faced by producers and traffickers. Apart from the

[5] Cannabis is another plant-based drug of historic concern for drug control efforts. However, concerns over cannabis have largely waned as jurisdictions in the Americas have moved to liberalize access to the drug. Methamphetamine is the other substance of concern to drug supply control agencies. As discussed later, production in Mexico has grown in the last decade and a half due in part to supply control efforts in the United States that have restricted clandestine domestic production.

[6] Coca leaf grown in Bolivia was often processed in Colombia into cocaine hydrochloride. In the 1990s, drug traffickers may have seen an opportunity to consolidate business activities in Colombia given the expanses of ungoverned territory in that country, making it ideal to cultivate coca unimpeded by counter narcotics efforts.

[7] One possible explanation is that farmers in Colombia shifted away from poppy to coca, as the latter is more resilient to aerial eradication efforts if properly treated after being sprayed. Another possibility may stem from the fact that Mexican trafficking organizations successfully learned the synthesis method employed by Colombian traffickers to make powder heroin, allowing them to outcompete Colombian suppliers.

immediate risks of product "losses," e.g., from crop eradication or drug seizures, producers and traffickers might also incur costs from asset destruction or seizures, arrest, prosecution, and physical harm (both from state actors and competing criminal elements). In turn, producers and traffickers can offset these costs by demanding greater compensation, often by charging higher prices (Reuter and Kleiman, 1986), thus passing on a portion of the costs to the consumer (Babor et al., 2010). An important element of outright prohibition is that it can drive up prices of illegal drugs through production inefficiencies, preventing producers from benefiting from capital investment or economies of scale that could further reduce costs of operation (MacCoun and Reuter, 2011).[8] Higher prices can discourage initiation and reduce the amount of a drug consumed by current users (Babor et al., 2010).

Supply reduction efforts can occur all along a supply chain, from production to retail. Programs that target drug production and trafficking include eradicating illegal crops, closing clandestine laboratories, controlling primary inputs, like precursor chemicals, promoting alternative development, and interdicting drugs before they enter retail markets. Domestic law enforcement efforts in retail markets can also fall under the rubric of "supply reduction," but they fall outside the scope of this paper. For reference, Figure 1, reproduced from Finklea (2019) provides a framework for thinking about drug supply chains. Drugs produced overseas are trafficked to the U.S. where they are either intercepted by law enforcement or avoid detection, making their way to domestic markets. At ports of entry, typical indicator of supply involve seizure numbers, weights, and location. Indicators of drugs produced abroad involve hectares of illicit cultivation, numbers of clandestine laboratories used to manufacture finished product, seizures of drugs leaving or transshipping source countries, seizures of pre-cursor chemicals, or the number of arrests and prosecutions involving drug traffickers.

*Disruption*

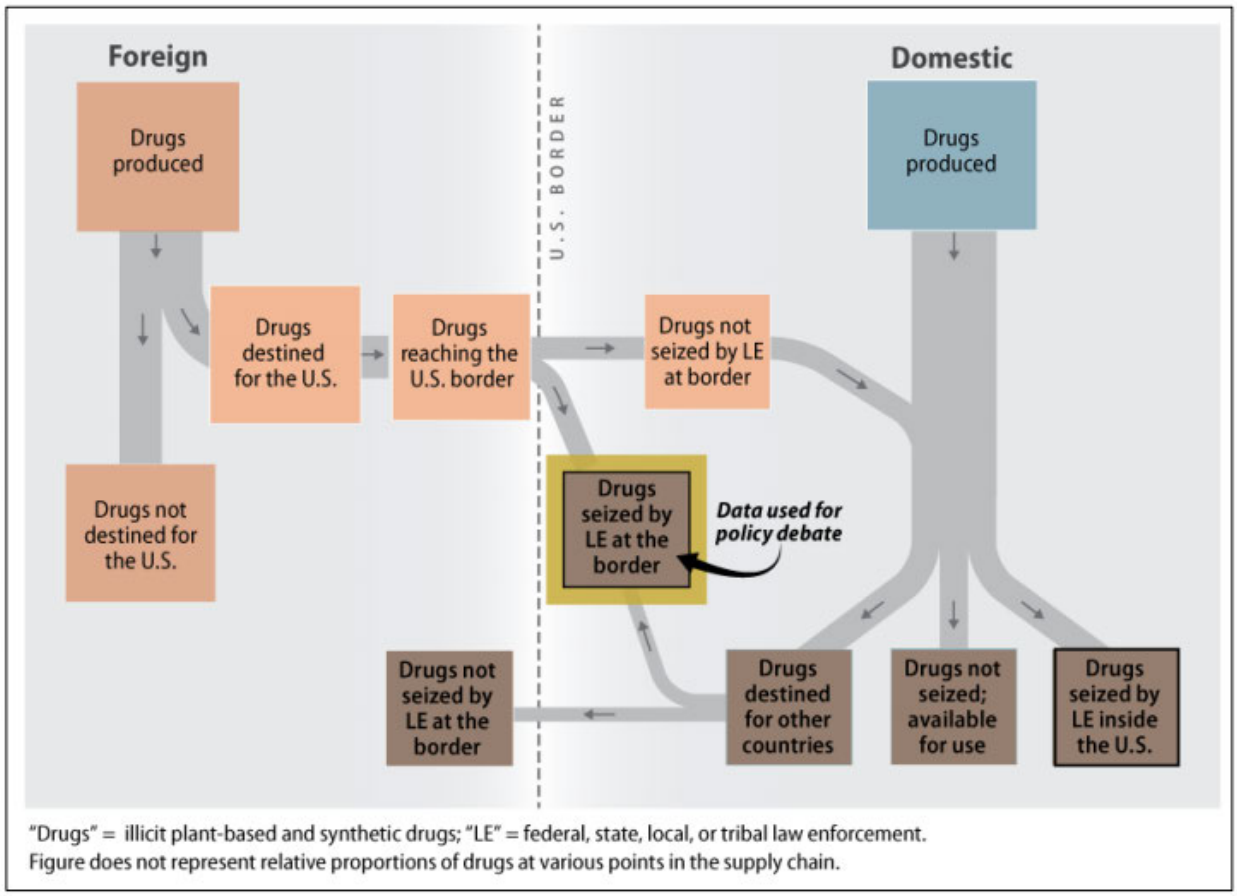
Drug supply disruption efforts have been criticized, but our understanding of their effectiveness is asymmetric. We can see markets that persist, but we cannot see those that are prevented from forming. We do know that once established, illegal drug markets are resilient (Babor et al., 2010). Though supply disruption may be successful in individual instances and for limited periods, the goal of indefinitely reducing supply has not been achieved outside a few narrow instances. When it comes to prices, supply reduction efforts aimed at production and interdiction may be even more limited as prices in source countries account for a small fraction of the retail prices of drugs sold in the United States (Caulkins and Reuter, 2010). In short, the limitations of supply disruption's capacity to reduce availability and raise the price of drugs are troubling, given the high costs of such interventions (Pollack and Reuter, 2014). In essence, supply-side interventions, policies, and programs, can shape supply but not necessarily eliminate it.

Table 1 documents some major supply disruptions that drug policy researchers identify as partially "successful" because they have had notable downstream impacts. As the reader will see, such prior disruptions are often limited or temporary. Even though a disruption often does not eliminate the source

[8] It is important to note that this is no longer a theoretical argument. After cannabis legalization, the price of regulated retail cannabis in state markets in the United States has fallen rapidly—even under federal prohibition. For example, the average post-tax price of a gram of cannabis sold in retail stores in Washington dropped from $23 to under $10 in less than two years after legalization (Smart et al., 2017). Some have estimated that after federal legalization, the pre-tax price of cannabis could fall by 90 percent, assuming it was grown in ideal outdoor conditions on an industrial scale with mechanized equipment (Caulkins, 2010).

of drugs, restricting trafficking routes or access to primary inputs has affected supply—sometimes in harmful ways. Traditional indicators have been used to gauge short-term policy impacts on market activity. In several cases, declines in health outcomes associated with use, such as overdoses or treatment admissions, or changes in supply-side measures, such as increases in retail prices, were a result of the disruption.

*Figure 1: Framework for drug supply*




Source: Reproduced from Finklea (2019)

In the 1970s, U.S. and French law enforcement dismantled the so-called "French Connection" that trafficked Turkish heroin from France to the United States while Turkey, itself, banned—and subsequently licensed—opium poppy cultivation.[9] The subsequent decline in heroin flowing into the United States lasted long enough to raise prices and deter use, which, in combination with expanded methadone treatment, resulted in declining overdoses and heroin treatment admissions (Musto, 1999; DuPont and Greene, 1973). This seemed to reduce American heroin problems until the late 1970s when Mexico and Southeast Asia replaced Turkey as sources of heroin.

The near complete eradication of Quaaludes (methaqualone) is a rare instance of drug control efforts removing a popularly abused drug from markets and cultural experience in a matter of years. Though Quaaludes are not plant-based, it is one unique supply disruption case that merits inclusion. This

[9] For details of the ban see e.g., Windle (2014).

prescription sedative was diverted and abused in the United States and elsewhere during the 1960s and 1970s, but its reclassification to Schedule I under the U.S Controlled Substance Act in 1984 effectively banned U.S. production. Related international efforts to control precursor chemicals contributed to a reduction in illegal production and trafficking more broadly (UNODC, 2019; Wantanabe, 1996). Methaqualone precursors are controlled in many developed markets and such regulations have helped to reduce, if not eliminate, supply in North America and Europe. Nonetheless, methaqualone produced in India has been reported as a popular recreational drug in East and South Africa since the early 1990s (UNODC, 2019; Wantanabe, 1996). Methaqualone's exit from U.S. markets may be due to cultural factors and the availability of other sedatives, such as the benzodiazepine class of substances. Nonetheless, it is noted as one important case study whereby expansive international supply controls in developed markets had the intended effect of eradicating the availability of this substance in illegal drug markets in a matter of a few years. However, this success may be unique to this one substance.

The Australian heroin drought of late-2000 and early-2001 that resulted in a sharp decrease in heroin availability and purity is a peculiar case that cannot easily be attributed to any single event or intervention. Australian law enforcement began focusing greater attention and resources on stemming the country's growing heroin problem in the late 1990s. This resulted in a spectacularly large seizure in Fiji and the arrest of the principals in a Chinese trafficking ring. Those events disrupted the heroin markets in both Australia and British Columbia. While the British Columbian market recovered quickly, the Australian market did not. At about the same time, the Taliban banned opium poppy cultivation in Afghanistan, resulting in dramatic, short-lived drop in global opium production that might have had a reinforcing effect, but the asymmetry is still puzzling.[10] There is no strong explanation for the source of the disruption; Degenhardt et al. (2004) make the case by elimination that it was a supply shock but cannot specifically attribute this to enforcement efforts.

More recently and closer to home, the U.S. federal government and states have tried to reduce access to precursor chemicals used to manufacture methamphetamine. Since the mid-1990s, the federal government has introduced restrictions on access to precursors like ephedrine, pseudoephedrine, and phenylpropanolamine. Several states have also passed laws that have made it harder to obtain precursor-containing medications. Analysis suggests that these laws are associated with reductions in clandestine labs, emergency department visits, and crime (McKetin et al., 2011; Dobkin et al, 2014; Cunningham and Liu, 2003; Cunningham, Liu and Callaghan, 2016). Yet, the temporary disruption in methamphetamine production in the U.S. has been superseded by production in Mexico, which, since 2012 has exported an increasing amount of higher potency methamphetamine (DEA, 2019).

Though the ongoing fentanyl outbreak in the United States is the most severe, it is not the first. Since the 1980s there have been several documented instances of clandestine production of fentanyl in the United States that were associated with increased numbers of overdose deaths. The limited nature of some of these outbreaks sometimes reflected the lack of a distribution network that could connect the supply to users (Pardo et al, 2019). For contemporary outbreaks where fentanyl made its way into the heroin supply, law enforcement was able to end the incursion once it located the lab. For example, a lab in Mexico was

[10] The Taliban ban during the 2000-2001 growing season, itself, represents a noteworthy "case study" insomuch as it generated temporary, but significant downstream effects (Paoli et al. 2009).

producing fentanyl that was being sold as heroin in parts of the Midwest from 2005 to 2007, but overdoses declined after locating and dismantling the source in mid-2006.

Earlier disruptions are notable for their dominance by a single production source or trafficking network. Law enforcement could disrupt these operations by focusing on the weakest link in the supply chain. Locating and dismantling a lab, trafficking ring, or curtailing the availability of precursor chemicals generated downstream effects, such as increased prices and reductions in availability, that were reflected in drug market indicators. Yet, these features of prior disruptions may not hold for other areas of illegal drug production. Fentanyl production is no longer centered on one lab; the U.S. market draws heroin from across continents, even if Mexico features prominently; and methamphetamine production appears to occur on an industrial scale in Mexico and a microscale in the United States (DEA, 2019).

Going forward, supply disruption efforts may face yet greater challenges from the confluence of a more interconnected and globalized world, coupled with the manufacture of synthetic drugs. Technologies may allow new forms of illegal distribution or more efficient drug production; immediate and encrypted communication, as has already occurred though the internet and with the benefit of cell phones; and increasingly sophisticated counter measures among traffickers.

*Table 1 Drug Supply Disruptions*

| Supply Disruption Case | Drug and Period | Intervention | Short-term Outcome | Long-term Outcome | Confounders | Source |
|---|---|---|---|---|---|---|
| French Connection and Turkish opium poppy ban | Heroin during the early 1970s | Turkey banned opium poppy in 1971. Police broke up major trafficking networks from refineries in France in 1972 | Disruption in heroin supply in U.S. markets; decline in heroin problems for 5+ years | Mexico, Pakistan, Southeast Asia eventually replaced Turkey as heroin source for US | Contemporaneous expansion of methadone, droughts in poppy growing areas | Musto (1999); DuPont and Greene (1973) |
| Quaaludes (methaqualone) in the US | Quaaludes late 1970s, early 1980s | Up-scheduling to Schedule I under U.S. law; enhanced international diversion control and investigation | Near complete global disruption; appearance of counterfeit tablets | Successful monitoring of precursors. Possible shift in consumption towards benzodiazepines | Declining popularity of Quaaludes | UNODC (2019); Wantanabe, (1996) |
| Australian heroin drought | Heroin in 2000/2001 | Increased law enforcement attention resulting in extremely large seizure in Fiji and arrest of principals in major Chinese heroin trafficking ring | Steep decrease in availability and purity and sharp increase in price of heroin; decline in heroin problems but rise in methamphetamine problems. | Market stabilization, but recent prevalence remained lower than pre-drought era | Global supply constraints, e.g., temporary Taliban opium poppy ban, declining opium poppy production in SE Asia | Degenhardt et al. (2004) |
| Methamphetamine precursor control in the US | Methamphetamine in 1990s and early 2000s | Series of state and federal laws aimed at curbing access to precursor chemicals (bulk and retail) | Decline in small clandestine labs; decline in methamphetamine problems | Shift production to larger industrial labs in Mexico. Purity and potency today is very high, deaths are climbing | | DEA (2018); Dobkin et al. (2014); McKetin et al. (2011) |
| Nascent fentanyl outbreaks in the US | Fentanyl in early 1990s and mid-2000s (separate cases) | Closure of clandestine lab | Decline in fentanyl availability and decline in problems (overdoses) | | | Pardo et al. (2019) |

Source: Pardo and Reuter (forthcoming)

*Literature*

Beyond the cases of market disruptions, what can systematic research tell us about the effects of supply reduction efforts on quantity, purity, or price? Pollack and Reuter (2014) review the available quantitative literature on supply reduction policies aimed at producers, traffickers, and sellers. This white paper extends their review to capture some research published since 2014, while incorporating one systematic review of methamphetamine control policies, and one conceptual analysis of the Australian heroin drought, but does not claim to be exhaustive. Table 2 is adapted from Pollack and Reuter (2014), detailing the available research evidence on supply reduction programs that focus on source-country control and interdiction. Given the limitations of studying drug policy (e.g., the inability with which treatment can be randomly assigned), causal inference is challenging. Most of the statistical studies employ correlational time-series models, of which just a few employ rigorous methods to infer causality, and a small minority takes advantage of natural experiments. Lastly, plant-based drugs, especially heroin and cocaine, dominate the literature and the results may not always transfer readily to synthetic drug markets.

Some studies employ complex simulations based on economic theory to determine the costs and benefits of interdiction and eradication (Mejia & Restrepo, 2012; Clemens, 2008; Mejia et al., 2017; Mejia & Restrepo, 2016; Crane, Rivolo & Comfort, 1997). These applied economic studies, which, according to Pollack and Reuter (2014), fit available data "relatively crudely," generally find a negative impact of policy interventions on total supply or use. Clemens (2008) and Crane, Rivolo & Comfort (1997) identify an increase in the prices of drugs sold in domestic markets in the U.S. or reductions in consumption associated with source-country interventions. However, some studies also note the substantial resources needed on the supply-side of the equation to generate modest reductions. Mejia & Restrepo (2012) find that a three-fold increase in U.S. counter narcotics efforts in Colombia would result in a 13 percent decline in cocaine trafficking. Further, Mejia and Restrepo (2016) report that it would cost nearly $1 million in eradication efforts to reduce cocaine trafficking by one kilogram and about $175,000 to interdict one kilogram. In short, the collection of simulation studies points to interdiction as economically preferable to crop eradication, but, overall, they report modest gains for substantial costs.

Other articles have used supply data, including seizure data, measures of illegal cultivation or hectares eradicated, to observe and measure the impact of source-country control interventions on prices or availability instead of simulating the relationship. With the exception of Mejia & Restrepo (2017), which capitalized on a natural experiment when Colombia halted aerial herbicidal eradication illicit crops along the Ecuador border in 2006, most of these observational studies are correlational, though some attempt to employ more rigorous methods (e.g., instrumental variable approaches) to elicit causal inferences.

In this empirical literature, coca crop eradication and interdiction have been associated with a decrease in coca production or cocaine availability, but declines are not universal and, when observed, they vary in size. Ibanez and Klasen (2017) report a reduction of 0.44 hectares cultivated for one hectare eradicated, while Moreno-Sanchez, Kraybill, and Thompson (2003) report no change in net production because farmers compensate for interventions by cultivating crops more extensively. Cote (2019) finds that of all in-country interdiction efforts (coca leaf, coca base, or cocaine hydrochloride), cocaine hydrochloride seizures had the largest effect size (one kilogram of cocaine seizures was associated with a reduction in coca cultivation by 0.009 to 0.061 hectares). In terms of eradication's effect on price, Gallego and Rico (2013) used an instrumental variable approach and concluded that aerial or manual eradication does not affect the price of products derived from coca cultivation. Mejia and Restrepo (2017) found that aerial

eradication of an additional hectare reduces coca cultivation by 0.02 to 0.03 hectares, a rather small amount for the cost. Overall, the evidence on supply-side policies are mixed, with studies suggesting greater effects in reducing drug supply or raising price from interdiction than eradication.

Weatherburn and Lind (1997) examined heroin seizures in Australia and Keck and Correa-Cabera (2015) looked at interdiction at the U.S. border and their associated effects on drug availability or price. Weatherburn and Lind (1997) found no statistical relationship between heroin seizures and price, purity, or perceived availability in Australia's retail markets in the 1990s, but dramatic seizures preceded the country's heroin drought at the turn of the century, as manifested in sharp increases in the prices and declines in purity of heroin available in street markets. In an analysis of U.S. border interdiction efforts, Keck and Correa-Cabrera (2015) note that enforcement, as measured by Border Patrol operations, was positively correlated with cocaine and cannabis seizures, but not with heroin seizures. Most puzzling, the authors reported a significant and negative relationship between seizures and prices; that is, as seizures increased, the price of drugs reported in retail markets by U.S. law enforcement declined. This might be due to mismeasurement or bias in the data, but it is also possible that seizures increased because flows increased, signaling a net increase in supply. The inability with which to draw clear inferences from seizure data suggests that, alone, they are a rather weak indicator.

McKetin et al. (2011) undertook a systematic review of ten studies of regulatory and interdiction efforts to control methamphetamine in North America and report generally favorable changes in outcome indicators (e.g., treatment admissions, arrests, price, and purity) after enacting precursor controls or after major interdiction events. The intervention effects ranged from 12 percent to 77 percent, with the most substantial effects involving precursor controls imposed in the United States during the 1990s. Yet the authors note that importation of methamphetamine or precursor chemicals from other countries appeared to undermine the effectiveness of regulatory controls in the long run. More recent studies have documented similar relationships between regulatory controls that seek to limit access to precursor chemicals and improvements in methamphetamine-related outcomes (Dobkin et al, 2014; Cunningham et al., 2013; Cunningham, Liu and Callaghan, 2016). However, these effects may not persist because domestic clandestine production of methamphetamine has largely declined in favor of imports (DEA, 2019).

In summary, the research on supply reduction policies yields mixed results, but it allows the possibility that such policies can yield intended effects under limited circumstances. That is, policies aimed at interfering with illegal drug production or interdicting drugs in transit are, at times, associated with increases in prices, reduction in purity, or decreases in use. However, statistical studies and simulations report greater cost-effectiveness for interdiction than eradication, at least as these programs pertain to cocaine. The return on investment is larger for policies that focus on drugs in transit rather than the primary inputs, perhaps with the exception of synthetic drugs, like methamphetamine. Studies evaluating coca or opium poppy eradication point to these as having small effects relative to their cost. The relative cost effectiveness of interdiction is likely due, in part, to the fact that the prices of primary inputs, like coca and opium poppy, make up a small fraction of the prices of drugs sold in retail markets (Caulkins and Reuter, 2010).

Overall, the findings from the recent literature echo earlier systems analyses that compare various supply control interventions for cocaine (Rydell and Everingham, 1994). Rydell and Everingham estimated that eradication generates 15 cents in savings per dollar spent as compared with 32 cents for interdiction and

52 cents for domestic law enforcement that targets retail markets. Although outside the scope of this paper, Rydell and Everingham found even larger returns to treatment, with every dollar spent on treatment saving $7.46 in reduced crime costs and productivity losses.[11]

In short, the return on investment from supply control efforts may increase with proximity to retail markets. This is not to say that supply-side interventions have had no effect shaping the supply of drugs in a country or region, but that efforts to eradicate illicit cultivation may: 1) require substantially more resources over a sustained period of time, and 2) incur additional negative consequences (e.g., ecological harms, lost livelihoods of farmers living on economic margins, etc.). The limited peer-reviewed literature, including simulation studies, suggests that supply-side interventions have the greatest impact when drugs are interdicted as they leave a producer country or in transit on their way to final markets. Interdicting drugs may be preferred for two reasons. First, product at this stage is worth more to traffickers as the primary inputs, like coca leaves or poppy gum, make up a minute share of the value of the final price. And second, because interdicting drugs (either in transit inside a country or as it leaves ports of exit) may be less intrusive in that there is a natural bottleneck at this point in the supply chain.[12]

We note that there is a literature on the effects of supply reduction on other harm-related outcomes, such as violence near points of production or in trafficking (Dube & Naidu, 2015; Angrist & Kugler, 2008; Dell, 2015; Castillo, Mejia & Restrepo, 2018). Most of these studies find that supply reduction interventions are positively associated with increases in violence. Nevertheless, the majority of the literature focuses on how supply control policies affect indicators, like price and availability, which policymakers, drug control agencies, and scholars typically point to or work with. Though harms, like violence, occurring near or along points of supply is of concern, they are often not accounted for in the policymaking process which aims at reducing the availability and use of drugs found in drug markets in the United States.[13]

[11] This largely has to do with the "in-treatment" effect of reducing chronic users' consumption levels while undergoing treatment even if relapse occurs after treatment has ended.

[12] It is useful to think of the supply network as having an hourglass shape, with many market actors at both ends of the supply chain (this is because there are many subsistence farmers growing coca and many retail dealers in major markets in the U.S.), but fewer individuals refining or wholesaling drugs and even fewer individuals trafficking them (Babor et al., 2010).

[13] For example, the Administration's overarching strategic objective, as stated in the 2019 National Drug Control Strategy, is to reduce the number of American lives lost to drug use (ONDCP, 2019). In effect, this singular objective ignores any outcomes—good, bad, or neutral—associated with policies other than American lives lost.

*Table 2: Literature on supply-side policies*

| Study | Drug | Intervention (Level of Supply) | Setting | Data | Study design | Findings |
|---|---|---|---|---|---|---|
| | | | *Cocaine* | | | |
| Mejia & Restrepo (2012) | Cocaine | Crop eradication, interdiction (production and trafficking) | Colombia | Multiple | Calibrated theoretical model | Interdiction more cost-effective than crop eradication. Three-fold increase in U.S. effort would decrease wholesale cocaine supply in transit countries by about 13% |
| Mejia & Restrepo (2016) | Cocaine | Crop enforcement, interdiction (production and trafficking) | Colombia | Multiple | Calibrated theoretical model | Authors find that the marginal cost to the U.S. of reducing cocaine transacted in retail markets by one kilogram is $940,000, if resources are allocated to subsidizing eradication efforts; and about $175,273 if resources are allocated to subsidizing interdiction efforts in Colombia |
| Ibanez and Klasen (2017) | Cocaine | Crop eradication (production) | Colombia | Local survey data, and measures from SIMCI | Linear fixed effects estimation | One additional hectare eradicated decreases coca supply by 0.44 hectares, indicating that coca can only be eradicated at a very high cost. |
| Moreno-Sanchez, Kraybill & Thompson (2003) | Cocaine | Crop eradication (production) | Colombia | UNDCP and Colombian cultivation data | Linear model, with and without temporal trends | Results indicate that coca eradication is an ineffective means of supply control as farmers compensate by cultivating the crop more extensively. The evidence further suggests that incentives to produce legal substitute crops may have greater supply-reducing potential than eradication. |
| Gallego & Rico (2013) | Cocaine | Crop enforcement, interdiction (production and trafficking) | Colombia | UNODC crop data Integrated Illicit Crop Monitoring System (SIMCI) Spraying data from Colombian national police | Instrumental variables analysis: topographic features instrument for intensity of eradication | 'Manual eradication campaigns and aerial spraying of illicit crops do not impact the price of the main products of coca cultivation' |
| Mejia et al. (2017) | Cocaine | Crop eradication (production) | Colombia | Aerial spraying data | Quasi-experimental difference-in-difference estimation | Spraying one additional hectare reduces coca cultivation by 0.022 to 0.03 hectares |

| | | | | | | |
|---|---|---|---|---|---|---|
| Crane, Rivolo & Comfort (1997) | Cocaine | Interdiction and source country enforcement (trafficking) | Colombia | STRIDE, intelligence on enforcement events in Colombia on en route to U.S. | Simulation model | Authors find observable upward excursions in U.S. cocaine street prices, with U.S. interdiction efforts in conjunction with source country support as likely cause. Authors also find price excursions produced measurable reductions in U.S. cocaine use |
| Cote (2019) | Cocaine | Crop eradication, laboratory dismantling, and interdiction (production and trafficking) | Colombia | UNODC crop data | Generalized method of moments estimation with fixed effects | Dismantling of laboratories causes a reduction of 0.003 to 0.006 hectares per squared kilometer in coca cultivation, coca base seizures cause a reduction of 0.003 to 0.008 hectares per squared km, coca leaves seizures cause a reduction of 0.006 to 0.019 hectares per squared km and cocaine seizures cause a reduction of 0.009 to 0.061 hectares per squared km. |
| | | | | *Heroin* | | |
| Clemens (2008) | Opium | Crop eradication (production) | Afghanistan | Various UNODC data surveys | Calibrated theoretical model | Substantial increases in crop eradication' needed to achieve 3–19% reduction in production. Cessation of crop eradication would result in 1.6–9.6% estimated increase in opiate production |
| Weatherburn & Lind (1997) | Heroin | Heroin seizures over 1 kg (trafficking) | Cabramatta, Australia | Police seizure and price data, local methadone clinic data on admissions to methadone treatment | Correlational time–series analyses | No effect of heroin seizures on price, purity or perceived street availability Methadone admissions not affected by price, perceived availability, or local heroin arrests; no relationship found between these arrests and street heroin price Nevertheless, two-thirds of those who sought entry to local methadone programs indicated price as a reason for stopping using heroin |
| Keck and Correa-Cabera (2015) | Heroin, cocaine, and cannabis | Border interdiction (trafficking) | US-Mexico | Seizure and enforcement data | Bivariate regression | A positive significant relationship was found between border enforcement and cocaine and marijuana seizures, with no significant effect found with regard to heroin seizures. No statistically significant relationship was found between border enforcement and the price of marijuana. However, the results indicate that border enforcement is statistically significant and negatively related to cocaine and heroin prices, with an increase in border enforcement reducing the price of both drugs. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | *Methamphetamine* | | | |
| McKetin et al., (2011) | Methamphetamine | Precursor regulatory controls; interdiction (production and trafficking) | North America | 10 peer-reviewed articles | Systematic review | Two of the largest impacts were seen following interdiction efforts, involving the closure of rogue pharmaceutical companies. Methamphetamine precursor regulations can reduce indicators of methamphetamine supply and use. |
| Cunningham et al., (2013) | Methamphetamine | Precursor chemical controls in Mexico | North America | STRIDE seizure data | Time series analysis | Mixed-isomer exhibits constituted about 4% of the methamphetamine exhibits before Mexico's controls, then rose sharply in association with them and remained elevated, constituting about 37% of methamphetamine exhibits in 2010. d-Methamphetamine exhibits dropped sharply; l-methamphetamine and racemic methamphetamine exhibits had small rises. |

Notes: STRIDE = System to Retrieve Information from Drug Evidence; UNODC = United Nations Office on Drugs and Crime; UNDCP = United Nations Drug Control Programme (now the UNODC); SIMCI = Integrated Illicit Crop Monitoring System

## 3. Drug supply-oriented indicators

Supply disruption efforts have, at times, been able to move markets favorably, if only temporarily, as inferred from changes in indicators (e.g., prevalence rates, overdoses, seizures, purity, prices, etc.). As noted above, most of the effects of these efforts are short-lived as markets adapt, production is displaced, traffickers find new routes, or alternative drugs emerge. Therefore, indicators should, to the best of their design, be able to account for short- and long-term trends in measures. Overall, supply-side indicators include measures that aim to measure or set bounds on production and trafficking directly (e.g., number of clandestine labs, area under cultivation, number and weight of seizures, etc.) or to shed further light on the extent and nature of the supply of drugs. The latter include the purity and price of drugs, the location of seizures, and the chemical signature of seizures.

Nevertheless, supply-side indicators are limited for several important reasons. They may not accurately reflect the true nature of supply due to biases in data collection or weakness in the underlying measures (see Paoli et al., 2009); they may be difficult to interpret, especially when divorced from other indicators (for example, changes in seizures may indicate increased flows or better interdiction efforts, confounding interpretation); and/or they may be too narrow, failing to capture other important measures, like harms. These limitations may hinder effective policy design and implementation, even though some can be overcome. Data quality and measurement issues can be improved by allocating more resources to enhance data collection, and interpretability may be achieved by using other indicators to help triangulate measures (e.g., comparing seizures alongside health harms). But overall, many available supply-side indicators are too narrow in that they can fail to incorporate other important dimensions, like harm. This section discusses several available supply-side indicators, how they can inform drug policy analysis, and what their limitations are.

*Production indicators*

Obviously, not all of these indicators are relevant at the same point in the supply chain. For example, data on the area under cultivation or number of clandestine labs are obtained at or close to the point of production and, depending on their quality, can be used to estimate potential supply of cocaine or heroin. Given that these are generally geographically fixed measures, at least in the short term, they can also tell us something about where production is occurring and, potentially, where to consider a policy response. Coca cultivation has largely been concentrated in the Andes, often waxing and waning across parts of Peru, Bolivia, and Colombia. Eradication efforts are aimed at the geographic areas where coca is produced, but such efforts may encourage producers to take countermeasures or move production.[14]

For illicit crops, a sense of production comes from estimates of area under cultivation. Using satellite imagery, remote sensing, or other on the ground surveys, efforts have been made to calculate the number of hectares devoted to illegal crops, like opium poppy or coca. These measures are then used to inform production potentials, based on surveys of illegal cultivation, to account for the number of harvests per year, discounts for eradication, transformation of plant materials to minimally- or semi-processed

[14] The recent discovery of clandestine coca cultivation and cocaine base processing facilities in Guatemala in mid-2019 is notable indication that producers are looking to reduce risk of detection and lower costs associated with illegal coca cultivation and cocaine trafficking (Menchu, 2019).

products like coca base/paste from coca leaves or dry opium from opium poppy, and conversion from these products into cocaine hydrochloride or heroin (UNODC, 2016).

The United States government, through the State Department and ONDCP, and the UN Office on Drugs and Crime (UNODC) publish—sometimes conflicting—estimates of either area under cultivation or total production potential. U.S. estimates are not accompanied by a methodology and are subject to ex post revision, so one cannot determine the reasons behind such inconsistencies, leading some researchers to rely more heavily on the UNODC estimates (see e.g., Paoli et al. 2009). These competing and sometimes conflicting measures suggest an important and hard to overcome measurement limitation of this indicator. In short, which reflects the "true" amount of cultivation?

Estimating total production potential requires making several assumptions. First, satellite or remote sensing imagery may miss cultivation if plots are concealed by interspersing poppy or coca with other crops, which farmers sometimes do to avoid detection by eradication forces. Second, measures of total harvests are informed by surveying farmers, but harvest yields may vary widely depending on the inputs (e.g., fertilizers, pesticides, etc.) used by farmers to enhance yields or reduce time between harvests. Therefore, increasing yields may result in increases in total production even if area under cultivation does not change, requiring continued re-estimation to account for changes in agricultural practices. Last, the estimates require use of conversion factors for each stage of processing, e.g., from coca leaves to coca paste or base to cocaine hydrochloride. These factors can change as farmers or drug traffickers improve or alter their extraction and refining capabilities. UNODC notes in its methodology that data collection limitations do not allow them to calculate margins of error for these different factors (UNODC, 2016), thus calling into question the reliability of point estimates.

Because a drug market is global and shifting, the measure of production in any producing region is not a reliable indicator of the supply in any consuming region. For example, though coca cultivation in Colombia is at historic heights (DEA, 2019), an examination of demand-side measures in the United States does not indicate a corresponding jump in cocaine use. Some have noted that this may suggest that rising production in Colombia may be meeting growing demand in other markets outside of the Western Hemisphere (DEA, 2019). Therefore, to the extent with which U.S. policymakers interpret or care about rising production, indicators may need to account for market conditions in other parts of the world.

*Trafficking and retail indicators*

Evidence on drug seizures or number of arrests and prosecutions can be obtained anywhere in the supply chain, from farmgate to retail. Seizure amounts are generally reported in bulk weight and not adjusted for purity. Often, their retail-level prices are also reported alongside weight (see Kucher, 2019). Policymakers, law enforcement officials, and researchers use these indicators to gauge the extent of drug flows, and the routes and tactics by which drugs are trafficked. Regarding flows, a marked shift in the number of seizures by land toward those at sea or by air may suggest changes in trafficking strategies. Similarly, the conveyance or concealment of seizures may provide details into the sophistication of traffickers and their methods. Numbers of seizures hidden in legitimate commerce versus non-commercial vehicles, like go-fast boats or semisubmersibles, may give insights into operational tactics of traffickers.

Other information can be obtained from sophisticated chemical analysis of drugs obtained during seizures or police operations. These include purity, quantification and detection of filling agents, formulation, and

chemical signature analyses. From undercover retail-level buys, purity-adjusted prices of drugs sold in retail are calculated from data on the purity, weight, and price of a given sample.[15] Measures of price are important as price increases may indicate that supply control is having its intended effect; further, price increases should reduce drug use.

Therefore, purity-adjusted prices should best capture the effects of policy all along a supply chain insomuch as the final "true" price of a drug in a market should include the costs of its inputs, including costs of production and trafficking, along the chain, which, in turn, should reflect any policy interventions en route.[16] That said, the costs of production make up a small share of the retail price (Caulkins and Reuter, 2010). Purity-adjusted figures can also enable comparisons of conditions across markets in the U.S. and elsewhere. Chemical signature analyses can provide insights into the source of a drug, the inputs used to make it, or other elements of sophistication in manufacture. Knowing what precursor chemicals are used or what synthesis method is employed may provide useful information for tailoring law enforcement, regulatory, or diplomatic responses.[17] Other dimensions of supply gleaned from chemical analysis of drug seizures include types and amounts of cutting or bulking agents in seizures, which can have implications for domestic policy especially as purity pertains to harms posed to users.

However, seizure measures overlook important caveats or make general assumptions that may not be apparent. For example, drug seizures or undercover buys are some of the most often cited supply-side indicators. Yet, they are limited for several reasons. First, undercover purchases of drugs in retail markets are non-representative and biased. DEA and other local law enforcement agencies conduct undercover buys unsystematically (i.e., they focus on known retailers or retail markets that have been brought to the attention of law enforcement). Undercover buys may not capture the "true" price of drugs if, for some reason, agents rely on confidential informants who may sell drugs to agents at higher prices than would be sold otherwise.

Seizure events are a function of quantity shipped, smugglers' concealment efforts, and law enforcement's interdiction efforts (Reuter, 1995). Changes in any one of these could result in changes in seizure measures; for example, an increase in seizures along a route could reflect changes to interdiction operations that has increased the seizure rate or an increase in the throughput of drugs. In addition, single one-off seizure events can distort measures.[18] Seizure data reported to the UN show how noisy seizure

[15] The Drug Enforcement Administration regularly monitors retail markets through retail-level purchases of drugs. Those samples are analyzed in labs to then calculate a purity-adjusted price series.

[16] Changes in farmgate prices will be reflected in retail prices. However, given that the primary plant-based inputs to retail drugs make up a small fraction of the retail price, it is hard to measure changes in farmgate price from retail prices. That said, changes in farmgate prices may have to do with the market dynamics of where coca or poppy are grown. For example, recent increases in farmgate prices of coca in Colombia may be due to various factors, one of which could be the fact that no trafficking organization serves as a single buyer (i.e., having monopsony power over producers, allowing it to dictate price), which was likely the case when the FARC controlled much of the territory and illicit activities in regions where coca was cultivated.

[17] For example, signature analyses have been used to understand the geographic origin of certain drugs, but even a chemical signature can be wrong or misleading. For example, the DEA misattributed the source of heroin consumed in the U.S. to Colombia for several years when, in fact, the State Department had reported that opium poppy cultivation in that country had already ended. The misattribution occurred because Mexican drug producers had figured out how to replicate the Colombian synthesis method for making white powder heroin. Nonetheless, knowing the possible location of origin is important in ascertaining the source of supply.

[18] This can be overcome by using moving averages.

data can be; a country may report a large seizure in a single year but very little in years before or after, making it hard to draw clear conclusions about supply volumes or routes. In addition to seizures, another measure sometimes reported by U.S. counternarcotics agencies is that of "detections," which indicates the number of possible drug trafficking events that are detected by surveillance or intelligence irrespective if they result in a seizure (Finklea, 2019).

Table 3 provides an overview of traditional[19], routinely collected supply-side indicators, the source by which they were obtained, where in the supply chain they are collected, what insights they might or are intended to offer for understanding market developments or activity, and their limitations.

*Table 3: Traditional Supply-side Indicators*

| Indicator | Source | Where in supply chain | Insight | Limitations |
|---|---|---|---|---|
| Estimates of area under cultivation (may not apply to synthetic drugs) | Satellite imagery; aerial surveillance; surveys | At point of production | Production potential and location | Measurement, hard to interpret and can be too narrow |
| Drug and lab seizures | Law enforcement data | Near production or along supply route | Flows, locations of supply, scale and sophistication of production and trafficking | Measurement, hard to interpret alone |
| Arrests and prosecutions | Criminal justice data | Anywhere | Scope of supply and actors involved | Measurement, hard to interpret and can be too narrow |
| Chemical seizure analyses (e.g., signature profiling) | Crime labs; DEA | Retail | Source, inputs, and sophistication of supply | Measurement |
| Price and purity | Crime labs; DEA | Retail | Indications of supply potential and retail availability | Measurement |

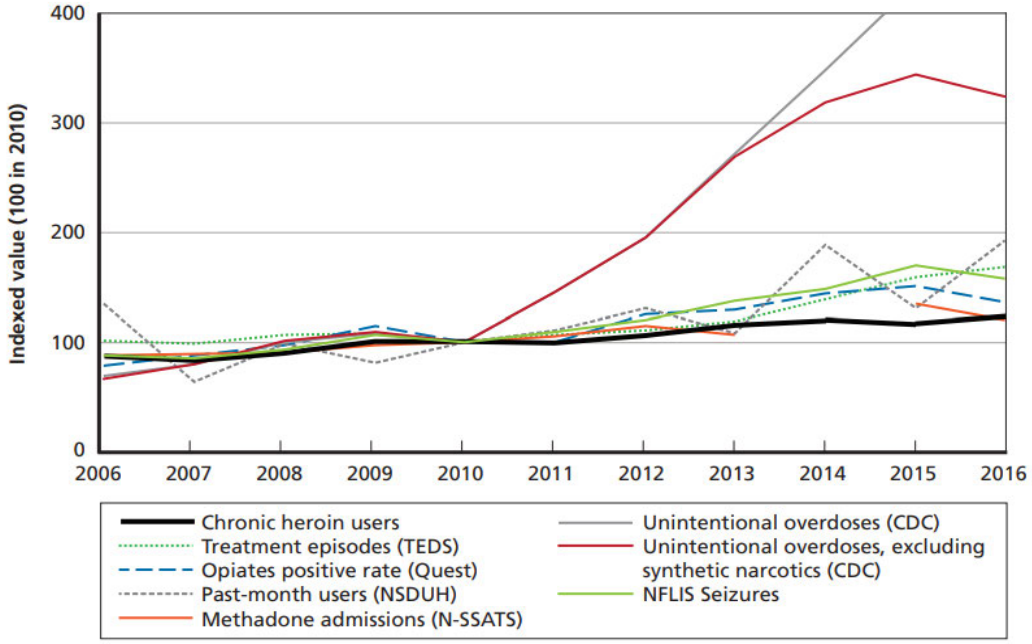
*Inferring from indicators*

As noted in the introduction, drug policy practitioners and scholars use supply-side indicators separately or in combination with demand-side indicators to probe market conditions and improve their understanding of drug problems and trends. Simply, if measures suggesting increasing purity-adjusted prices and declining drug-use measures concur, then one could infer that supply interventions may be

[19] Other non-traditional indicators that are not supply-side measures, such as use of wastewater analyses, are being used by European drug agencies to provide additional insight to changing drug markets (Singleton et al., 2018).

having the intended effect. In Figure 2, reproduced from Midgette et al. (2019), a series of supply- and demand-side indicators have been indexed to 2010 to show relative changes. As shown, increasing supply, indicated by the number of heroin seizures reported in the National Forensic Laboratory Information System (NFLIS), correlates with overdose deaths that do not include synthetic opioids. Comparing indicators in such a manner can provide a degree of triangulation to better interpret indicators and understand market changes.

*Figure 2: Heroin Use and Supply Indicators*




Source: Midgette et al. (2019)

Among the most informative supply-side measures, as noted above, are purity, prices, and taken together, "purity-adjusted prices." Though this indicator, as reported by the Drug Enforcement Administration, is highly-imperfect,[20] can capture the effects of supply-side interventions and generally correlates with other outcome measures, including emergency department episodes, overdose deaths, and positive urinalysis (Caulkins, 2007). In effect, it might serve as a useful indication of the collective effect of supply control (especially if purity-adjusted prices change rapidly), even if cannot be used to parse the effects of specific interventions or programs (e.g., eradication versus interdiction).

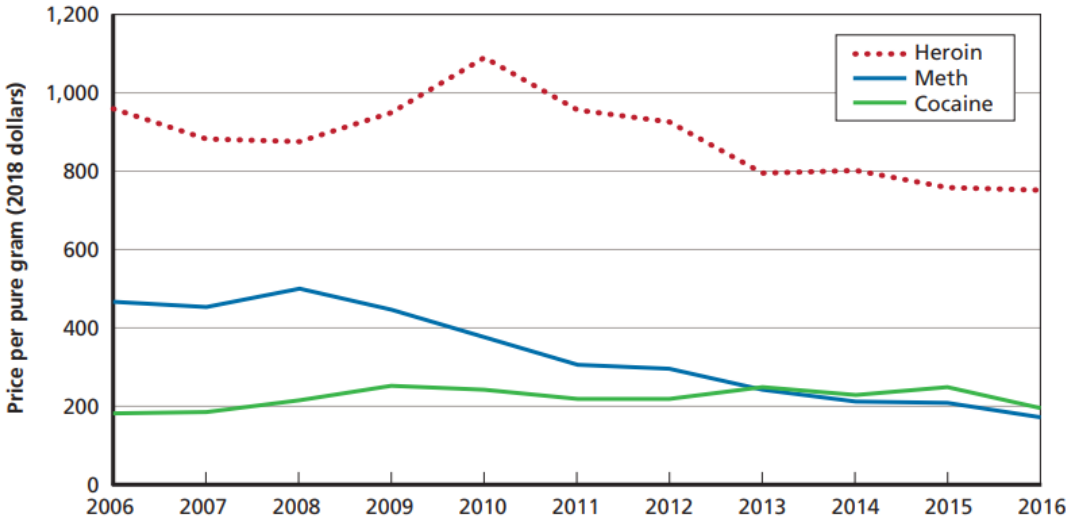
Figure 3 shows a purity-adjusted retail price series for cocaine, heroin, and methamphetamine from 2006 to 2016 calculated by Midgette et al. (2019) using DEA seizure data.[21] As shown, the prices per pure gram

[20] Some have argued it should not be used for analysis (Horowitz, 2001).

[21] Midgette et al.'s (2019) purity-adjusted prices sometimes differ from the DEA's. For example, DEA reported that the price per pure gram equivalent of heroin rose from $725 in 2014 to $930 in 2016 (DEA, 2018), whereas Midgette et al. calculate that the price remained relatively stable over that period at just under $800 a gram. Given that DEA does not report the methods behind its calculations, there is no way to determine the reason for the disparity. Nonetheless, it seems unlikely that the purity-adjusted price of heroin would be rising over this period given that opium poppy production in Mexico rose from 11,000 to 32,000 hectares between 2013 and 2016 (ONDCP, 2018).

equivalent for heroin and methamphetamine have declined over this period, with methamphetamine prices declining by over 50 percent. Some have suggested that methamphetamine price declines are attributable to the increased efficiency and production capacity of Mexican drug trafficking organizations, which have, over the years, improved their synthesis methods and replaced U.S. domestic suppliers who face restrictions on precursor chemicals (DEA, 2019). These price declines correlate with rising drug use indicators, such as overdoses and treatment admissions, suggesting that those that use drugs are price sensitive.

*Figure 3: Price per Pure Gram of Drugs*




Source: Midgette et al. (2019)

Purity-adjusted price can also be triangulated with other measures (such as overdose deaths, or estimated production potential for drugs) to aid their interpretation and offer a better-informed understanding of markets. For example, looking only at data on cocaine overdoses in the U.S. and coca cultivation in Colombia, without reference to purity-adjusted prices, one might draw inappropriate inferences. Deaths involving cocaine in the U.S. have risen from 7,448 to 10,375 between 2006 and 2016 (NCHS, 2019), and coca cultivation in Colombia, the principal source of cocaine consumed in the US, has risen from 80,000 to 140,000 hectares (UNODC, 2018), leading some to suggest that the increased coca cultivation in Colombia is causing the increase in deaths involving cocaine

However, a more nuanced examination suggests a different explanation. Keeping in mind that the purity-adjusted price of cocaine has remained stable over this period at around $200 a gram, it is hard to argue that greater availability is resulting in all these overdoses. While true that greater availability may result in rising overdoses, not all these deaths are likely due to greater cocaine supply. Analysis of individual-level overdose death data shows that rising cocaine overdoses are largely a result of exposure to potent synthetic opioids, like fentanyl. By 2017, half of cocaine-involved overdoses also mentioned synthetic opioids (Pardo et al., 2019). In fact, the rate of cocaine overdose deaths absent potent synthetic opioids has remained relatively flat over this time period. Therefore, one might look to other explanations for rising coca cultivation in Colombia. A dramatic shift in policy in Colombia, away from aerial eradication methods, coupled with emerging markets in other parts of the world, like Asia and South America, and

rising demand in Europe might be associated with rising coca production in the Andes. Increases in cocaine seizures, including large, multi-ton seizures, in other parts of the world support this other explanation (EMCDDA, 2019).

*Caution on supply-side measures*

For obvious reasons, supply-side indicators provide a limited understanding of the supply of illegal drugs (Degenhardt et al., 2003; Royuela et al., 2009; Singleton et al., 2018). As discussed earlier, many of these indicators suffer from measurement and interpretation limitations. Data collected by law enforcement agencies or estimated by countries are often not reported in a uniform or systematic way that allows for cross-country comparison (Singleton et al., 2018; Kilmer et al., 2015). Operational priorities, legal definitions, and joint law enforcement operations may result in mismeasurement, such as double counting a single seizure. Furthermore, policymakers and analysts might also have trouble independently interpreting drug supply indicators like seizures, area under cultivation, and arrests. Therefore caution is warranted whenever examining them. Being explicit as to the limitations of these data can help make for a more informed analysis.

Having data on seizure events (e.g., number, weight, and purity) is better than having no measures at all, but ideally one would want to be able to calculate the flow or the share of drugs that enter the country by different routes, ports of entry, or source country. This measure would greatly aid drug supply disruption efforts. For example, if agencies knew that half of U.S.-bound cocaine entered via a particular route, then it could redirect efforts to that route. However, it is difficult to calculate these measures without knowing the total volume produced or trafficked (i.e., the denominator).

Taking together these limitations, it is important to triangulate supply-side indicators with other measures that can better inform drug policy analysis and implementation. Seizures should be paired with data on production and purity-adjusted prices in retail markets. Combining multiple indicators provides a more complete picture, validating the measures against each other. This can be further enhanced by combining indicators from the demand side, offering a more nuanced understanding of market activity and thus help to overcome some of the limitations faced by these indicators.

## 4. Supply indicators and future drug challenges

Most drug policy indicators, both supply- and demand-side, were developed largely to inform markets of plant-based drugs, like cannabis, heroin, and cocaine that have typically been produced overseas and smuggled into the United States. Amphetamine-type substances are some of the more prevalent synthetic drugs that have entered the contemporary drug policy landscape at different times, but still these synthetic drugs have traditionally been limited to a handful of chemicals, like methamphetamine or ecstasy (MDMA). The drug challenges of the future are likely to be increasingly related to substances of synthetic origin that are sometimes supplied in new ways. Synthetic alternatives present distinct challenges to supply-side efforts over plant-based drugs. The ability with which many can be produced, smuggled, and designed to circumvent drug laws or routine chemical/toxicological analysis limits the utility of several available indicators. Furthermore, a small minority of these new drugs may serve as attractive alternatives for those that use drugs (Reuter and Pardo, 2017).

For producers, synthetic drugs may increasingly displace plant-based drugs for several reasons. Climate change may put strains on cultivation of illegal crops, which can suffer from too little or too much water

and blight, force relocation, or lead to changes in preferred varieties, if available. Further, the time and space required to cultivate crops—and their relative immobility—make them susceptible to eradication. In contrast, synthetic drugs can be manufactured wherever there is access to precursor chemicals and the technical expertise for synthesis, without geographic specificity. It might take a season or more to establish an illegal crop in a new location, whereas a clandestine lab capable of producing large amounts of a drug can be set up quickly and concealed almost anywhere, including residential settings and urban environments. The time taken to manufacture synthetic drugs is much shorter, sometimes a matter of days compared with months between harvests.

For traffickers, synthetic alternatives, like fentanyl, may be substantially more potent than traditional drugs, reducing trafficking costs per dose as a minute amount of the drug could be enough to supply a modest user base.[22] Because of this, not only is it easier to conceal drugs in traditional drug supply routes, such as over the Southwest border in vehicles, but also through legitimate commercial channels like the package or parcel system. Taken together, these elements help make some synthetic drugs attractive cost-cutting alternatives for drug trafficking organizations and drug dealers.

Lastly, the ability with which wholly new chemicals can be designed to circumvent existing drug control is one factor that favors synthetics over plant-based drugs (Reuter and Pardo, 2017). Adding or removing molecules to existing drug compounds allows producers and distributors to avoid prosecution. The growing number of new psychoactive substances changes the nature of the problem as drug control agencies must continue to stay informed about the ever changing chemical nature of psychoactives. This is a challenge as law enforcement agencies sometimes do not have the resources to detect new drugs in seizures or routine undercover buys, limiting the ability of available supply-side indicators to assess such changes with speed and accuracy.

Much like the introduction of cell phones, which allowed buyers to coordinate with sellers without the need for open-air drug markets, the internet and globalized trading system have helped to revolutionize drug supply. Buyers and sellers can connect around the world without ever meeting. Many new drugs are manufactured in China and openly advertised on the internet, making it easy for anyone to have them shipped to their house through the mail or private courier systems (Pardo et al., 2019). This supply route differs from traditional maritime or terrestrial trafficking routes commonly employed by transnational crime groups. In many ways, the direct-order nature of buying synthetic drugs online atomizes drug distribution. Anyone, including those without a criminal record or history of drug trafficking, could use the internet to import ten grams of a highly potent drug, like fentanyl, making him a small-time wholesaler that never has to deal with transnational criminals.

A move toward synthetic drugs, especially new drugs produced in faraway labs, is likely to stretch policy responses as well as the value of existing indicators, which already suffer limitations of data, interpretability, and narrow scope. One way of doing so might be to compare supply-side measures alongside demand estimates to provide a more complete picture of current and emerging market trends.

[22] Fentanyl is about 20-30 times more potent than heroin per morphine equivalent dose (Vardanyan and Hruby, 2014). DEA has noted that a dose of fentanyl sold in illegal markets may be as little as 1 milligram (DEA, 2018). Therefore, a 10-gram packet of pure fentanyl, which could easily be concealed in or on the body, would be enough for 10,000 doses at the retail level.

On the demand side, the National Survey on Drug Use and Health (NSDUH) does not ask in great detail about use of emerging substances, which might provide details for drawing out or developing related indicators. Even if it did, it is unlikely that individuals purchasing unregulated products in illegal markets know precisely what drug they consumed. Confirming use through urinalysis, especially for chronic users, would provide information to this end. The federal government used to do this through the Arrestee Drug Abuse Monitoring (ADAM) Program (Kilmer and Caulkins, 2014), but, in 2013—at the start of the most recent fentanyl outbreak—it cut the program and gave up essential insight to the size, scope, and behavior of chronic drug users (Midgette et al. 2019). Perhaps of still greater utility would be to monitor drug markets via wastewater analyses. Countries in Europe have been doing this for decades and can collect, in near real-time, data on what drugs are used and in what amounts in a local market (Castiglioni et al., 2014). These market surveillance methods may serve as an ideal early warning measures as they can screen for multiple drug metabolites without having to rely on the memory of survey respondents. These demand-side indicators can help inform policymakers as to market-level changes regarding the supply and use of new drugs.

Likewise, existing supply-side indicators are confounded by the emergence of new synthetic drugs. Measurements of production cannot be informed by satellite imagery and the lack of regulatory oversight in chemical and pharmaceutical industries in countries like China and India make it difficult to determine the scale of illegal production. In some cases, large semi-legitimate laboratories may be able of producing various types of synthetic substances (O'Connor, 2017), which can be directed to illegal markets.

In terms of interdiction, indicators that use seizure data will present further challenges in a more-dynamic market. First, some synthetically-based, highly-concentrated substances can be sent easily by post or in legitimate commerce. The volume of post sent from China to the U.S. has increased from 27 to 500 million packages between 2012 and 2017 (Pardo et al., 2019). This increased volume has impeded and overwhelmed screening efforts. Further, the supply of new chemicals may circumvent many existing field detection and testing kits, which are designed to detect known substances. That said, analysis of drug seizures at ports of entry and in retail markets can still help inform how supply is evolving in terms of concealment methods and chemicals produced.

The emergence of new drugs may also amplify existing challenges in state and local reporting. As it is, states may not report data uniformly to the National Forensic Laboratory Information System and often do not report purity, the number of drug-drug mixtures (e.g., fentanyl-adulterated heroin), or price. These more reliable, accurate, and precise measures are needed to help understand new sources of drugs and how markets are changing. Without having insights into these other dimensions of the supply of drugs, policymakers and practitioners are limited in understanding how policy may affect market activity. For example, available seizure data from the DEA has so far not shown a substantial price decline for heroin or other drugs that are thought to contain fentanyl (Pardo et al., 2019). This is surprising considering the low cost of fentanyl per morphine equivalent dose and its increased availability via the internet. Pardo and colleagues note that, "None of the standard methods of tracking drug prices is designed to handle a situation in which a primary drug (in this case, heroin) routinely appears in a mixture with another drug that has similar effects."

In short, the long-standing approach of controlling drug supply has led to the development of many indicator metrics that relied on production potential, quantity seized, and other measures relating to plant-based drugs. The limits of these indicators, explored in the previous section, are compounded by

the emergence of many new chemicals that are smuggled via novel routes (such as legitimate commerce or post) from new sources overseas.

Available indicators may not measure the drug supply accurately or reliably—particularly for newer synthetic drugs, which appear to be a growing problem. Furthermore, contemporary indicators do not consider harms of supply-side interventions. Existing indicators can help inform market evolutions, but policymakers might want to consider what these indicators mean beyond taking them at face value. Therefore, an alternative approach to considering broader harms from supply may help to guide policymakers' understanding of the problem and enhance policy design.

## 5. Incorporating harms into measures

Historically, U.S. drug policy has elevated the goal of reducing drug consumption. Hence, traditional indicators used by policymakers, such as treatment admissions and prevalence rates, are intended to measure drug use. Drug use can be harmful to both the user and those around them. Traditional "harm reduction" policies accept that reducing consumption may take time or may be infeasible for some and therefore seek to reduce the types of harms generated by drug use. Increasing access to sterile injection equipment, like needles and syringes, has shown to reduce transmission of blood-borne disease while not outright discouraging injection drug use (Jones et al., 2010). In contrast, traditional supply reduction efforts have generally overlooked a pragmatic vision that there may exist variation in harm generated by drug trafficking. Instead, it continues to favor reducing supply by focusing on kilograms seized and hectares eradicated irrespective of other factors that may augment or mitigate broader harms.

In this vein, not much consideration has been given to how existing indicators relate to harms beyond their association with use and its consequences. In essence, a kilogram seized is treated equally irrespective of where in the supply chain it was interdicted or the modus operandi of the trafficking organization from which it originated. Yet, some drug trafficking methods, routes, or organizations may be more "harmful" in the sense that they are more corrupting, prone to threatening or employing violence, or environmentally or socially destructive (Caulkins and Reuter, 2009).[23]

If supply-side efforts aimed at traditional challenges are, at best, limited to temporary disruptions, then existing indicators may need to incorporate other dimensions of the phenomenon that help to capture externalities and consequences. Taking these other factors into an accounting of drug supply may help improve policy. Nonetheless, a holistic focus of harms would also account for use-related harms (e.g., overdose, addiction, etc.), which fall outside the scope of this white paper but remain important.

This section summarizes an approach to systematically and empirically incorporating harm in supply-oriented drug policy that could inform the development or improvement of supply-side indicators. The approach is developed in a set of articles by Greenfield and Paoli (e.g., Greenfield and Paoli, 2012; Paoli, Greenfield and Zoutendijk, 2013; Greenfield and Paoli, 2013; Paoli et al., 2015; Greenfield et al. 2016), though others have called for measuring harms or incorporating harms into drug policy (e.g., MacCoun 1998; MacCoun and Reuter, 2001; Caulkins and Reuter, 1997). In his seminal work, MacCoun (1998) specifies the total harm of drug use as a function of the average harm per use among both users and non-users and total use, which is, in turn, a function of the number of users, the quantity each user consumes,

[23] As discussed in this Section, the extent with which harms can be linked to trafficking requires an analysis of other measures, like homicides or incidences of corruption (as measured by impunity rates or incidence of bribery).

and the shape of consumption and distribution. MacCoun and Reuter (2001) then concretize this formulation in a simple equation that specifies total harm as the product of drug-use prevalence (number of users), intensity of use (average number of doses per user), and the average harm per dose.[24]

Approaching supply-oriented drug policy with a harm-based lens, let alone incorporating harms in alternative supply-side indicators, has not yet been explored seriously by most of the world's drug control agencies (for expressions of interest and nascent attempts, see, e.g., UNODC, 2005; UNODC, 2009, UK Drug Policy Commission, 2009). Technical and conceptual challenges, as noted below, have likely hindered progress, but Greenfield and Paoli have developed and implemented a framework that can further it. Having a set of indicators—or better understanding—of harms as they relate to production and trafficking in different locales and along different routes would greatly inform policy design and implementation.

This section does not provide a prescriptive path to what a set of harms-based supply-side indicators should be. Rather, it directs policymakers and practitioners to a relatively new approach to rigorously assessing the harms of illegal activities, including drug production and trafficking. Readers are encouraged to consider the original articles, as this section can only briefly synthesize the richer discussion of the theory and application of harm assessment, including lessons learned. A true accounting exercise of harms would require a serious rethinking and reorientation of how U.S. drug policy is operationalized and is outside the scope of this document. Nonetheless, discussed below is an approximate approach of how one could undergo such an effort.

As stated in the introduction of this white paper, most policymakers, practitioners, and scholars would agree that illegal production, trafficking, and use of drugs can cause harm, even if they disagree on the specifics. Therefore, reducing any one of these activities should, in theory, reduce total harm. Yet, it is important to distinguish from traditional goals aimed at reducing the supply or use of drugs and the harms stemming from production, trafficking, or consumption. Put another way, the operational goal of supply-side policies and interventions is to raise prices and reduce availability of drugs while deterring individuals from engaging in drug use or supply. These proximate goals, in turn, indirectly shape harm outcomes. Though drug-control agencies might believe, at least implicitly, that supply-side policies reduce harms, they do not attempt to measure such changes directly and can also overlook the impacts that policies, themselves, might have—positive or negative—on the broader universe of affected interests of those who are "touched" by illegal operations and the policies around them. Incorporating a more holistic approach to supply-side policies may help reduce some policy "blind spots" when it comes to the unintended (and sometimes harm enhancing) consequences of supply-side interventions.[25]

Not surprisingly, attempting to capture the fullness of harm is more complicated than trying to measure hectares of coca or kilograms of cocaine and presents its own challenges, but neither the complications nor the challenges are insurmountable. More specifically, Greenfield and Paoli (2013) enumerate the technical and conceptual challenges of harm assessment and then demonstrate how their framework addresses them. The former, i.e., technical challenges, largely involves matters of standardization,

[24] Although cleanly parsing factors that contribute to harm, this equation—and the underlying harm per dose formulation—is better suited to tracking health-related outcomes than supply-side activities.

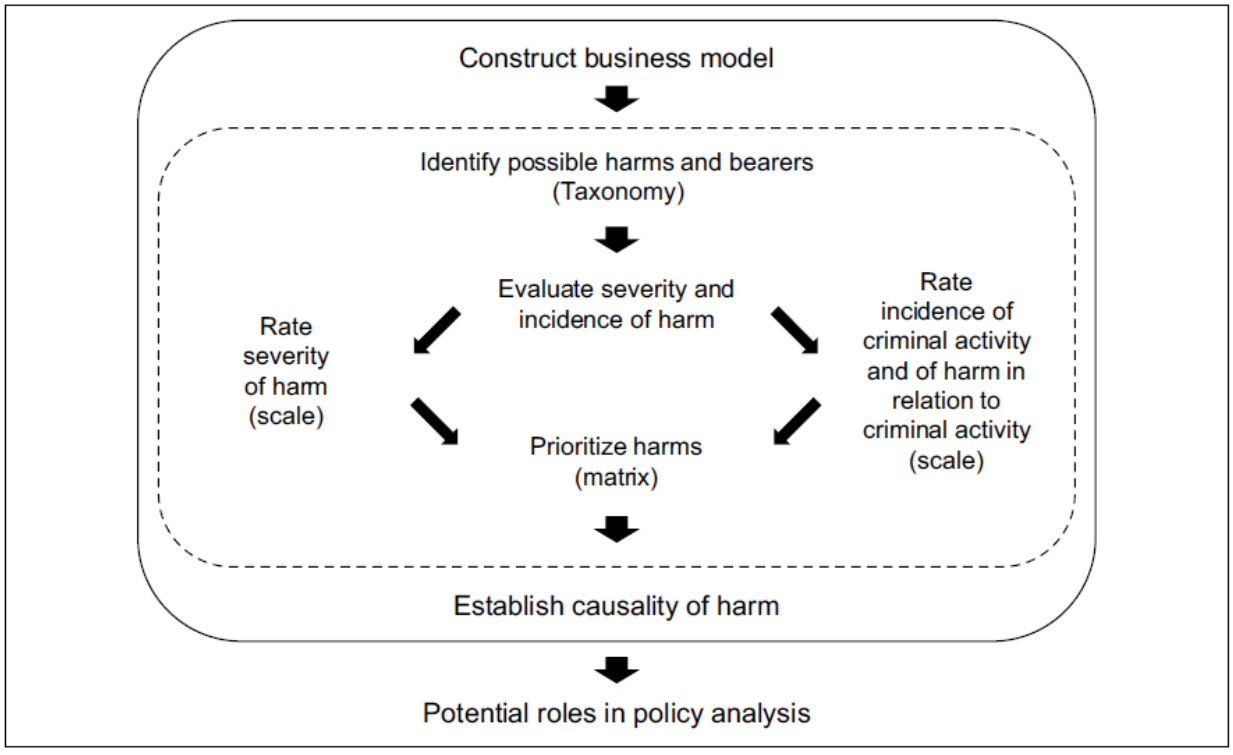
[25] This white paper does not provide an exhaustive list of unintended consequences of supply-side policies, but some have noted several, such as the displacement effect of eradication or trafficking efforts that exacerbate deforestation (McSweeney et al., 2014; Davalos et al., 2016).

measurement, and commensurability, the latter, i.e., conceptual challenges, largely involves matters of normativity, and some of each pertain equally to current supply-side indicators.

Among the challenges, those of "normativity" stand out as most enduring insomuch as they are subjective. Policymakers must eventually face decisions about whether to label particular consequences as "harms" or give standing to those who might bear them. Greenfield and Paoli (2012) provide the simple but instructive example of asking if self-inflicted harms, like those of drug use, should be considered harms at all, and if so, for whom? That said, the challenges of normativity are hardly unique to harm assessment. As might be said of most or all policy matters, science can provide evidence for decision making but it, alone, cannot decide whose interests to protect, from what consequences, or at what cost.

Greenfield and Paoli (2013), drawing from earlier work in the drug policy, criminology, and national security fields, including that of MacCoun (1998) and MacCoun and Reuter (2001), put forward a harm assessment framework to capture 1) the bearers of harms, 2) the severity and incidence of harms, and 3) the causality of harms. In a companion study, Paoli, Greenfield, and Zoutendijk (2013) apply the framework to cocaine trafficking in Belgium, using data gathered from criminal justice sources and from interviews with market participants in the early 2000s. Figure 4, from their work, depicts the flow of the harm assessment process.

*Figure 4: Harms assessment process*




Source: Paoli, Greenfield, and Zoutendijk (2013)

The first step in the process is to construct a "business model" of supply of drugs which serves, in part, as a list of activities, like production, trafficking, and any "accompanying" or "enabled" activities (such as money laundering or drug retail distribution), and the policy environment. Depending on what perspective

is taken, one could use this framework to understand harms in the source country from drug production and trafficking; or in the destination country due to trafficking and distribution.

The next step is to identify the "ultimate or near-ultimate" bearers of harm, consisting of individuals, the private sector (e.g., civil society and businesses), the government or state agencies, and the physical and social environment (Greenfield and Paoli, 2013). Focusing on these four end "classes" of bearers should capture the broader systematic constructs of the "community" or "economy," helping to simplify the analysis. The authors note that harms can occur through various means, like violence or corruption, but those means are not necessarily harms in and of themselves. The harms from violence, for example, can be physical, psychological, material, or reputational in nature. Thus, the authors describe the types of harms across four categories, which vary slightly in their interpretation for each class of bearer:

1) *functional integrity*, which includes physical or psychological harms for individuals (like death or anxiety), but operational integrity to the private sector, state agencies, or the environment;
2) *material interest*, which can include loss of or damage to economic resources or loss of revenues or taxes to businesses or the government;
3) *reputational*, which stem from how others see the individual or a private or public entity that incurs damages from the activity or accompanying violence, corruption, etc.; and
4) *privacy*, which includes violations to one's personal or corporate identity, such as the unauthorized access of personal information or sensitive corporate or public data.

In their framework, individuals and entities can experience harms of all types, sometimes from the same event, but the environment can experience damages only to its functional integrity (physical, operational, and aesthetic) caused, e.g., by pollution, deforestation, or occupancy from illegal activities. Though this dimension of harm is relevant to the environment, it also plays into the other bearers inasmuch as they experience social degradation and loss of utility from the environment. For example, farmers may not be able to cultivate legitimate crops in fields under the control of drug traffickers; tour companies may not operate in zones where smugglers move drugs; or families may not be able to take their children to the park where drug dealing occurs. But one can also argue that an environment could experience reputational harm, which then contributes to its further decline. For example, reputational harm to an environment may reduce community investment in its protection, upkeep and renovation, which could further contribute to harms to its physical integrity (Kelling and Cole, 1997).

The next step in their assessment process is to prioritize harms by determining their incidence and severity with ordinal scales and benchmarks. Their approach is similar to multiplying intensity of use and harm per dose as per MacCoun and Reuter (2001), but it draws most directly from a common approach to risk assessment in the national security community (e.g., Greenfield and Camm 2005) and a benchmarking method proposed initially by von Hirsch and Jareborg (1991). The severity of harms ranges from the most severe (catastrophic, which can include death of an individual or the cessation of operations for a business) to the least severe (marginal, which includes momentary discomfort or pain for an individual and perhaps small losses to a business). To compare harms of different types, the authors have adopted a common benchmark for each class of bearer, consisting of the standard of living for individuals, mission

capability for private and public entities, and sustainability for the environment. The incidence of harms can range from "always" to "rare."[26] The authors describe the scales as "bandwidths," not point estimates.

Table 4 shows the juxtaposition of severity and incidence in a five by five matrix that Greenfield and Paoli have employed across applications, including to cocaine trafficking. Conceptually this allows the harms to be assessed across the two dimensions such that a catastrophic but rare event may be a lower priority (medium to high) than a serious but persistent event (high to medium).

*Table 4: Prioritizing matrix of severity and incidence of harms*

| | **Incidence** | | | | |
|---|---|---|---|---|---|
| **Severity** | Always | Persistent | Occasionally | Seldom | Rare |
| Catastrophic | H | H | H | H/M | M/H |
| Grave | H | H | H/M | M/H | M |
| Serious | H | H/M | M/H | M | L |
| Moderate | H/M | M/H | M | L | L |
| Marginal | H/M | M | L | L | L |

Note: H = highest priority; M = medium priority; L = Lowest priority
Source: Paoli, Greenfield, and Zoutendijk (2013)

Greenfield and Paoli note that rating and ranking harms does not require quantification but gladly incorporate whatever quantitative data are available. By allowing for a mix of qualitative and quantitative evidence, the framework can be used by experts to consider harms that are not amenable to quantification and to gauge harms even if quantitative data are limited. This approach does not prevent comparing different types of harms for a class of bearers, e.g., among individuals or entities, because the authors employ common benchmarks for each class, but it does prevent comparing harms across bearers, such as medium priorities for individuals or state agencies.

The last step is to establish the causality of harms. This requires an accounting of the harms in relation (in both time and space) to the activity and an honest assessment of the harms of an activity relative to the broader policy and legal environment. Some harms are a direct result of these systematic factors or the environment in which they occur. For example, the violence or corruption generated by cocaine trafficking and the harms they entail result from prohibition, counter narcotics policies, and weak governance, not from supply per se. The method here is to consider the degree of harms given the counterfactual, e.g., what might have happened had cocaine not been prohibited? Paoli, Greenfield, and Zoutendijk (2013) note that this exercise is to determine which harms are innate to the activity or related to some other intermediary factor, such as a law, regulation, or mode of enforcement.[27]

Paoli, Greenfield, and Zoutendijk (2013) then apply the framework to the case of cocaine trafficking in Belgium. They conducted interviews with market participants and collected information from prosecutorial cases and other criminal justice sources, including some standard indicators such as the

[26] In more recent work, Greenfield and Paoli have re-specified incidence as "continuously," "persistently," "occasionally," "seldom," or "rarely" (see e.g., Greenfield, Paoli, and Zoutendijk, 2016).

[27] Undertaking this exercise allows the policymaker to tease out other elements from harm. If, in fact, it is not the drug that causes the harm but other environmental and legal factors, then to what extent can the policymaker change those other factors such that overall harm is reduced? Such a pragmatic and nuanced approach may help generate new thinking. For example, drug interdiction in one environment may be less harmful than another.

number and weights of inbound seizures, by transport, to evaluate the various degrees and measures of harms from drug supply. This mixed-methods approach is quite unique in that it examines different dimensions of harms across different bearers. Readers are encouraged to refer to it in full as it is briefly summarized here for expositional purposes.

First, Paoli, Greenfield and Zoutendijk (2013) model the traffickers' modus operandi. They define trafficking in terms of import, export, and wholesale distribution, which they refer to as "primary" trafficking activities. They also assess the consequences of violence, corruption, and money laundering as "accompanying" activities and dealing as an "enabled" activity, but they do not assess the consequences of drug use.[28] They further break down mode of import by sea, land, or air. Next, the authors identify plausible harms based on what they have come to understand about the modus operandi of cocaine traffickers in Belgium at that time. The authors detail the functional, material, reputational, and privacy harms to various bearers at point of import, wholesale and distribution, and retail. For example, the authors note that physical or psychological harms may be experienced by individuals, such as traffickers that body-pack cocaine in internal cavities, or state agents who might be victimized by traffickers. Government entities and businesses may experience operational, reputational and privacy harms should state agents or employees of private transport companies become corrupted.

Next, the authors evaluate the severity and incidence of harms for the bearers that they identify in their business model. Here, they use data from prosecutions and seizures, as well as interviews with market participants, to inform the ratings. This allows them to rate the incidence of seizures across points of entry (e.g., number of seizures by land, air or sea over a period of time) as well as the scale with which seizures occur (for example, larger seizures occurred by sea than air) and the incidence of harms, themselves. Here they assess functional and other harms to traffickers, dealers, and other individuals, noting that ruptured cocaine packets in body-packers could result in a catastrophic harm (i.e., death or overdose), but that such event was rare per law enforcement and hospital data, suggesting such a harm was of medium to high priority. They also consider harms to the government from corruption, finding that such harms generate marginal harm to governmental integrity and reputation but that they remained rare, resulting in low priority. Harms to private-sector entities from corruption occurred occasionally, but they were still a low priority. They then considered the general reputational harm to the Belgian government from lawbreaking to be marginal but to occur persistently from cocaine trafficking, resulting in a medium priority.

The final step is to assess causality of the harms. The authors limit the total set of harms to those of import, export, wholesale distribution, and retail. This is analytically helpful as harms of use may be mitigated or augmented by other factors, including the immediate environment in which drug use occurs as well as the psychological state of mind and physical health of the person taking the drugs. However, nothing about the framework inherently limits its application to supply. In future work, one might still incorporate information about the harms of use, to form a more-comprehensive picture. Nevertheless, Greenfield, Paoli and Zoutendijk (2013) note that the harms from import, export, etc. arise from the legal status (i.e., prohibition) of the drug. They argue that there would be little or no body-packing and likely less corruption and violence if cocaine were legal and its supply were regulated, not outlawed.

[28] Though it would be comprehensive to evaluate harms from use, these are often distal to supply. Paoli, Greenfield and Zoutendijk (2013) note that they keep their analysis relegated to harms related to supply and supply-oriented policies.

This harm assessment framework is conceptually rigorous and informed by data, allowing a policymaker to step back and examine the broader scope of the problem. As Greenfield, Paoli, and Zoutendijk (2013) show, a breakdown of elements within or at a certain point in the supply chain of drugs, in this case import, export, wholesale distribution, and retail of cocaine to, from, and in Belgium, can offer insights into the prioritization of harms as well as their causal accounting, perhaps making for better policy responses.

Applying this framework to the Americas, one could assess harms along the supply chain as cocaine is produced in South America and transshipped to the United States through Central America.[29] Bearers of harms might include those to the individuals whose physical or psychological integrity may be threatened by coming into contact with smugglers along the coast of a country like Honduras, state agents that are liable to be corrupted or victimized by traffickers, the individual physical and psychological harms to traffickers who risk their safety to engage in drug trafficking, the reputation of state agencies, and the environment.

Taken together, assessments of these harms can be combined to offer a broad understanding of who bears how much harm and why. As for causality, one might imagine that cocaine trafficking in Central America and some of its attendant harms would not be occurring if not for its illegality or if traffickers perceived trafficking by maritime routes to be less risky or costly. Accounting for the broader legal and regulatory environment may offer additional insights to policymakers who want to think about reducing harm from cocaine trafficking. That said, one might wish to use the framework to draw in, assess, and compare harms further down- or up-stream.

To illustrate how incorporating a harms assessment might work from a practical standpoint, one might consider the example of drug production and trafficking. Table 5 explores how existing supply-side indicators fit into the above framework and what additional measures may improve the understanding of harms. We have noted the bearer of the harm in parenthesis in the Harm column. Such a harms-based accounting approach may help improve policy design and implementation.

To examine this further, one could compare variations in harms within particular area of supply. As an illustration, if law enforcement established the modus operandi of different trafficking groups, then it could leverage intelligence to enhance targeting of more “harmful” organizations (in the sense that their supply is immediately harmful in the environments where they operate), such as those that more frequently employ violence (see Kleiman, 2012 for a detailed assessment of how to employ focused deterrence to violent drug trafficking groups). In essence, this is a pragmatic strategy. Law enforcement focus is not on groups that move the most product, but groups that are most violent or most egregious in terms of their social harms.

Use of this accounting framework could be extended more broadly. Drug trafficking can occur by sea (e.g., go-fast boats, semisubmersibles, and commercial shipments that reach the United States) or by land (e.g., overland routes that traverse Central America and Mexico and are smuggled over the Southwest border). Overland trafficking routes may be more harmful as traffickers are more likely to come into contact with

[29] This requires a consideration as to the relative harms of trafficking cocaine from Colombia to the United States. Currently, seizure indicators do not make any distinction between relative harms of where seizures occur. A kilogram of cocaine seized at sea is treated equally as a kilogram seized overland in Central America. There are fewer potential bearers of harms of drugs trafficked on open water versus along terrestrial routes that make their way through towns and cities.

state actors, private citizens, and other observers. They may apply violence or corruption to ensure that drugs arrive to the United States. In contrast, sea routes may be less harmful simply because there are fewer state and private actors. The magnitude of harms from violence or corruption may be similar between the two routes (e.g., bribing or threatening an official at a sea port or a mayor of a town are harmful), but the incidence in which such opportunities occur are fewer for maritime routes.

*Table 5: Matching current indicators with measures of harms*

| Supply stage | Current indicator | Harm (bearer) | Measures of harms |
|---|---|---|---|
| Production | Area under cultivation | Functional integrity, material interest, reputational (environment) | Area deforested, amount of pollutants/chemicals dumped into waterways |
| | | Functional integrity (individual) | Incidence of violence, forced displacement |
| Trafficking | Drug Seizures | Functional integrity (individual) | Incidence of violence, homicides, shootings |
| | | Functional integrity, material interest, reputational (state agencies, private sector) | Polls of public trust in authorities, cases of bribery or corruption |
| | | Functional integrity (environment) | Area deforested, public spaces occupied |

Identifying the possible incidence of harm (e.g., number of homicides, number of corrupted officials, number of clandestine airstrips built, etc.) and then determining their frequency—rare to always—a policymaker can have a better appreciation of the overall amount of harm that may be generated by the trafficking of cocaine from Colombia to the United States across a particular route or when comparing the modus operandi of different trafficking groups.

The harm assessment framework discussed here, in brief, is just one possible method of accounting for harms from supply of drugs and future frameworks might extend it, refine it, or replace it, but it offers an empirical framework that has been applied to cocaine trafficking in Belgium and in other disparate environments (Greenfield et al., 2016). With it or something like it, greater efforts could be made to move beyond the unidimensional supply-side indicators that drug control agencies and policymakers rely on. This requires a shift in prioritizing quantifiable metrics like kilograms seized or individuals prosecuted. That is not to say that traditional indicators are useless, but that they can better serve a wider goal by taking a more holistic approach to evaluate the functions they serve, i.e., to reduce harms associated with drug supply.

It is helpful to examine the broader dynamics of the problem; policy, especially drug policy, can sometimes fall on traditional measures without considering how they inform an understanding of a problem. For example, one might wonder to what extent a kilogram seized varies in terms of its associated harms, depending on where it is seized. Put another way, can policy responses better shape the amount of "harms" experienced by different individuals—or institutions—at different points along the supply chain? Is a kilogram of cocaine seized at the U.S. border less "harmful" than a kilogram seized at a lab in

Colombia? Do harms vary when comparing different business models and modus operandi across trafficking groups?

## 6. Concluding remarks and considerations going forward

The limits of supply-side interventions are documented in the small number of key disruption cases. Though interventions aimed at controlling production or dismantling trafficking organizations were able to disrupt supply for a period of time, in most instances, markets adapted in the long term. Demand-side indicators, like overdoses or treatment admissions, were often used to help determine the extent with which supply disruptions impacted use-related outcomes. The small empirical literature on supply-side interventions suggests limited evidence for source-country control efforts. There is near universal agreement in this small body of research that eradication is less cost-effective than interdiction for cocaine.

Nonetheless, output indicators of supply interventions (e.g., kilograms seized, hectares eradicated, etc.) continue to take precedence. In terms of these indicators, available measures are limited in three ways. They sometimes fail to accurately measure supply (e.g., crop estimates may be inaccurate), they are sometimes difficult to interpret on their own (e.g., changes in seizure amounts do not distinguish between changes in enforcement versus changes in flows), and they can be too narrow in scope in that they often overlook equally important matters, like harm.

It is helpful to keep in mind how certain measures inform an understanding of a phenomenon as well as the limits of those measures. That is not to say that supply-side indicators are meaningless any more than saying unemployment numbers are meaningless to inform an understanding of the economy. But a handful of unidimensional measures may provide an incomplete and potentially misleading picture. Supply-side measures can inform policy inasmuch as they can help us understand market activity, the location and patterns of trafficking and production, and the sophistication and degree of illegal actors involved, but they cannot tell us all we need to know about today's markets or their consequences and might be even less useful to understand future drug challenges, such as new synthetic drugs that can be produced anywhere and easily concealed. Changing chemicals may limit detection capabilities and confound law enforcement, leading to considerable measurement error.

But more to the point, there is a risk that supply-side indicators become the goals of policy implementation rather than informing it. Operational budgets and strategies may rely on changes in seizures, without any broader effort to consider what they mean relative to other measures of production, trafficking, or use. Additionally, available indicators fail to account for the harms generated by responses to and stemming from the illegal production or trafficking of drugs. Indicators like quantity seized or hectares eradicated have never been particularly good at incorporating the variation in harms across different points in the supply chain or bearers of those harms. Further, disruptions in stemming the supply of drugs may result in greater harms elsewhere. Squelching the flow of cocaine through maritime routes in the Caribbean pushed traffickers to terrestrial routes through Mexico and Central America, which is arguably more harmful for participants and observers as traffickers threaten violence or employ corruption to facilitate drug trafficking. Eradicating illegal crops in one area may push farmers into new territories, contributing to further environmental harm from deforestation. The goal of drug control agencies, as operationalized by many of these indicators, is to reduce the supply of drugs as measured by weight of seizures or crops eradicated. A more nuanced, yet challenging, approach would be to incorporate harms into drug supply reduction efforts.

Though conceptually and technically challenging, an accounting of harms could provide greater insights into how to optimize supply-side responses. For example, if one were able to determine that harms generated by a particular group or trafficking route were more deleterious than those from some alternative, then responses could be optimized to reduce overall harm rather than overall flow. This requires a serious accounting of harms as well as a sober recognition that difficult choices might need to be made about supply-side responses.

This white paper has detailed the various uses and shortcomings of available supply-side indicators. Though many of these measures can help inform developments in markets, they may be limited as drug phenomena change. Should plant-based drugs become less important in the future, available indicators may not fully capture the scope or extent of the problem. Additionally, measures should do more to incorporate harms. Accounting for the harms, such as those related to violence or corruption, across different trafficking groups may help law enforcement target the most flagrant or socially damaging actors, and not merely those that move large quantities of product.

The Commission could both explore a serious re-examination of drug supply indicators such that they are better suited new developments in drug supply and markets and also work to incorporate harms assessments into measures. Some possible measures of harms include incidence of violence (e.g., homicides or shootings), ecological destruction (e.g., deforesting for clandestine runways or dumping of chemicals into rivers from drug production), and corruption (e.g., cases of bribery or public trust of officials).

To that end, there are several considerations for future policy research and design. A harms-based indicator of supply would do more to capture the wider measures that are often overlooked by traditional indicators. This will take time and honest assessment of harms at each point in the supply chain. But more important, agencies charged with enforcing drug control laws would need to incorporate harms into traditional output measures that have long been the focus. This does not mean law enforcement should give up on reducing supply. Rather, the objective may need to move beyond mere production numbers or flow of drugs to something that also accounts for the damages of illegal supply and responses. A recommendation from a political body, such as the Commission, calling for a redesign or reprioritization of traditional supply-side indicators is a helpful start. Along those lines, the Commission should explicitly note the limitations of existing indicators—what they fail to measure, how they are often hard to interpret, and why they are troubled by their lack of consideration of harms.

This white paper illustrates parts of the problems with existing supply-side indicators. One consideration for the Commission is to draw from the existing harms literature to help guide the development of alternative indicators that incorporate harms. The framework put forward by Greenfield, Paoli, and others is one starting point, allowing for follow-on work to account for harms of drugs in the supply chain. Such a harms-based assessment can account for other dimensions of a problem and perhaps make supply-side interventions more effective and less intrusive by targeting the most violent or socially harmful actors.

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