

Does tougher enforcement make drugs more expensive?

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ABSTRACT

Aims To review empirical research that seeks to relate marginal increases in enforcement against the supply of illicit drugs to changes in drug prices at the level of the drug supply system being targeted. **Method** Review of empirical studies. **Findings** Although the fact of prohibition itself raises prices far above those likely to pertain in legal markets, there is little evidence that raising the risk of arrest, incarceration or seizure at different levels of the distribution system will raise prices at the targeted level, let alone retail prices. The number of studies available is small; they use a great variety of outcome and input measures and they all face substantial conceptual and empirical problems. **Conclusion** Given the high human and economic costs of stringent enforcement measures, particularly incarceration, the lack of evidence that tougher enforcement raises prices call into question the value, at the margin, of stringent supply-side enforcement policies in high-enforcement nations.

Keywords Crop eradication, dealer risk, drug enforcement, drug markets, drug prices, interdiction.

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THE CONVENTIONAL WISDOM AND ITS ROOTS

In most democracies, the principal program for controlling drug use and related problems is the enforcement of laws prohibiting sale and consumption (e.g. [1] the Netherlands). Many authors and government documents assume that tougher enforcement results in higher prices and lower availability, with more emphasis on price effects. This paper assesses the empirical research evidence for this assumption.

The price effect model has its roots in economics harking back to Gary Becker's classic analysis of crime [2]. Reuter & Kleiman provide one statement used in many subsequent drug policy analyses [3–5]. In their model, the principal cost of delivering drugs such as cocaine, heroin and methamphetamine to final users is providing compensation to producers/smugglers/traffickers/sellers for incurring the risks of the trade. These risks have two components: risks from the government (arrest, incarceration, seizure of drugs and assets) and risks from other participants (theft of drugs and assets, violence) or even from those unconnected to the trade who simply choose to prey on it.

Within a standard supply–demand framework, street dealers and other participants must thus be paid a risk premium to work for drug-selling organizations. More stringent enforcement is generally posited to raise the required risk compensation. (See Viscusi [6] on various assumptions of the model applied to risks in legal occupations.)

Note that even with relatively limited supply-side enforcement, legal prohibition can generate substantially higher prices than would prevail in legal markets for the same products. For example, illegal enterprises encounter serious management and coordination costs [7]. Criminal conspiracies cannot efficiently outsource various technical tasks, from information technology to financial services. Subterfuge also deprives drug-selling organizations from deploying efficient large-scale production technologies. Recent studies examining the potential impact of marijuana legalization document the potential for dramatic (pre-tax) price declines exceeding 80% if producers can pursue conventional farming [8]. The government does not have to incarcerate many marijuana growers to inhibit them from adopting these efficient growing methods. Miron offers a rare dissent from the claim that legalization would much reduce prices, focusing on the

Table 1 Enforcement programs and their targets.

<i>Program</i>	<i>Targeted sector</i>	<i>Price effect</i>
Eradication	Coca or poppy-growing	Coca leaf or opium price
Precursor controls	Source-country refining	Export price minus coca leaf or opium price
Refinery destruction, in-country enforcement	Source-country post farm-gate refining and distribution	Export price minus leaf or opium price
Interdiction	Smuggling	Import minus export
Investigation	High-level domestic trafficking	Wholesale minus import
Street level enforcement	Retailing	Retail minus wholesale

Source: Adapted from [12].

similarity between ratios of retail to farm-gate prices for some legal commodities and cocaine and heroin [9].

Our focus is then on the price effects of tougher enforcement, such as raising the risk that a drug dealer is incarcerated. There is surprisingly little evidence that additional enforcement of any kind, at the margin, appreciably raises drug prices. The striking decline in US street cocaine and heroin prices (adjusted for purity) between 1980 and 2005—a period in which incarceration risk rose by perhaps an order of magnitude—provides the most troubling data-point ([10,11]).

The next section presents some of the methodological problems facing efforts to assess the influence of enforcement on prices. That is followed by a review of the empirical evidence, showing that the modest number of existing studies, all facing serious conceptual or data limitations, has failed to find evidence that tougher enforcement has raised prices substantially. The following section summarizes and integrates the evaluations. The final section discusses the implications of the lack of credible evidence on tougher enforcement and briefly suggests a research agenda.

METHODOLOGICAL ISSUES FOR ASSESSING THE EVALUATIONS

Framework for the reviews

Supply-side enforcement encompasses many different interventions, which target specific links in the long supply chain for illicit drugs. For example, European governments have created a marine task force with a home port of Lisbon to interdict drugs smuggled by sea from Colombia to Africa or Europe (MAOC-N; <http://www.maoc.eu/who.php>). Governments also enforce prohibitions against trafficking of cocaine within their own territories. The first program should affect the price that traffickers charge for shipping cocaine from the producing region, i.e. the difference between the export price of cocaine leaving South America and its price on arrival in western Europe. Programs aimed at high-level trafficking within Spain (against importers and first-level distribu-

tors) should show up in the difference between import price and domestic wholesale price. In each instance the result will be an increase in retail cocaine prices, albeit perhaps a small one [3]. Table 1 matches programs, market levels and proximate prices targets, arrayed in order of the production stream.

Three enforcement programs aim to reduce source-country drug production and thus raise prices: crop eradication, precursor control and in-country enforcement. Eradication, involving aerial spraying or manual destruction of crops, aims to literally limit the current quantity of drugs available for export and to discourage farmers from growing these crops again. In addition, most nations implement strict regulations on the sale and distribution of chemicals that are used in the production of heroin or methamphetamine. Finally, Europe and the United States push source-countries to pursue traffickers and refiners more vigorously, often providing military equipment and training or protecting judges against retaliation by drug sellers. There are no evaluations of the price effects of in-country enforcement programs or precursor controls for source countries.

Efforts to apprehend and punish retail sellers, which account for most supply-side arrests, raise the risks faced by retailers. These interventions may raise prices by shifting the supply curve as described above; yet the same policies may also elicit counterintuitive effects. Strong measures against retail sellers may reduce market efficiency by raising transaction costs, for example by reducing the ease with which buyers can find sellers. That will shift the demand curve to the left, which can actually lower equilibrium prices. Such effects are considered in only one of the studies reviewed [13].

Money-laundering controls are not included among the enforcement programs because there are no empirical evaluations of its effect on drug prices.

Challenges for evaluation

Both the variables of interest, enforcement intensity (the independent variable) and purity-adjusted price (the dependent variable), present major empirical challenges.

Differences across studies are frequently driven by different strategies to address these empirical challenges.

Enforcement intensity could refer to various adverse events for dealers (arrests, convictions, incarceration, seizures of drugs, seizure of assets) relative to various denominators (transactions, grams, dollars, individuals). Ideally, one would create an index for the sum of the adverse consequences of apprehension by police, perhaps weighting drug seizures by the replacement value of the drugs and giving a dollar cost to each month's loss of liberty and to the experience of arrest itself. Unfortunately, the estimates of the imputed value of losing a year's liberty in prison are both controversial and imprecisely measured [14]. Moreover, consistent data on government drug and asset seizures are available only at the national level. These data aggregate across levels of the trade, hindering efforts to distinguish prison-time specific to domestic trafficking offenders from those imposed on retailers. Unfortunately, the lack of authoritative estimates of the denominator (e.g. number of dealers) somewhat cripples the exercise.

Price refers to the price at the targeted stage of production or distribution. The fact that most of the value added in retail price for both cocaine and heroin comes in the final two transactions (retail and low wholesale) suggests that changes in very high-level prices (e.g. import or earlier) will have little effect on retail price [3]. The question here is whether the specific enforcement intervention (e.g. interdiction) raises the price at that stage of distribution (i.e. import price).

Price and purity data are available on a consistent basis only for the United States. STRIDE (System to Retrieve Information from Drug Enforcement), a data collection program of the Drug Enforcement Administration provides such data for a large number of undercover purchases and seizures, totaling roughly 100 000 per annum. Purity-adjusted price series for three drugs (cocaine, heroin and methamphetamine) are available nationally and for approximately 30 major cities. These series show the price at various levels of the market but only as far as the middle of the distribution chain. For example, for powder cocaine, the largest amount for which a national series exists is >50 raw grams, which is probably two transactions above the retail level, where purchases are closer to 0.5 raw grams; it is far below the import level. STRIDE is an administrative data set, not a random sample, and it has been severely critiqued by a National Research Council (NRC) Committee [15,16]; for a response see Arkes *et al.* ([17]). No other country has a transaction-level data set on price and purity, although the UK's ENDORSE database provides some of this information [18]. This certainly helps to explain why so few studies report on consumer countries other than the United States.

THE EVIDENCE

Search strategy and inclusion/exclusion criteria

The starting-point for selecting items was the authors' knowledge of the existing literature, conversations with expert colleagues, searches of the bibliographies of prior reviews of the enforcement literature and a limited number of on-line database searches (for prior reviews, see [16,19–21]). Only Manski *et al.* [16] included price effects. McKetin *et al.* [22] did include price effects in their review of precursor controls. Only English language items were searched, although there was no indication that authors competent in other languages were aware of non-English language items. We did not perform a structured search of the form provided in a Campbell Collaborative search. This is a limitation of the current analysis.

This review covers only enforcement aimed at producers, sellers and other supply-side participants. It excludes enforcement aimed at users, as demand-side interventions theoretically have different impacts on drug prices. It also excludes one relatively well-evaluated supply-side intervention specific to methamphetamine; namely, regulation of the legal distribution system from which the drug or its precursors enter the illegal market. Although the evaluations document transient enforcement-related disruption to the methamphetamine market [23,24], the intervention is different in nature from drug enforcement itself.

Some studies are difficult to incorporate within this review, yet might still provide insight into the effects of enforcement on price. Perhaps most intriguing, a large literature explores what has been called the 'Australian heroin drought'. Some sort of supply-side event led to a sharp increase in the price, and decline in the purity, of heroin in Australia almost immediately after Christmas, 2000. This was not a short, sharp shock, but persisted for at least 5 years. Degenhardt *et al.* argued, by elimination, that this event had to be an enforcement activity [25]. That interpretation remains hotly disputed [26]. Moreover, no one has persuasively identified the intervention that actually produced this effect.

Other long-term increases in drug prices might also reflect supply-side enforcement. It appears that purity-adjusted retail cocaine prices in the United States rose by about 40% in the period 2007–09 and remained at those new levels at least to 2011. Although prices are low when compared with the 1980s and 1990s, they were still elevated in 2011 over the levels seen in the mid-2000s [27]. This may be a consequence of the post-2006 crack-down in Mexico, but there is again no rigorous analysis that specifically tests the relationship.

There are many difficulties in interpreting such macro-events as the Mexican crack-down or the Australian heroin drought. They suggest that a specific

supply-side intervention did raise prices, but there may have been many other instances of the same intervention that failed to do so. Thus they have a forensic or proof-of-concept value rather than making a more specific analytical contribution.

We array the studies in order of the movement of the drugs from production to final sale. Table 2 presents a summary version of the evaluations.

Eradication

The literature on price-effects of crop eradication consists almost entirely of simulation studies (e.g. [28,29]). These studies present complex models with reasonable theoretical foundations, but then necessarily fit the data relatively crudely in model calibration to assess the effects of a variety of potential interventions and shocks.

Most empirical studies of eradication focus upon the effects on production [30]. The only empirical estimate of price effects found is a work in progress. Gallego & Rico examined the impact of manual eradication and aerial spraying in Colombia on prices of coca leaf, paste and base [31]. Using 2005–11 subregional panel data, the authors found that each of these prices was relatively unresponsive to such actions. These are preliminary results.

Interdiction

Crane, Rivolo & Comfort examined the effects of specific interdiction and source country events (e.g. a targeted attack on Bolivian cocaine refineries in 1986) on US retail cocaine prices between 1989 and 1997 [30]. They report that such events were usually followed by substantial, albeit temporary, price increases. Their analysis was flawed *inter alia* by (i) a contested method of creating a price series from the STRIDE data and (ii) an undocumented and contested identification of what constituted heightened interdiction events (for a detailed critique see [15]).

High-level enforcement

DiNardo modeled the relationship of the quantity of cocaine seized domestically to US retail prices between 1977 and 1987 [33]. Because large seizures (1 kg or more) account for the bulk of cocaine seized, this is classified as an assessment of interventions reaching high-level trafficking. DiNardo failed to find any effect on retail price; he did not examine the proximate target, wholesale prices.

Yuan & Caulkins (1998) also analyzed high-level domestic enforcement efforts in the form of seizures by the federal agency, the Drug Enforcement Administration [34]. Their model used 1981–92 monthly time-

series on prices and seizures for both cocaine and heroin and tested for 'Granger causality' as to whether higher seizures raised prices, using a variety of specifications of seizures: total number, weight (DiNardo's measure), pure weight and dollar value. (Granger causality implies that the time series of seizure levels has value in predicting future drug prices above and beyond the predictive value contained in the time series of past drug prices itself.) The authors estimated that cocaine and heroin seizures each constituted approximately 7–8% of total consumption. Yuan & Caulkins found weak evidence of Granger causality only if enforcement is measured by the number of seizures, rather than weight or value. Even then, coefficients were not statistically significant. They found, surprisingly, that cocaine seizures had a small price-decreasing effect for heroin, and that heroin seizures had a similar effect on cocaine prices; perhaps seizures are an indicator of resource commitment, so higher cocaine seizures signal lower heroin enforcement and hence the lower price.

In another time-series analysis, Weatherburn & Lind, in one of the few studies of interventions in consumer countries other than the United States, assessed the effect of large seizures of heroin in Sydney, the largest market in Australia [35]. They created 2-weekly time-series on price, seizures and a set of other variables for the period March 1993–March 1995. The seizures series was very erratic, with four of the 51 periods accounting for the vast bulk of the seizure total; they estimated that on an annual basis seizures were between 3.7 and 18.2% of the total Australian market. They found no relationship between seizures in period t and purity-adjusted price in period $t + n$, where n was allowed to vary from 1 to 15.

Retail-level enforcement

Freeborn (see also [36]) is unusual in the presentation of a theoretical search model that incorporated adaptation of buyers and sellers to increases in enforcement, before estimating a reduced-form equation [13].

Search models provide a useful reminder, within a structured economic model, that equilibrium prices do not capture the full range of economic factors facing buyers and sellers in illicit markets. Search costs and search time impose substantial burdens on buyers—burdens which sellers do not capture in the form of economic rent [37].

Search models also allow a surprising range of relationships between enforcement and market prices. Higher arrest risk for sellers can induce price decreases, as sellers now have an incentive to dispose of their incriminating goods more quickly. Symmetrically, the model suggests that tougher enforcement against buyers might lead to higher prices, as buyers can reduce their

Table 2 Drug enforcement and price response: selected studies.

Paper	Substance	Level of distribution	Location	Data source	Study design	Findings
Mejia & Restrepo (2012) [28]	Cocaine	Crop enforcement, interdiction	Colombia	Multiple data sources	Calibrated theoretical model	Interdiction more cost-effective than crop eradication Three-fold increase in US effort would decrease wholesale cocaine supply in transit countries by about 13%
Clemens (2008) [29]	Opium	Crop eradication	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
Gallego & Rico (2013) [31]	Cocaine	Crop enforcement	Columbia	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'
Weatherburn & Lind (1997) [35]	Heroin	Heroin seizures over 1 kg	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
Crane, Rivolo & Comfort (1997) [32]	Cocaine	Interdiction and source country enforcement	Colombia	STRIDE, intelligence on enforcement events in Colombia on en route to US	Simulation model	Authors find observable upward excursions in US cocaine street prices, with US interdiction efforts in conjunction with source country support as likely cause Authors also find price excursions produced measurable reductions in US cocaine use
DiNardo (1993) [33]	Cocaine	High-level enforcement	United States	STRIDE price data Monitoring the Future demand data	Regression modeling	'In short, I have failed to find any significant effects of law enforcement on the price of cocaine faced by users'
Yuan & Caulkins (1998) [34]	Cocaine and heroin	High-level enforcement	United States	STRIDE price data	Regression modeling with Granger tests for causality	Mixed, statistically insignificant relationships between enforcement and price
Kuziemko & Levitt (2004) [38]	Cocaine	Street dealing	United States	STRIDE, state-level incarceration data	Difference-in-difference regression analysis using state-level drug pricing and enforcement efforts	Use of total drug arrests implies focus on street sellers (and users) Order-of-magnitude increase in arrests associated with 5–15% price increase
Freeborn (2009) [13]	Cocaine	Street dealing	United States	STRIDE	Search-theoretic model	Search-theoretic model yields predictions contrary to basic supply-demand framework Heightened policing raises consumer search costs, which reducing competition and raising market prices

STRIDE = system to retrieve information from drug enforcement; UNODC = United Nations Office on Drugs and Crime.

exposure to undercover agents posing as sellers by buying from the first seller, rather than searching for the lowest price.

Freeborn then regressed prices on measures of arrest rates and average sentences, separating probation from incarceration; the period covered was 1986–2000. The rates were calculated with a denominator that used National Household Survey on Drug Abuse data to estimate state user populations. She separated supply-side enforcement (arrests and punishment for selling) from demand-side enforcement (arrests and punishment for possession). The resulting point estimates were consistent with her theoretical predictions, i.e. supply-side enforcement was price-decreasing and demand-side enforcement was price-increasing. However, the only statistically significant result was that increases in the length of probation sentences were negatively associated with retail price.

Kuziemko & Levitt used state-level panel data over the period 1983–96, when the number of individuals incarcerated for drug offenses increased nearly 10-fold [38]. They regressed purity-adjusted retail prices of cocaine on arrest rates per capita, the probability of a drug arrestee entering state prison and a number of state characteristics. They found that '[t]he combined impact of changes in drug policy between 1985 and 1996 is thus estimated to have raised cocaine prices between 5 and 15%', a modest return for such a large increase in incarceration.

INTERPRETING THE EVIDENCE

The first observation about the evidence is its paucity. There is a multi-stage supply chain in the distribution system for cocaine, heroin and methamphetamine. For no stage are there more than four studies available and for no stage do the studies provide consistent evidence. No study finds a large and sustained price effect.

All but two of the studies reported cover cocaine; heroin is the exclusive focus of Weatherburn & Lind [35], and is included along with cocaine in Yuan & Caulkins [34]. The time-periods covered stretch from the early 1980s to approximately 2010. There is no reason to believe that the same parameters apply to different drugs or time-periods.

There are still other elements of complicating heterogeneity in the literature. Operationalization of increased intensity of enforcement has varied. Some studies use seizures as the principal indicator. This is reasonably well measured, at least in the United States, and can be converted into an intensity measure, as there are systematic, if only episodic, efforts to estimate total consumption of specific drugs [39]. Studies that use either arrests or incarceration data, no matter in which country, are bedeviled by the lack of credible estimates of the number

of dealers in order to convert raw numbers into a measure of intensity. Another problem is that the dependent and independent variables are often measured at different levels of aggregation.

Except for source country programs, the studies are predominantly executed on US data, with STRIDE as the data source for prices, albeit employing a variety of methods to construct the series. The absence in most other countries (apart from Australia) of data collection that permits systematic purity adjustment to prices makes it hard to conceive of how comparable studies can be performed. Moreover, given the relatively high intensity of drug enforcement in the United States, as measured by incarceration levels, the results may not generalize to other wealthy democracies. The United States may have reached the point of diminishing returns from drug incarcerations, but that may not be true for the many other nations that use incarceration much more sparingly. The price effects of increased arrests, of more intense policing generally or dimensions of interdiction other than seizures remain to be examined.

The limited response of prices at specific market levels to the targeted interventions may reflect some fundamental factors. First, many of the genuinely cost-increasing effects of prohibition raise average prices, but are likely to provide much smaller opportunities to raise prices at the margin. Secondly, there is often, perhaps always, a high-cost backstop alternative that is hard to suppress: a land route resistant to interdiction, remote and small plots for growing coca, an indoor distribution system for retailing. These backstops set some upper limits on the ability of enforcement to raise prices (e.g. [40]). Thirdly, enforcement may also lower risks of violent victimization among both users and sellers if it removes violent suppliers. That is likely to reduce, rather than to raise prices, with potentially ambiguous implications for ultimate social welfare (e.g. [41]). Increasing use of violence-oriented 'group accountability' law enforcement models render these dynamics especially pertinent to current debates in the United States [42].

IMPLICATIONS

The standard model justifying vigorous law enforcement against drug sellers, from production to retailing, asserts that increases in these levels of enforcement actions will increase price. As shown, there is little evidence in support of that proposition, and a modest amount of weak evidence against it.

This is far from a judgment on whether or not drug enforcement is effective in suppressing markets. Research is limited by the fact that most existing studies address well-established markets. Enforcement (even at some fairly minimal level) may be most effective in suppressing

new markets. Precisely because these markets did not emerge, the effect of enforcement has not been studied. It is notable that very few of the many attractive new drugs that are developed each decade actually become popular enough to generate major markets. That may reflect the endogenous dynamics of fashion. It may also be a latent result of aggressive enforcement early in the epidemic life-cycle of specific substances. Stringent enforcement measures may be especially effective as potential new users and sellers seek to find each other in the emergence of a new market. The work of Caulkins and colleagues also suggests that enforcement effectiveness is sensitive to where a market is in terms of epidemic stages (e.g. [43,44]).

Regarding markets for the most prominent and socially costly substances, the existing research base suggests an agnostic position: there is not sufficient evidence to state whether a particular intensification of enforcement will raise prices; hence nothing should be said, is the conventional position.

However, given that nations commit billions of dollars and lock up hundreds of thousands of individuals in part on the basis of this belief, it is insufficient to offer only the usual call for 'further research'. It is a long-noted irony that enforcement receives most of the policy resources, but that treatment and prevention receive most of the research dollars [45]. Gaps in existing research should indeed be addressed, but that is a long process. Meanwhile, punitive policies enacted or defended on the basis of their capacity to raise prices merit have heightened scrutiny. In the absence of evidence that enforcement can raise prices—or that price increases are actually welfare-enhancing across a range of interventions—some wealthy societies should probably spend less on enforcement at the margin, particularly enforcement measures that bring high social costs in other domains.

In particular, these findings suggest more discriminating policies regarding street-level sellers. Stringent policies in this domain have resulted in mass incarceration in the United States, with its attendant human costs. Policymakers should also revise approaches to source-country crop eradication. Given the lack of evidence that such efforts have substantial impacts on street drug prices, and the strong theoretical argument that the effects should be slight, greater attention to the environmental, economic and social challenges of such approaches is especially wise.

Declaration of interests

None.

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