

A calibrated model of the psychology of deterrence*

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ABSTRACT

Can law enforcement cause 80 per cent of narcotics traffickers to give up their favoured methods or cease smuggling altogether, even though seizure rates under the most favourable conditions seldom exceed 30 per cent and arrest rates are lower still? Several counter-cocaine operations have achieved these goals. Principal among them is the force-down or shoot-down policy, in which the Government of the United States of America assisted the Peruvian Air Force with detection and monitoring so that smugglers could be prevented from flying cocaine base from Peru to Colombia. With the threat of lethal force, an 8 to 12 per cent interception rate held down trafficking to less than 15 per cent of former levels, causing the collapse of the Peruvian cocaine trade. Less severe consequences worked at higher interception rates in the transit zone to the United States. The present article presents an analysis of an extensive set of interviews with incarcerated drug smugglers that derives a mathematical function representing their willingness to smuggle. This function is the basis for a model of the psychology of deterrence, which was verified and calibrated using detailed data from counter-cocaine operations. Three major findings are that (a) traffickers ignore the risk of interception up to a point, (b) interception rates beyond a certain threshold cause trafficking activity to collapse rapidly and (c) some traffickers are undeterrable, even when faced with certain interception.

Keywords: deterrence; cocaine; interception; trafficking.

Introduction

Cocaine smuggling is a high-risk activity. Even though some smugglers are attracted by risk or desperate for quick profits, one would expect that, as the chances of being caught, imprisoned or killed increased, many would stop smuggling. The present article focuses on the following two questions:

- (a) What is the level of risk necessary to deter most smugglers?

*The views expressed in the present article are those of the author and do not represent an official position of the Institute for Defense Analyses or of its sponsors.

(b) If smugglers can be deterred, can their behaviour be predicted through use of a mathematical model?

These issues can be addressed directly, by examining interception operations at different levels of risk, indirectly, by examining the literature on risk-taking, or subjectively, by interviewing captured smugglers. As data are available for only a few operations, they are insufficient to derive a functional form without other justification to link the data sets. Nevertheless, these known operations can be compared with a model, once one has been developed. Although the literature provides some clues as to the form of a deterrence model, it is not sufficient to build a useful mathematical model of the behaviour of a large group of smugglers. While interviews with imprisoned smugglers seem liable to bias, prisoners serving long prison terms apparently want to share their knowledge and brag about their exploits, if they can do so without self-incrimination or adding to their term of imprisonment. Although interview data represent only the opinions of smugglers, their opinions are the basis for their decisions to smuggle and thus the ultimate basis for deterrence. Fortunately, interview data are available with sufficient detail to build a mathematical model of deterrence.

Throughout the present article, the following military definition of deterrence is used: “the prevention from action by fear of consequences—deterrence is a state of mind brought about by the existence of a credible threat of unacceptable counteraction” [1]. This definition addresses the following essential elements: the perpetrator’s psychology (state of mind) that arises from the probability of consequences (a credible threat) and the consequences themselves (unacceptable counteraction).

Interview data

In 1989, the United States Customs Service sponsored a research team from Rockwell International to interview former drug smugglers in federal prisons concerning the conditions under which they would be willing to continue various illicit activities [2]. The interview team contacted the United States Bureau of Prisons and selected inmates whose offence code identified them as currently serving sentences for violations of pertinent sections of the Comprehensive Drug Abuse Prevention and Control Act of 1970. The research team selected a sample of inmates from nine federal prisons in five states and one state prison in Texas. To avoid selection biases, no distinction was made on the basis of weight or type of narcotic, arresting agency or location of arrest, length of sentence, age, sex or demographic profile. Prior to the interviews, inmates were told that their answers would be treated in confidence and that any information given by them would not be traceable to them. Almost half of the sample of inmates with drug convictions agreed to participate, yielding a final sample size of 112. Of those, 109 gave useful responses and five of those did not answer some of the key questions. This is nevertheless a high response rate for so long an interview process and so sensitive a subject.

The responding inmates were quite diverse demographically and in terms of experience. They were between 20 and 50 years old; half were citizens of the United States, while the others consisted of equal numbers of Colombians, Mexicans and other, various nationalities. There were about equal numbers of secondary school dropouts, those who had completed secondary education and university graduates, as well as a few holding doctoral degrees. A total of 50 per cent had smuggled marijuana, 40 per cent had smuggled cocaine and 10 per cent heroin. Some had smuggled more than one drug or drugs other than cocaine, heroin or marijuana.* They had smuggled drugs between one and 10 times and an average of approximately six times.

Interviewers were selected on the basis of their investigative expertise, bilingual capability, law enforcement background and drug control experience in order to ensure that frivolous answers were kept to a minimum. Interviewers commented that the variety of inmate respondents and the commonality of their responses indicated that there were no identifiable biases. Some of the survey respondents commented that, before being imprisoned, they had underestimated the chances and consequences of being caught. Some inmates went so far as to suggest that the authorities should conduct a campaign of informing currently active smugglers about the penalties for drug smuggling. This led the interviewers to conclude that the answers given from the perspective of the associate were more likely than the answers given from the point of view of the inmate himself or herself to be representative of the majority of active smugglers.

Three principal questions (Q1, Q2 and Q3), all of a common form, yielded the data that became the framework for a mathematical model of the willingness to smuggle. Those questions and the allowed responses to each of them were as follows:

I would not smuggle drugs into the United States if my chances of getting caught (Q1); caught and convicted (Q2); caught, convicted and imprisoned (Q3); were 1 in 10 times (R1); 1 in 5 times (R2); 2 in 5 times (R3); 4 in 5 times (R4); or every time (R5).

Inmates were asked to answer the questions from two separate points of view. The first, under the heading of "self", required responses from inmates regarding their own actions, perspectives and future smuggling intentions. The second, under the heading of "associate", required similar responses, but from the perspective of a former associate or friend in the smuggling business. In each of questions Q1, Q2 and Q3, inmates were asked to choose, first for "self" and again for "associate", from one of five probabilities of interception: R1, R2, R3, R4 or R5. Table 1 summarizes the responses provided by the inmates. It should be noted that the responses in each of these probability-of-interception categories represented those who would be deterred by the selected level of risk, but not

*The data obtained were aggregated and it is consequently not certain that the cocaine smugglers' responses were distributed similarly to those of the other smugglers. However, the eventual consistency and uniformity of the results justify combining the data.

by the next lower level of risk. Thus, someone not willing to smuggle against a probability of being caught of "2 in 5 times" might be willing to do so if the probability were only slightly greater than the previous category of "1 in 5 times".

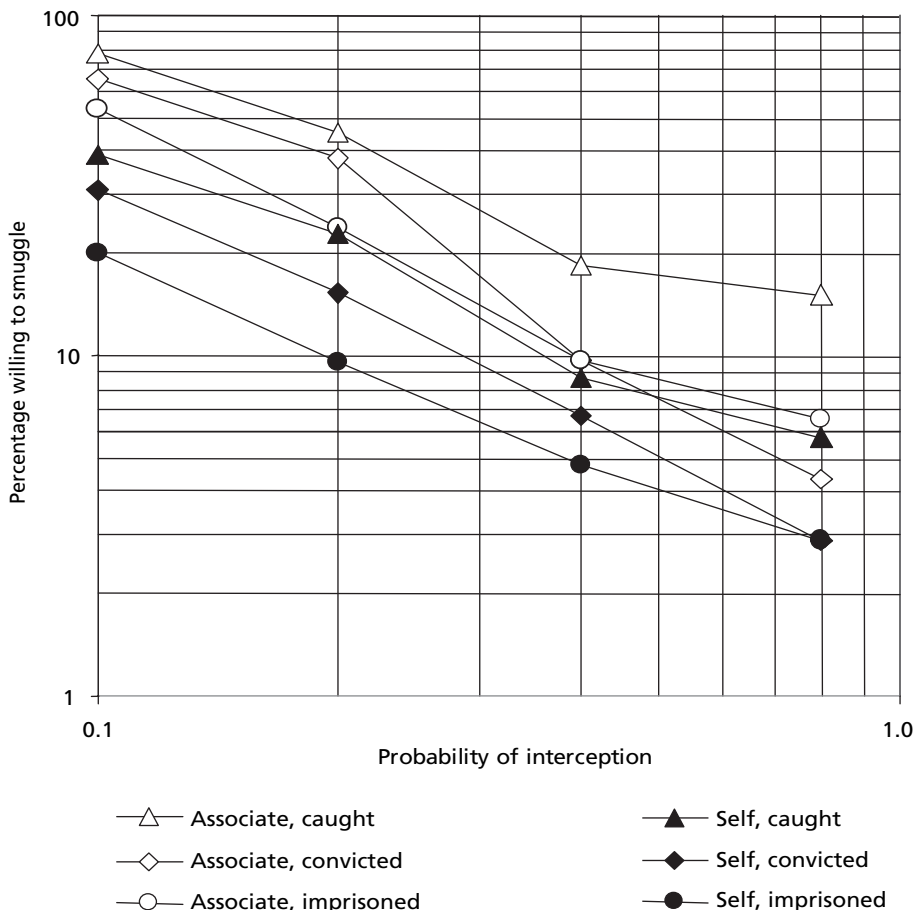
Table 1. Additional number of inmates not willing to smuggle as risk increases from one probability to the next higher probability

| Probability of interception | Consequences | | | | | |
|-----------------------------|----------------------------------|-----------|----------------------|-----------|--------|-----------|
| | Caught, convicted and imprisoned | | Caught and convicted | | Caught | |
| | Self | Associate | Self | Associate | Self | Associate |
| 1 in 10 | 83 | 43 | 72 | 32 | 63 | 21 |
| 1 in 5 | 11 | 27 | 16 | 25 | 17 | 29 |
| 2 in 5 | 5 | 13 | 9 | 26 | 15 | 25 |
| 4 in 5 | 2 | 3 | 4 | 5 | 3 | 3 |
| Every time | 3 | 6 | 3 | 4 | 6 | 14 |
| Total respondents | 104 | 92 | 104 | 92 | 104 | 92 |

For the remainder of the present article, the data in table 1 should be considered to constitute six separate subsets of data for the combinations of the two types of response (self versus associate) and the three degrees of severity of punishment (imprisoned, convicted, caught). Figure I displays all six data subsets as cumulative trends on a log-log plot. Each trend declines in an approximately linear fashion, and the extension of each trend would intersect the probability of interception of 1.0 (anticipation of certain apprehension) at a finite value. This means that some inmates would be willing to smuggle even if they knew beforehand that they would be caught, consistent with comments volunteered by some of the survey respondents. It should be noted that the proportions for each data subset that correspond to a "probability of interception" equal to 0.1 follow a regular progression in "percentage willing to smuggle" for all six cases. From the top down, the ordering is "associate, caught", "associate, convicted", "associate, imprisoned", "self, caught", "self, convicted" and "self, imprisoned". This progression makes sense because the inmates were more willing to smuggle against less severe penalties and because imprisoned smugglers judge the consequences more severely than they imagine their former associates would have while free. At a probability of 0.4 and on to 0.8, however, responses to the "associate, convicted" question abruptly deviate from this logical order. It is assumed that some element of the interview process corrupted these few responses; therefore, this case was ultimately dropped from the data subsets employed to characterize the willingness function mathematically.*

*To restore the regular progression in figure I and table 1 would require only six responses to be moved from "2 in 5 times" to "every time". Moving three responses would bring the number in that bin for "associate, convicted" within one standard error deviation from the estimated value.

Figure 1. Proportion of inmates willing to smuggle for each probability of interception for each of the six data subsets



Mathematical representation of the willingness function

Three simple functional formulations of the willingness function were considered. In all three, W represents the willingness to smuggle and P_1 represents the probability of interception. First, the Pareto function, $W(P_1) = (1 - P_1)^{\alpha - 1}$, matches the general qualitative appearance of military deterrence plots; there are so many examples of this behaviour that it is a standard technique for representing data. Second, the attrition filter function, $W(P_1) = \exp(-\alpha P_1)$, represents a multi-stage process of absorption through a series of filters; for example, the willingness of criminals to repeat offences once released from prison [3]. It is plausible that traffickers experience their activities as going from risk situation to risk situation and therefore perceive their chances of success in the same way. Third, the risk perception function, $W(P_1) = (P_0/P_1)^\alpha$, with $W(P_1) = 1.0$ for

$P_1 \leq P_0$, arises from the psychophysics of perception processes. For example, subjects asked to match various light intensities to sound intensities or to a numerical scale produced a power-law relationship between the two physical intensities [4]. Matching two scales works well as it does not require subjects to adapt a common scale; it allows them to select their own numbers and a scale is derived from the ratios of the numbers chosen. One might expect that smugglers would match their perceptions of the penalties of being caught and suffering various consequences against the probabilities of being caught in a similar power-law relationship.

When the interview data were compared with each of the three candidate functions, neither the Pareto nor the attrition filter function was even approximately correct; however, the risk perception function appeared to represent the data quite well. Because the response data were grouped into probability of interception intervals (bins), whereas the willingness function was a continuous cumulative distribution, differences in the cumulative willingness function between the upper and lower bin boundaries were taken to estimate the fraction of inmates who responded within the range of each bin. The fitting procedure minimizes the sum of squares of deviations between observed counts and model predictions. The last two bins, 0.4 to 0.8 and 0.8 to 1.0,* were combined so that all sample sizes were greater than four. As shown in table 2, it was determined that one common exponent parameter, α , and a different P_0 for each data subset gave excellent agreement (excluding the troublesome “associate, convicted” combination discussed previously) [3].

Table 2. Parameters of estimated willingness function

| Parameter | Self | | | Associate | | |
|-----------------|------------|-----------|--------|------------|-----------|--------|
| | Imprisoned | Convicted | Caught | Imprisoned | Convicted | Caught |
| P_0 | 0.021 | 0.032 | 0.041 | 0.054 | 0.068 | 0.078 |
| Standard error | 0.004 | 0.005 | 0.005 | 0.005 | 0.004 | 0.004 |
| Common exponent | -1.029 | | | | | |
| Standard error | 0.068 | | | | | |

Interpretation of model parameters

The willingness function was interpreted to imply that smugglers entirely ignore some small probability, P_0 , of being apprehended. This small probability is a threshold degree of risk of apprehension that must be exceeded before smugglers are deterred. Once this threshold has been exceeded, however, only

*The data in the 0.8 to 1.0 interval represent both the intended responses for 0.8 to 1.0 and those for greater than 1.0; in other words, those willing to smuggle knowing they would be intercepted.

somewhat larger probabilities of apprehension deter relatively large numbers of would-be smugglers. This threshold is the point at which deterrence sets in and is a strongly non-linear feature of the willingness function and, hence, of deterrence in general.

The willingness function also implies that a non-zero fraction, $P_0^{1.029}$, of the smuggler population would be willing to smuggle even if they knew that they would fail, that is, when $P_1 = 1.0$. Inmates volunteered comments that validated this surprising result. Some said that the advance bonuses they received provided for their families better than the wages they could have earned in the period of time they were in prison.

Additional support for the willingness function

Other risk-taking contexts were examined to determine whether the form of the willingness function held generally. Only two contexts with comparable data were found: early automobile use and United States Coast Guard enforcement of restrictions on fisheries (allowed areas for fishing and fishing practices).

Although driving an automobile was a legal activity in 1900, it was essentially an "extreme sport", with a 1:200 chance of dying for every eight hours of driving time; however, only 1 in 6,600 Americans drove at that time [5]. By 1910, approximately 50 times more people were driving and the fatality rate per hour had dropped to one fiftieth of its former value. This is an inverse power relationship identical to the drug smugglers' willingness function established by this research.

The United States Coast Guard provided data on the frequency of boarding to inspect fishing vessels, on the number of violations of fisheries' restrictions and on the number of fishing vessels in the area during inspections [6]. For two fishing districts with ample data, it was possible to compute the decline in the proportion of fishing crews violating restrictions and the proportion of fishing boats being boarded. The relationship between these two proportions follows a simple inverse power comparable to the earlier drug smuggling findings. These data also corroborated the unexpected feature of the willingness function, that there is a residual proportion that is not deterred even by very high probabilities of being intercepted. For instance, typically less than 10 per cent ever violate fishing restrictions, but 1 per cent continue to violate even when the probability of being apprehended is as high as 80 per cent.

Deterrence of cocaine traffickers

Several operations mounted against cocaine traffickers were able to achieve a significant level of deterrence. The data from those operations provide information about real trafficker behaviour and an opportunity to validate the form of the willingness function and calibrate its parameters.

Trafficker flights over the Caribbean into the United States

Before 1989, counter-drug pilots could only intercept about 5 per cent of the trafficker flights bringing drugs into the United States from South America, and at most another 15 per cent were deterred [7]. Between 1991 and 1996, however, the capability to detect air traffickers improved significantly after the operational deployment of two relocatable over-the-horizon radars. With the radars' wide area of coverage, detection efficiency increased to the point that about three quarters of all trafficker flights were observable. Consequently, interception rates increased over this period by between 20 and 35 per cent and attempts to fly cocaine across the Caribbean declined from about 350-400 per year to about 80-100 per year. Combined with the interceptions, this meant that successful drug trafficking flights were at less than 20 per cent of former levels.

Operation "Frontier Shield" against go-fast boat drug smuggling into Puerto Rico

The 90-day "pulse phase"* of Operation "Frontier Shield", mounted by the United States Coast Guard, and the companion Operation "Gateway", mounted by the United States Customs Service, began on 1 October 1996 and were designed to intercept non-commercial trafficking into Puerto Rico and the eastern Caribbean [7]. The United States Customs Service imposed severe penalties for non-compliance with customs inspections, consisting of the seizure of boats or aircraft, thereby significantly increasing the costs of illegal entry and smuggling into Puerto Rico. During the pulse phase, there were 1,251 targets of interest, 648 boardings were carried out by the Coast Guard, 7 vessels were seized, 19 arrests were made and 6 metric tons of cocaine were seized [8]. Overall, seizure rates for all forms of trafficking increased from 10-15 per cent before the operation to nearly 30 per cent during the pulse phase, which is consistent with having doubled the interception forces. During this period, trafficking in the eastern Caribbean dropped sharply, from 38 per cent of total traffic down to 23 per cent, and it continued to drop thereafter. The willingness to smuggle is somewhat less than double these percentages because initially nearly 60 per cent of all drug traffic traversed the eastern Caribbean. Thus, the combination of deterrence and interceptions did not quite make successful trafficking drop below 20 per cent.

Air-bridge-denial operations

The strongest evidence for deterrence is the extensive operational data collected during several operations mounted in the 1990s against trafficker flights

*Pulse operations begin with a concentration of counter-drug effort to deter traffickers. The belief is that the effects of this disruption of organized trafficking will last long after the concentration of effort has subsided to a more typical level of effort.

transporting cocaine base from Peru to Colombia. Calibration of the full deterrence model requires independent estimates of P_1 and W for each period of interest.* The Narcotics Affairs Section of the United States Embassy in Peru obtained reports on almost all flights over the air bridge and verified the reports of air interceptions. The ratio of interceptions to flights is an estimate of P_1 . For the value of W , the following data sources were used: (a) estimates of the amount of cocaine being smuggled on each observed flight, supplied by the Tactical Analysis Team of the United States Embassy, and (b) the estimate of all cocaine produced based on satellite crop surveys of total Peruvian coca production, carried out by the United States Crime and Narcotics Center. Then an estimate of W is the ratio of all cocaine flown to all available to be flown. During 1993-1994, a period of stable counter-drug air interception effort, the estimates made by the Tactical Analysis Team accounted for nearly 90 per cent of estimated Peruvian production. Also during this 16-month period, air trafficking surged on three occasions to more than double its minimum, yet the observed amount flown during the first and second halves of this period balanced within 1.5 per cent [3]. This argues for the consistency and near completeness of the flight observations because analysts could not have adjusted monthly reports to satisfy end-of-period balances. Therefore, the drop from this unimpeded trafficking period to the stable periods following the implementation of the force-down or shoot-down policy period provides a quantitative estimate of the impact of deterrence.

Three Peruvian air-bridge-denial operations and the intermediate periods provide calibration data for the willingness of cocaine smugglers to continue their flights despite facing lethal consequences [3]. Operation Support Justice III** began in September 1991 in Colombia and in November 1991 in Peru and ended on 29 April 1992. This early operation was quite effective in reducing traffic because Peruvian Air Force pilots often fired upon aircraft being used by traffickers. However, lacking adequate procedural constraints, the Peruvian Air Force mistakenly fired on a C-130 aircraft operated by the Government of the United States, killing one crew member. The Government of the United States ended its detection and monitoring support for the operation shortly afterwards.

Operation Support Justice IV began in November 1992 in Colombia and in January 1993 in Peru and ended on 1 May 1994. The Government of the United States resumed detection and monitoring support, with tight restrictions on engagements to prevent fatalities. Although coca prices dropped significantly, traffic in illicit drugs continued unabated, with almost all of the available

*Monthly reports of interceptions were grouped into statistically significant operational periods (each period had four or more interceptions) and all sources of detection bias were examined to estimate the plausible range of uncertainty. As these adjustments and uncertainty ranges did not significantly affect the result, they have not been explained in the present article [3].

**Operations Support Justice I and II were short training exercises. Although Operation Support Justice II was a notable success, with one interception made and 42 aircraft seized, and resulted in a small dip in coca base prices, it lasted less than two months and cannot be called a major operation.

cocaine base transported. The operation ended when the Government of the United States withdrew its support because Colombia wanted to reinstate lethal engagements.

The intermediate periods before and between the various Support Justice operations did not involve lethal interception, except for the period between the end of Operation Support Justice IV and the implementation of the force-down or shoot-down policy. During this latter period with poor detection efficiency, only a few interceptions were made. The force-down or shoot-down policy was implemented after both the United States Congress and President approved support for lethal engagements under prescribed operational conditions. The policy was implemented in January 1995 in Colombia, but only effectively implemented in Peru in March 1995. The operation was an immediate success: illicit traffic plummeted for the following seven months and coca base prices dropped well below the point at which growers could break even. Operations continued throughout 1999, with only a brief pause in December 1995. By 1999, coca cultivation in Peru had shrunk to 34 per cent of its former level. Although it seems remarkable that the pilots of the aircraft carrying the illicit drugs did not surrender to Peruvian interceptors and accept their chances in court or jail when confronting almost certain death in the air, it has been shown that people are willing to accept 1,000 times as much risk when they are in control as when someone else is controlling the risk [5].

Other events in Colombia and Peru

Raids of Colombian cocaine hydrochloride laboratories were carried out by the Colombian National Police in December 1996 and January 1997. The raids destroyed a large complex of cocaine laboratories and diminished demand for cocaine base from Peru for several months, compounding the effect of the force-down or shoot-down policy.

While there were many noteworthy secondary events in the 1990s, none of them can be credibly argued to be the primary cause of significant damage to the coca market in Peru [3]. In September 1992, five months after Operation Support Justice III ended, the Government of Peru captured Abimael Guzman, the leader of the Sendero Luminoso (Shining Path) guerrillas. Thereafter, the influence of the Sendero Luminoso plummeted and government control within the growing areas increased, but the level of trafficking remained unchanged. In mid-1995, two months after the force-down or shoot-down policy was implemented in Peru, three principal leaders of the Cali Cartel were arrested. However, the precipitous drop in cocaine prices in Peru had already occurred in conjunction with the implementation of the force-down or shoot-down policy. Formal time series analysis has demonstrated that the air interception operations alone explain price fluctuations in the United States during the 1990s [9]. The timing of other secondary events was such that they could not be a plausible cause of trafficking decline or price and purity effects in the United States [3].

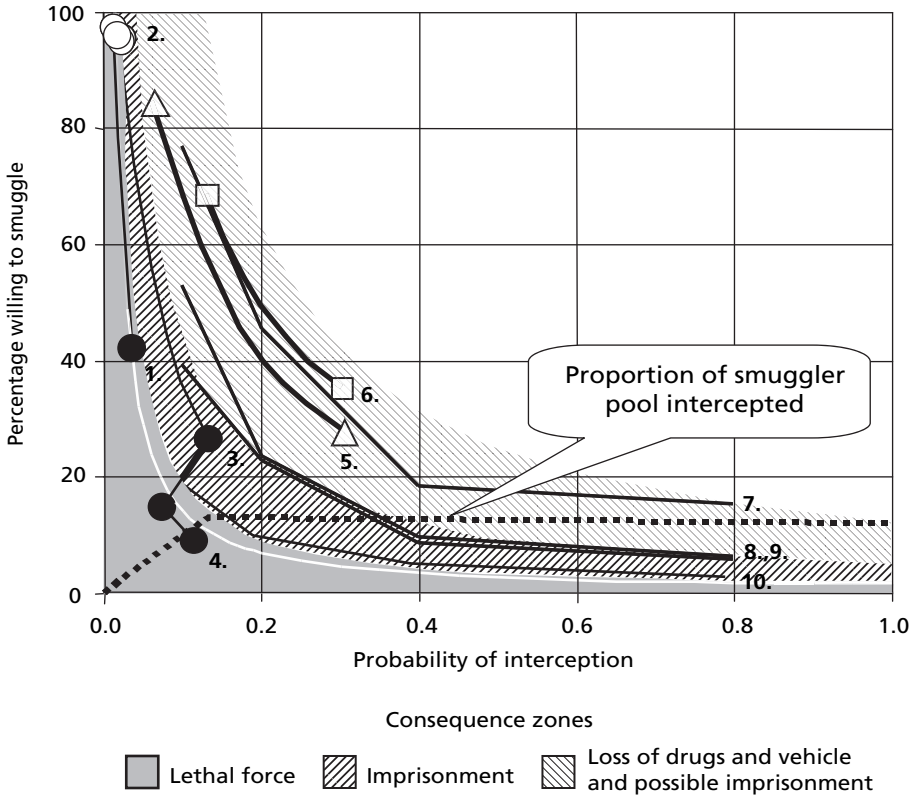
Calibration of the willingness function with real operational data

Figure II shows the willingness function overlaid with real counter-cocaine operational data as a means of calibrating the deterrence thresholds for several sets of conditions. The willingness functions for three different values of P_0 define the boundary contours for three zones of deterrence consequences, representing risk exposure to distinctly different consequences for smugglers: (a) lethal force, (b) imprisonment and (c) loss of drugs and vehicle and possible imprisonment.

The “lethal-force zone” is bounded on the right by a threshold parameter of 2 per cent. The estimate of the average deterrence threshold for lethal interception across all of the operational periods with potential lethal force is 1.2 per cent, which defines the willingness function contour shown within the lethal zone in figure II. Just below a deterrence threshold of 1.2 per cent, traffickers appear to ignore even the risk of lethal consequences. Above that threshold, from 1.2 to 2 per cent, increasing numbers of traffickers would stop smuggling. The “imprisonment zone” encompasses deterrence threshold values from 2 to 5 per cent, corresponding to the interval between “self, imprisoned” and “associate, imprisoned” for the smugglers interviewed in prison. Somewhere in this range of thresholds defining the zone, almost all traffickers reach their individual threshold of deterrence when facing a threat of imprisonment. Finally, the “loss of drugs and vehicle and possible imprisonment zone” encompasses deterrence thresholds from 5 to 13 per cent. This zone begins where the previous one ended and reaches nearly double the deterrence threshold for “associate, caught”. This upper boundary is a practical choice, representing a limit to deterrence arising from a combination of consequences in which interception leads to capture in only some instances. For operations with these mixed outcomes and as the interception rate increases, the willingness of smugglers to continue should fall within this zone.

While the loss of vehicle or drugs alone becomes a deterrent somewhere in the remaining 13-100 per cent range of “thresholds”, economic losses probably outweigh the psychological concerns as interception rates reach 30 per cent or more. Figure II does not show the boundaries of the willingness function in this range because no data are available for them and psychological deterrence provides little advantage as a force multiplier.

At the far left with circular data points, figure II shows the complex sequence of air-bridge-denial efforts by plotting the interception rates and the willingness of traffickers to smuggle for each successive operation. Black circles designate operational periods involving the threat of lethal force, while white circles represent rules of engagement involving non-lethal interception. Typically, for the non-lethal interceptions, the Peruvian Air Force strafed the smugglers’ aircraft on the ground after the pilots had escaped, leaving the cocaine on board.

Figure II. Willingness function overlaid with operational data

Notes: The dates indicate the period of data consolidation for the points plotted in figure II with the following clarifications: two additional periods without lethal interception cover the periods before and after Operation Support Justice IV, which itself is split into two periods, the second beginning in October 1993. The force-down or shoot-down policy continued from its initiation to the end of the period shown, including a transition period of December 1995 to November 1996.

Air-bridge-denial operations in Peru:

1. Operation Support Justice III: November 1991 to April 1992;
2. Operation Support Justice IV: January 1993 to May 1994;
3. Force-down or shoot-down policy: March 1995 to November 1995;
4. Raids on Colombian laboratory complex: December 1996 to June 1997.

Other interception operations against cocaine smuggling:

5. Trafficker flights across the Caribbean: 1991 to 1996;
6. Operation "Frontier Shield": October 1996 to December 1996.

Inmate willingness to smuggle (cumulative) data subsets:

7. Associate, caught;
8. Associate, imprisoned;
9. Self, caught;
10. Self, imprisoned.

Interception procedures changed dramatically when the force-down or shoot-down policy was enforced. During the first nine months of implementation of the policy, only 26 per cent were willing to risk a 14 per cent chance of being intercepted. Since these percentages are averages taken over several months of an exponential decline in trafficking, the force-down or shoot-down data point in figure II does not fall precisely on the willingness function for interception with lethal consequences. Soon, smuggler pilots adjusted to the force-down or shoot-down policy because trafficking stabilized at a level well below 20 per cent during the transition period (plotted in figure II but not labelled or named). During this operational period and one including the raids on the Colombian cocaine hydrochloride laboratories, smugglers were constantly under threat of lethal consequences and the points in figure II marking these periods do match the willingness function. Figure II also shows Operation “Frontier Shield” and other operations to block trafficker flights across the Caribbean. Trafficking declined in response to the increased probability of interception for both of these operations according to the appropriate willingness function profile, that corresponding to the consequence of losing vehicles, cocaine and possibly being imprisoned if apprehended. During Operation “Frontier Shield”, traffickers learned to avoid eastern Caribbean routes and have never returned in such numbers; it is believed that deterrence effects linger in the smugglers’ memories.

Figure II also shows, by a dotted line, the proportion of the total potential smuggler pool that is intercepted for each level of interception probability corresponding to the deterrence model profile that defines the upper boundary of the zone with the least severe consequences. Initially, the number of interceptions rises in direct proportion to the probability of interception. But once the deterrence threshold has been exceeded, the decline in those willing to continue smuggling exactly compensates for the increased probability of interception to yield a constant number actually intercepted. This remarkable observation depends upon the fact that α , the fitted exponent in the willingness function, is statistically indistinguishable from -1.0 . Why this is so cries out for explanation, but, unfortunately, leads to too complex a discussion for the present article. However, it clearly suggests that the willingness function is a general property of the psychology of extreme risk-takers.

Other aspects of deterrence

During the interviews, the drug smugglers provided answers that offered insights into other aspects of deterrence [3]. Inmates were asked how many loads a smuggler or the owner of the drugs who did not smuggle would be willing to lose before stopping or changing methods. Unlike the willingness function, the mathematical representation of their responses was an exponential decay, which implies that each subsequent loss causes the same proportion of the remaining traffickers to quit. Thus, the inmates anticipated that for each additional load lost, with associates smuggling, 27 per cent of the remaining smugglers would drop out and, with associates as owners, 24 per cent would drop out. Smugglers

were also asked about their inclination to change location or method of operation as a function of perceived consequence. Their responses followed the same pattern as the willingness function, with the exception that the new thresholds were approximately half those of the former deterrence thresholds.

Finally, three important findings emerged from the analysis of drug-smuggler responses to questions on whether they would accept a greater risk of interception if offered higher fees. First, smugglers strongly discount the value of fees as the risk of interception increases. The fees necessary to induce everyone who might be willing to smuggle to do so rise in proportion to the square of the increased risk, such that, when the risk doubles, the fee required to persuade someone to smuggle increases fourfold. Second, the fees demanded by smugglers escalate as the consequences become more severe. Pilots flying cocaine from Peru to Colombia received about \$20,000 per flight if they expected to be unopposed, \$60,000 if they expected they might be intercepted but did not face a lethal threat and \$200,000 if facing a lethal threat, but with little chance of being intercepted. If they estimated their chances of being intercepted with lethal consequences to be greater than a few per cent, few were willing to pilot aircraft transporting cocaine even when offered \$2,000,000 [3,10]. Third, reconciling the inmate interview responses when they were asked, without reference to fees, if they would be willing to smuggle with their responses when they were asked about their willingness to take more risk in return for higher fees revealed the following: when simply asked about their willingness to smuggle, inmates assumed that they would be more generously compensated when they accepted a greater risk. This also suggests inmates can assess willingness to take risk in a single subjective response, independent of explicit considerations of compensation. The finding that subjects making decisions on taking risks for gains consider first whether the level of risk is acceptable and then examine the reward is just now emerging from psychology experiments carried out on college students [11].

Why deterrence matters

Although it has proved impractical to intercept or arrest more than approximately 30 per cent of those involved in the clandestine business of drug trafficking, law enforcement and other organizations attempting to control the supply of narcotics can nevertheless cause most traffickers to cease trafficking through the leverage offered by the psychology of deterrence. In the present article, several examples are given of deterrence causing a drop of 80 per cent or more in the number of successful smuggling attempts with interception rates of 30 per cent or less. If counter-cocaine activities did not cause the traffickers to cease trafficking in all cases, at least they forced them to resort to less effective and more expensive methods of trafficking.

The central contribution of the research described in the present article is the development of a mathematical expression for the psychology of deterrence, called the willingness function. This derived function is supported by a remarkably

diverse set of interviews with imprisoned smugglers and calibrated by data on several counter-cocaine operations, the most detailed and complex of which were the series of operations that shut down the air routes used by traffickers to fly cocaine base from Peru to Colombia. Other data from early automobile use and the enforcement of restrictions on commercial fishing also support the mathematical formulation. In addition, the very simplicity of the willingness function suggests that it might apply to extreme risk-taking in general.*

However, the promise of effective deterrence itself poses a dilemma. The resources and effort necessary to deter traffickers can only be justified if those directing counter-drug operations have the vision and confidence that deterrence is possible. This is one purpose of the present article: to describe the evidence justifying confidence in the ability of law enforcement organizations to deter traffickers from their criminal trade. Another dilemma arises from the typical methods used for measuring counter-drug performance, which is by number of traffickers arrested and by quantity of drugs seized. Because successful deterrence causes the production and movements of drugs to abate drastically, arrests and drug seizures also decline as traffickers give up their criminal enterprise. Therefore, new measures based on the economic and organizational damage to trafficker infrastructures are needed, such as dislocations in price per pure gram, disruptions to organizations revealed from arrested traffickers and real supply shortages on the streets. Such information would provide an early warning of changes, as well as more effectively sustain the support for successful deterrence.

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*The present article does not address directly experiments on the psychology of taking business risks and related modelling approaches, such as those based on expected utility theory [11]. Other, as yet unpublished, research carried out at the Institute for Defense Analyses re-analyses these documented results and obtains regression fits of comparable or better quality using the model developed in this article. This unpublished research also proves mathematically that the general mathematical form of expected utility theory models cannot fit the willingness function that is supported by the data presented in this article.

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