

# Lethal Closeness: The Evolution of a Small-World Drug Trafficking Network\*

BORIS SALAZAR\*\*

LINA MARÍA RESTREPO\*\*\*

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## Abstract

*The evolution of the drug trafficking network –so-called– ‘Cartel del Norte del Valle’, is studied using network analysis methods. We found that the average length between any pair of its members was bounded by 4—an attribute of small-world networks. In this tightly connected network, informational shocks induce fear and the unleashing of searches of threatening nodes, using available paths. Lethal violence ensues in clusters of increasing sizes that fragment the network, without compromising, however, the survival of the largest component, which proved to be resilient to massive violence. In spite of a success from the point of view of head counting, the US’ socialization program for drug traffickers did not effectively change the cyclical dynamics of the drug dealing business: war survivors took over what was left from the old network initiating a new cycle of business and violence.*

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\*\* Full-time Professor, Department of Economics, Universidad del Valle, Cali, Colombia. E-mail: bosalazar@gmail.com.

\*\*\* Professor, Department of Organizational Management, Pontificia Universidad Javeriana, Cali, Colombia. E-mail: ecolina@gmail.com

**Key words:** *violence, criminal networks, small-worlds, drug trafficking, connectedness.*

## Intimidades letales: la evolución de una red de tráfico de droga local

### Resumen

*La evolución del ‘cartel del norte del Valle’ es abordada a través del uso del análisis de redes. Encontramos que la menor distancia promedio entre cualquier par de sus miembros es menor que 4 —un atributo de las redes con la propiedad de mundos pequeños. En un mundo tan denso y conectado, choques informativos inducen miedo y el desencadenamiento de búsquedas de los nodos peligrosos, a través del uso de las trayectorias disponibles. La violencia letal emerge en clústers de tamaño creciente, sin comprometer, sin embargo, la supervivencia del componente más grande, que resultó ser resistente a la violencia masiva. Aunque el programa de socialización de traficantes de los Estados Unidos fue un éxito desde el punto de vista del conteo de cabezas, no cambió en forma efectiva la dinámica cíclica del negocio del tráfico de drogas: los sobrevivientes de la guerra se quedaron con lo que quedó de la vieja red iniciando un nuevo ciclo de negocios y violencia.*

**Palabras clave:** *violencia, redes criminales, mundos pequeños, narcotráfico, conectividad.*

## Intimidades letais: a evolução de uma rede de tráfico de droga local

### Resumo

*A evolução do “Cartel do Vale do norte” é analisado através do uso da análise de redes. Encontramos que a menor distância média entre qualquer par de seus membros é menor que 4, um atributo das redes com a propriedade de mundos pequenos. Em um mundo tão denso e conectado, choques informativos induzem medo e o desencadeamento de procuras dos nodos perigosos através do uso das trajetórias disponíveis. A violência letal emerge em clusters de tamanho crescente, sem comprometer, no entanto a supervivência do componente maior, que resultou*

*ser resistente à violência massiva. Embora o programa de socialização de traficantes dos Estados Unidos foi um sucesso, desde o ponto de vista da contagem de cabeças, não mudou de forma efetiva a dinâmica cíclica do negócio do tráfico de drogas: os sobreviventes da guerra se quedaram com o que ficou da velha rede iniciando um novo ciclo de negócios e violência.*

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## Introduction

In opposition to conventional wisdom, the worlds of drug trafficking are not made out of separated entities, but of tightly connected networks of social acquaintances, with average minimum paths not larger than 4 –a considerable fraction, at just two hops from each other. This closeness has proved to be lethal for their individual and collective survival. As the formation of links in drug trafficking networks involves both the opening of business opportunities and extremely volatile risk, the perception of unbearable threats induces lethal action against the sources of it.

Fear comes in the guise of discrete events, within a general background noise, equivalent to endogenous or exogenous informational shocks over the state of the network involved. One of those events may trigger the removal (killing) of the threatening nodes and of all the links and nodes connected to them. If at least one of them is a cut-point<sup>1</sup>, the ensuing fragmentation will be larger, inducing a smaller network, with a smaller giant component and a larger number of separated, small components. Exploiting the property of connectedness, and using as a main source the narrative of Andrés López's books<sup>2</sup> on the so-called '*Cartel de los sapos*', we reconstruct a specific Colombian drug trafficking network and suggest a dynamic process to describe and understand its endogenous fragmentation and reconfiguration, and its underlying property of resilience.

Our empirical and analytical exploration suggests that the unleashing of the basic forces of greed and fear, within a small-world network structure, induces an adaptative process over drug trafficking networks, whose main outcome is the spontaneous and violent control over the survival of chiefs, organizations and even over the value of their businesses, property and wealth. Extremely feared and power-

<sup>1</sup> A cut point is a node whose removal adds at least one component to the network.

<sup>2</sup> López wrote two books narrating the outcomes of the interaction between drug dealing chiefs within the context of the so-called '*Cartel del Norte del Valle*'. The title of the book alludes to the destructive effect that the US policy of exchanging confessions and money for lenient sentences had over the whole criminal organization. We also used printed media information.

ful drug trafficking chiefs vanish into the air in waves of bullet fire and treason, huge fortunes change hands in minutes, and a new generation of more violent, small time operatives climb up to the top of the business, in a seemingly cyclical and unceasing process of destruction and renewal.

The endogenous forces of destruction, however, do not managed to fully fragment the whole network undergoing violent transformation: a smaller ‘giant’, or largest, component survived all the incidents, suggesting that drug trafficking networks are resilient to huge waves of greed, fear and internecine warfare. The ‘center’, to express it otherwise, always held throughout all the period considered. Moreover, this result suggests that the basic structure of drug trafficking networks –and, in the first place, its big component— is preserved, no matter how destructive and violent its turbulent processes of interaction eventually turns to be.

It yields extra support to the hypothesis that drug trafficking will spontaneously survive as long as the most basic rules of the game do not change in a substantial way. Neither big chiefs, nor their prestige, abilities or business savvy –not even its reputed cruelty–, are in a position to compete with the silent strength of the structure and dynamics of the networks in which they act, kill and die. All the main characters of the story told by López are now dead, in a cell in an American prison or in hiding under another identity in the US. At the end of the process of warfare, destruction and fragmentation, a short-time military operator by the name of Luis Enrique Calle, *Comba*, has emerged as the reputed new leader of drug trafficking activity in Colombia.

## **1. Why the Small-World Property Matters in Drug Trafficking Networks?**

Empirical observation about the structure of the so-called ‘*Cartel de los sapos*’ network suggests that it has the property of connectedness: any pair of its members is linked through a finite and bounded path of steps or contacts. Moreover, they are pretty close to each other: only four steps separate, in average, any pair of its members. Four steps of

separation is indeed a small distance compared to the six or seven steps that separate human beings in most large or small-scale social networks enjoying the ‘small world’ property (Watts 1999, 2002; Watts and Strogatz 1998). The fact that this network happens to be a criminal one—and one of the most brutal, violent and powerful of the world for that matter—, only adds some extra excitement to an already awkward opening to investigate the consequences of the small world property on real life networks.

Most empirical research on the small world property has concentrated upon the unveiling of the topological properties of large real networks and of the consequences of small world connectivity for dynamical systems (Watts and Strogatz 1998; Newman 2001; Lijeros et al. 2001; Wagner and Fell 2001). Watts and Strogatz (1998) studied, for instance, the properties of the Hollywood film actors; US power grid and *C. elegans* networks, contributing, in passing, to a growing and progressive subfield: the study of the collective dynamics underlying human epidemics. (Ball et al. 1997; Nunez Amaral et al. 2000) Well into the writing of this article, we discovered that Goyal et al. (2005) used a similar strategy to ours to evaluate scientific cooperation between economists. However, they did not try to analyze the dynamical implications of the underlying pattern of cooperation.

A breakthrough global experiment on search in global social networks by Dodds et al. (2003) opened up a new vista into the empirical and cognitive potentiality of the small world property. In a critical note on Dodds et al., Mark Granovetter (2003) pointed out that confirming the robustness of Stanley Mailgram’s conjecture about how close everybody is to each other in a global society (no more than six steps in average) opens up new, and more profound, problems for network analysis:

The “small world” task of launching a message toward a target through an acquaintance is a clever way to estimate actual chain lengths. But it offers limited evidence on how much people actually know about their networks, and how they normally use them. (Granovetter 2003, 773, our emphasis.)

Granovetter's observation touched upon a generally overlooked difficulty: most of the empirical and theoretical analysis on the small world property stopped at confirming the existence, in real networks, of average chain lengths equal to or smaller than six. But they never tried to explore how people separated by those short chains of acquaintances would use the information contained in them and, more crucially, how they would collectively act upon that information. In short, it was a very static interpretation of a robust structural property of real social networks. Granovetter suggested a new line of inquiry:

The broadest issue this research raises is what chain-length estimation experiments tell us about natural social processes. They suggest the need to extend our study to a wide range of situations where network chain length actually matters. (Granovetter 2003, 774)

The connected world of Colombian drug dealers provides an opportunity to study the way in which real actors use information coming from small-worlds, launch successful searches of killing targets, and unleash processes of network transformation. Instead of the highly abstract processes normally used to study the vulnerability or resilience of real networks, we have here the opportunity to follow the unfolding of a spontaneous process of local search, violent removal of nodes, and network fragmentation within the boundaries of the dynamics of a real network. By the same token it is possible to compare the outcomes of blind and spontaneous fragmentation processes with the performance of formal destruction algorithms—optimal or random.

Here we stand in front of a sketch of the process we tried to study within the context of a Colombian drug trafficking network. An exogenous, or endogenous, event occurs affecting the relative position of one, two, or more network's members. It can be a negotiation—or the simple threat of it—with the US Justice authorities (including confessions involving the operation of rival chiefs and organizations), or a perceived attempt to attack the affected party, or a rumor indicating treason or duplicity. Given the size and reach of the perceived threat, the affected parties invest their coercitive resources into pursuing lethal action. In order to realize their plans they launch a search over

the network, trying to find a person close enough to the elimination target, so as to persuade him or her to cooperate in making the target “come out”. The search success is directly related to the average length of all chains linking victimizers and potential victims. As the average length is bounded by –and in several instances it is just that far– the probability of finding a contact that makes the victim “come out” is reasonably high.

Most events flowing in into the network do not affect its structure or unleash lethal searches for traitors and rivals. They are just business as usual –and sometimes not so usual: they may become unexpected sources of new and more successful business ventures and partnerships. For instance, when Víctor Patiño, Juan Carlos Ramírez and Jorge Asprilla were doing time together at the Villahermosa jail in Cali, Colombia, they had, in their own words, the best of times sending tens of tons of cocaine to the US every month (López, 2008). However, other events did have violent effects over the network structure, and, when they did happen, a predictable pattern of actions followed: searches are launched, dormant paths activated, and killing sprees triggered in clusters of searching, violence, and retaliation.

A few events of assassinations, facilitated by extremely short chains linking victimizers and victims, will be enough to illustrate the lethality of closeness in traffickers’ networks. In 1996, all powerful drug lord Orlando Henao befriended José Manuel Herrera, *El inválido*, one the brothers of its archenemy, *Pacho* Herrera, when both were doing time in jail and gained his trust. But after Henao ordered the killing of *Pacho* Herrera in a jailhouse to Palmira, José Manuel took revenge in his own hands and assassinated Henao in his cell at the Picota jail in Bogotá.

In order to kill Miguel Solano, Wílber Varela took advantage of the most effective path towards Solano: Solano’s old friend, *Chepe* Puello. An invitation to a trendy bar in Cartagena was enough to have Solano come out and become an easy target for *Comba* –then a hit men chief on the rise into Varela’s organization— and his men. And Puello fell through a similar path: a friend of his was contacted by people from



the Montoya organization, and Puello ended his days waiting for a beautiful model that was never to arrive, in a restaurant in Armenia. The most important link between US drug control agencies and Colombian traffickers, former Colombian police colonel Danilo González, was finally reached by his followers in the eve of his trip to the US by a mere fluke: González's lawyer lived in the same building where *Guacamaya*, one of his persecutors, had an apartment, too. None of them knew this, but when *Guacamaya* and his men were designing a plan to kill González, the colonel and his lawyer were seeing walking towards the building. The previous anxiety relaxed into the heat of going for the killing on the spot (López 2010, 143).

The traffickers' spontaneous reaction to incoming information had thus a solid basis on the structural properties of the trafficking network and on the underlying forces guiding traffickers' activity. Being a small world, the traffickers' network boasts high levels of betweenness and small average shortest path lengths between pairs of nodes. The combination of both properties has had a huge impact upon the high levels of violent activity unleashed by information and fear. Any piece of news involving flips, treasons, or negotiations with US authorities behind the backs of former associates and rivals activate mechanisms of survival on the affected parties. At that point, betweenness comes to the fore as a crucial property of trafficking networks: multiple paths pass through nodes that are connected to traffickers on both sides of the divide induced by information: friends and foes are linked by the same paths, not once but several times.

When searches are launched, many possible paths "compete" to become the one providing the required information. Even random searches can end up being successful: there are so many paths at hand that, once the search is started, hitting on an effective path is just a matter of time. Any of them can become a successful path to the potential victim and any of them, sometimes the same one, may ring the alarm for the latter one, configuring a pattern of open warfare between mutually endangered factions. Ensuing violence and attempts to negotiate temporary truces, or pacts of no aggression, use the same bounty of paths available within the traffickers' network.

Drug lords of course know the dangers of being so close to each other, but cannot do anything effective to overcome that basic weakness. A fully isolated life, with no contacts whatsoever outside the most inner circle of the own organization would imply, by the same token, a total lack of information about the actions, expectations and plans of their rivals. As a matter of fact, some of them have tried very hard to play the safe card of full isolation, but they have failed: the world they lived in was so connected that it was impossible to effectively disappear from the outside world. An exogenous event, out of their control, and coming out from a world they did not know—a world in which they needed serious help in order to just barely understand the rules of the game—would have been about to hit all of them with extreme force. But it was not just an isolated event. In fact, it was the opening of a *process* that would have to become a permanent, and shifting, background noise.

## 2. Background noise

Underlying the whole period under scrutiny was what would have to become the most effective weapon of traffickers' destruction: the possibility of closing legal deals with the US justice in exchange for money and information, concerning the trafficking operation of the parties involved and of their colleagues, associates and rivals. The idea was always in the air and involved, in its first incarnations, global deals with the Colombian government, including the mythical offer to pay Colombia's external debt, or finishing up the whole drug dealing business, in exchange for lenience and a peaceful life in Colombia. It never worked, firstly because the new and obscure trafficking chiefs of the so-called '*Cartel del Norte del Valle*' were at that moment at the peak of their drug dealing activity: global agreements to close down their business would have implied the loss of a flow of money well into the billions of dollars in revenue.

And, secondly, at the end of the 90s, a new alternative took over the space of potential negotiations between traffickers and state authorities. Instead of looking for agreements with Colombian authorities, traffickers started to recognize that the only state authority to negotiate with, if a serious deal was ever to be struck, was the US

government, in particular the agencies in charge of the control of drug dealing and the Department of Justice. In spite of this, there is no definitive evidence of how and who created this new alternative. It appears to be more certain to think it was rather a social creation, involving a complex and changing alliance conformed by DEA agents, US justice authorities, and a small number of incredibly lucky and skillful intermediaries — one of these, the CIA spy and fashion photographer Baruch Vega, can be read like a character out of a traffickers-biased John Le Carré's novel (Reyes 2007; Téllez and Lesmes 2006). However, there is no doubt that the official initiative came out of Janet Reno's tenure as US general attorney. The pompous title for this original turn of the screw in drug dealing control was the 'Colombian Traffickers Socialization Program', and a close friend of Reno's, Theresa van Vliet, was its visible head in South Florida (Téllez and Lesmes 2006, 41).

At the beginning, hope was the predominant mood in the traffickers' world. Informed that small drug dealers had struck deals with the US Justice, all big chiefs of '*El cartel del Norte del Valle*' considered the possibility of entering the process. Particularly active and hopeful was Carlos Castaño, the vocal leader of the paramilitary group AUC, and an authentic 'hub' of Colombian organized crime, whose stronghold on the mountains of the Northern department of Córdoba was visited all year round by traffickers, paramilitaries, politicians, and business men, in the search for killing rivals, asking for lenience, or planning the overthrow of a particularly weak government. Castaño promoted general meetings of the most conspicuous traffickers, he exchanged several e-mail messages with US justice officers, and was in his way to close a deal with the US justice when his former cronies in the AUC, including his own brother Vicente, ordered his execution.

Almost all the higher up drug lords of the '*Cartel del Norte*' traveled to Panamá, talked to lawyers and intermediaries, and in some cases, even waited two or three days long, in apartments located on exclusive northern suburbs of Bogotá, for the visit of Baruch Vega, in order to finesse out the details of his agreement with US Justice authorities —as Hernando Gómez, *Rasguño*, did, to seriously risk his

security, on December, 1999<sup>3</sup>. Particularly this year the sky literally fell on the Colombian traffickers' heads. The Millennium Operation had shown that all traffickers were vulnerable to the combined pressure and intelligence of US and Colombian special and police forces, and that negotiating with US authorities was a reasonable alternative, considering the bleak options of extradition to, and jail for life in the US (López 2008, 95-100). As long as the strategy of negotiating peace in exchange for information and money was dealt as a coalitional problem, addressed in a collective way, there was no trouble in the midst of the traffickers' network and the mood was still of hope.

But hope turned into mistrust and fear, and both turned into violence when negotiations with the US authorities stopped being coalitional and became individual. Of all the major chiefs considering a final negotiation with US authorities, only Víctor Patiño closed a successful deal<sup>4</sup>. Consequences were proportional to his success, and to the size of the threats to former partners: all his family, except for his mother, and all his associates—lawyers, hit men, accountants, business associates—were killed in a brutal process of annihilation ordered and paid by his former partner in crime, Juan Carlos Ramírez, *Chupeta*. Records found in one of *Chupeta's* computers established that he paid, between February 11<sup>th</sup>, 2004 and March 30<sup>th</sup>, 2006,

<sup>3</sup> The version of the dialogue between El Médico --one intermediary in the negotiation and a trafficker of merit himself-- and Martínez, Rasguño's right hand, shows the mechanisms of fear and the risks involved in coming out to the city:

--Pero yo no le he avisado a Julio, ni a Nicolás. Nadie sabe cuándo es la reunión--interpeló El Médico, molesto.  
 --Esa es la idea. Hace rato que el señor no le sale a nadie a la ciudad. Ésa es una excepción gigantesca y él no confía ni en Nicolás ni en Julio, así que ellos son los que menos tienen que saber de esto (...) --replicó Martínez (López 2007, 97).

Martínez's second sentence is the key to understand the logic of the drug lords' actions: "There has been a long time since the master does not come out to meet anybody in the city". 'Coming out' is the highest risk of all for a trafficker. Only when they feel safe enough they do come out to other people. But of course they may be in deep error and have to pay their mistakes with their lives.

<sup>4</sup> The program was very successful in the lower echelons of Colombian drug trafficking: Baruch Vega claimed --supported on undisputed written records-- having helped 114 Colombian traffickers closed their deals with the US justice. (Tellez and Lesmes 2006; Reyes 2007)

3,113 million Colombian pesos to assassinate 82 people belonging to Patiño's organization.

### **3. The Emergence of a Closely Knitted Social Network**

How traffickers happened to live in a social network so connected, making them so close to each other that any threat or suspicion—real or imagined—could end up having dire consequences for all parties involved? The very idea of traffickers living in a tightly connected social network goes against the common sense idea of traffickers as untrusting, anti-social individuals, living clandestine lives, protected behind silence and hundreds of heavily armed bodyguards and hit men. No doubt, the bodyguards have been with them all time long, and in this way, it has been mutual social closeness.

The reasons behind the emergence of such a closely knitted social world are not difficult to grasp. Traffickers live in the same neighborhoods; go to the same discos, bars and restaurants; share lawyers, accountants, masseuses, personal trainers, doctors, plastic surgeons, and business associates; they run into each other in buildings, condominiums, and spas, and with some frequency stories and secrets pass from one man to another through shared women after long nights of heavy partying.

There is no doubt that homophily—the propensity of human beings to associate with their likes—has been a major force behind the process through which small arrangements of men committed to criminal activities became a small-world social network on its own. But homophily is not a natural attribute of social arrangements. Neither is an instinctive human propensity. It is more rather the outcome of the interaction between perceived similarity and social proximity through a mutually reinforcing process that puts people together that look too much alike to each other, and share similar social stories and paths (Kossinets and Watts 2009).

Thus, connectedness is not just a matter of homophily. Basic forces of greed, fear and survival<sup>5</sup> are also behind the observed traffickers' preference for being close to those that look and act like them. They need to be close to each other in order to be aware of the plans, moves and fears of their potential enemies, as well as to know about new business opportunities. It is a tricky closeness. Ideally they would prefer to be close enough to their rivals and colleagues as to know their whereabouts and plans, and distant enough so as not being reachable by them. However, this is just an ideal strategy, easily overcome by the flow of events in traffickers' networks. In real life, the small-world's rules dominate, and not even hiding in a remote and secluded place insures a drug lord from being reached by his enemies through an unsuspected path. Geographical distances are overcome by social closeness and the unstoppable flow of information even between factions in the middle of a bloody feud. The fall of the evasive and powerful drug lord Diego Montoya is a good example of how social closeness can overcome all natural geographical obstacles. When *Carmelo*, one his closest associates, negotiated a deal with the US authorities, Montoya's fate was sealed: he was easily located in one his hideouts in Colombia's country side, and extradited to the US (López 2010).

#### 4. Evolution of a traffickers' network

The original traffickers' network coming out of López's books had 205 members, an average degree<sup>6</sup> of 4.54, 446 links, a betweenness degree of 0.1667, and a small average length of minimum paths, 3.71. It was a small-world social network, with a considerably high level of betweenness and a huge large component encompassing almost all nodes in the network: 199 nodes belonged to it.

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<sup>5</sup> Formal models depicting the outcomes produced by the interaction of greed, survival instinct and fear within network contexts are strongly needed. We are now working on that research line.

<sup>6</sup> Degree is the number of links incident to a node. Average degree is the summation over all nodes' degrees divided by N, the total number of nodes.

**Table 1. Structural measures for the original and final networks**

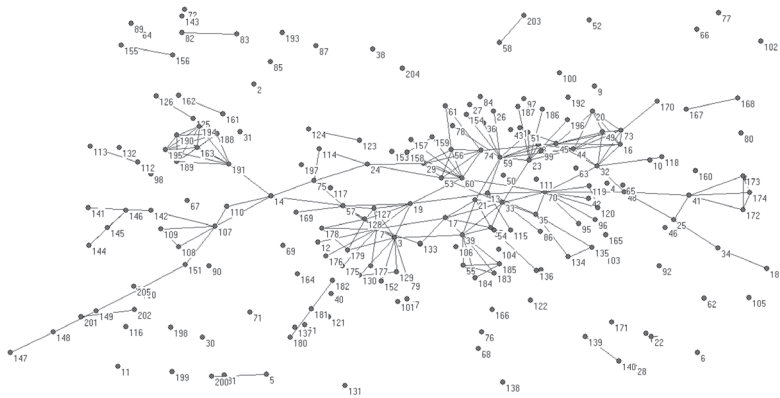
Structural Measures	First network	Final network
Size of the largest component	199	125
Average degree	4.5463415	2.0195122
Density	0.022286	0.0098996
Number of links	466	207
Size of events	0	92
Betweenness degree	0.1667	0.06948
Average distance	3.71603	4.59593
Diameter	12	14
Node with the highest betweenness degree	70 Víctor Patiño	14 Don Berna
Fragmentation	0.988857006	0.99505022

Source: Authors' estimation processed with Pajek, from *El Cartel de los Sapos*.

Fifteen years, and 23 events, later, informational shocks had induced clusters of lethal violence that visibly changed the network's basic structure. The network's average degree, the number of links, and the betweenness degree fell as a consequence of the process of killing and fragmentation induced by the informational shocks coming out, in the main, from the new US policy of exchanging leniency for confessions and money.

But fragmentation was never to endanger one of the basic attributes of the network: the largest component<sup>7</sup> remained connected through the whole period of turmoil and destruction. Though smaller with respect to the size of the original largest component, the final one still had 125 nodes—not a small size considering the brutal process of annihilation happened in the interim.

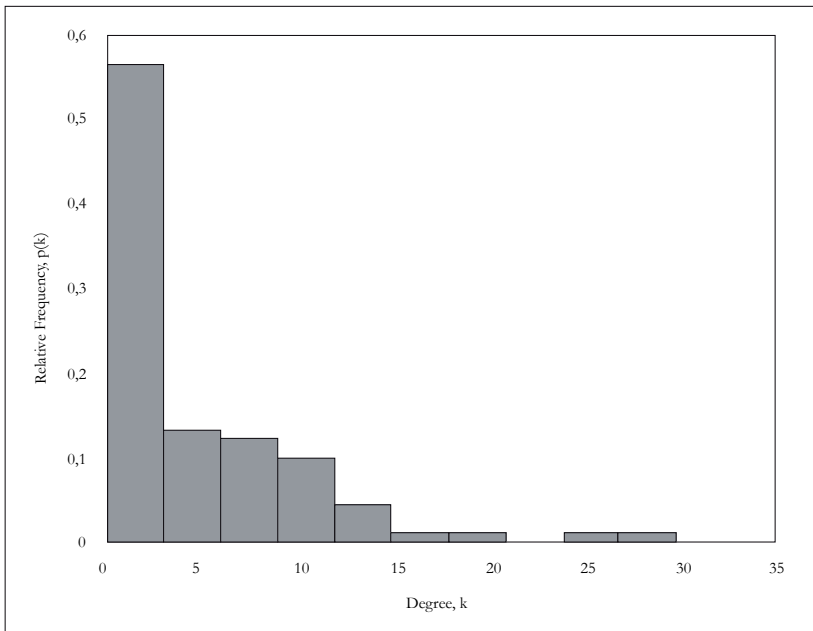
<sup>7</sup> A component is the maximal connected sub-graph of a network. A connected sub-graph is one in which all pairs of nodes have a path of links connecting them. Network analysts are interested in the size of the largest component of a network, or in the fraction of the total network occupied by the largest component. As components are connected, the probability of information and behavior flowing through the network increases generating collective action and aggregate dynamics.

**Graph 1. Traffickers' network after the final event**

The conjecture that the traffickers' network under analysis was in fact a small-world is largely confirmed when studying the network's degree probability distribution. Most of the nodes had small degree, and a few had degrees larger than 20, two of them reaching 30 links, following a power law: the probability of a node having a degree larger than  $k$  falls with coefficient  $\alpha$  according to:  $p_{>k} \propto k^{-\alpha}$ , where  $c$  is a constant and  $\alpha$  is the power at which the probability falls.



**Figure 1. Degree histogram: frequency of nodes having degree  $k$  vs.  $k$**



Source: Authors.

**Table 2. Frequency of nodes with degree  $k$**

Lower bound	Upper bound	Frequency	Relative Frequency	Density
<b>0</b>	3	116	0.566	0.189
<b>3</b>	6	27	0.132	0.044
<b>6</b>	9	25	0.122	0.041
<b>9</b>	12	20	0.098	0.033
<b>12</b>	15	9	0.044	0.015
<b>15</b>	18	2	0.010	0.003
<b>18</b>	21	2	0.010	0.003
<b>21</b>	24	0	0.000	0.000
<b>24</b>	27	2	0.010	0.003
<b>27</b>	30	2	0.010	0.003

Source: Authors.

In order to understand the relationships between the networks' structural properties (high betweenness degree and total degree) and the violent dynamics induced by the shifting background noise associated with the US new policy, we investigated the probability of a node staying into the network. As a high betweenness degree facilitated the flow of information and improved the probability of starting successful searches for threatening nodes, we conjectured that the probability of a node staying into network was negatively related to its betweenness degree, and positively related to its total degree in the original network. We estimated a logistic model where the probability  $P_i$  was defined by:

$$P_i = \begin{cases} 1 & \text{if the individual stays into the network after all events happened} \\ 0 & \text{otherwise (it was removed in previous event)} \end{cases}$$

It follows that,

$$\Pr ob(Y_i = 1 | X_{1i}, X_{2i}) = \frac{1}{1 + e^{-\alpha - \beta_1 X_{1i} - \beta_2 X_{2i}}} = \frac{e^{\alpha + \beta_1 X_{1i} + \beta_2 X_{2i}}}{1 + e^{\alpha + \beta_1 X_{1i} + \beta_2 X_{2i}}}$$

Where  $X_{1i}$  is the betweenness degree of node  $i$  and  $X_{2i}$  is its total degree.

The below results suggest that higher betweenness degrees predict a lower probability of staying into the network, whereas higher total degrees have the opposite effect. This is a reflection of the substantial effect that the multiplicity of available paths had on completing successful searches on chosen targets, and eventually assassinate them. The effect of total degree on the probability of a node staying into the network had the expected sign, suggesting that the sheer strength of his connections increases a node's probability of survival.

Two notes of caution are due here: First, the probabilistic model used here is static in nature and is not well endowed to treat the dynamic process of destruction and reconfiguration of the trafficking network we are trying to study. There are some formal alternatives available.

For instance, Heckman (1981) working on a list of very well-known stochastic processes (Markov models, Pólya schemes, Bernoulli models and renewal processes) suggested a strategy to deal with processes in which the relevant probability is changing as the stochastic process unravels. Heckman provided a heuristic to choose the relevant model according to the underlying process. If, for instance, only what happened in the last period was relevant to the persistence of a node in the network, a Markov process should be the model of preference. But if the whole previous history is relevant to explain the removal or permanence of nodes, a Pólya process will be the sensitive choice.

Although it seems according to intuition that higher total degrees could be a positive factor into the survival probability of any node, we have not uncovered the process by means of which higher total degrees contribute positively to the survival of nodes in a network going through a violent conflict. At this point, it is difficult to establish a trade-off between total degree and betweenness coefficients. Of course, higher betweenness coefficients induce more information through the network, facilitate killing searches, and contribute to the effective removal of nodes. But we do not know for sure if nodes with smaller betweenness coefficients, being less visible, are less prone to fall to the outbursts of violence, nor how higher total degree would contribute to the survival of nodes endowed with that property.

**Table 3. Logistic Regression**

Permanence	Coef	Std. Err	z	P> z	[95% Conf. Interval]	
Betweenness degree	-25.1323	9.435693	-2.66	0.008	-43.62592	-6.638684
Total degree	0.1390327	0.0563889	2.47	0.017	.0285124	.2495529
Constant	0.2329894	0.2114911	1.10	0.271	-.1815256	.6475043

Source: *El Cartel de los Sapos*, and processed by the authors with STATA.

**Table 4. Marginal Effects**

Permanence	Coef	Std. Err	z	P> z	[95% Conf. Interval]	X
Between-ness degree	-5.833648	2.1851	-2.67	0.008	-10.1164 -1.55094	.012607
Total degree	0.0322719	0.1303	2.48	0.000	.006735 .057809	4.54634

Source: *El Cartel de los Sapos*, and processed by the authors with STATA.

#### 4.1 Highest betweenness nodes removal process

We then analyzed the network's fragmentation process induced by informational shocks through a comparison with two ideal fragmentation processes, in order to assess the relative power of the first one. The first routine under review tried to answer this question: How effective would be a process whereby an external force, or state planner, knowing the betweenness degree of all nodes in the network, will remove in each of the 23 events, or rounds, the node with the highest betweenness degree? After 23 iterations, 289 links had disappeared from the network, there were 102 weak (or one-link) components, average degree fell to 1.726, average distance hits bottom with just 2.234, and only 112 nodes stayed within the largest component<sup>8</sup>.

**Table 5. Comparison of structural measures after the iterated removal of cut-points: first, simulated, and final networks**

Structural Measures	First Network	Simulation	Final Network
Size of the largest component	199	160	125
Average degree	4.5463415	3.2780488	2.0195122
Density	0.022286	0.0160689	0.0098996
Number of links	466	336	207
Number of components (event size)	0	47	92
Betweenness degree	0.1667	0.10797	0.06948
Average distance	3.71603	3.5193	4.59593

<sup>8</sup> Note that the largest component remains large, even after so many rounds of systematic destruction.

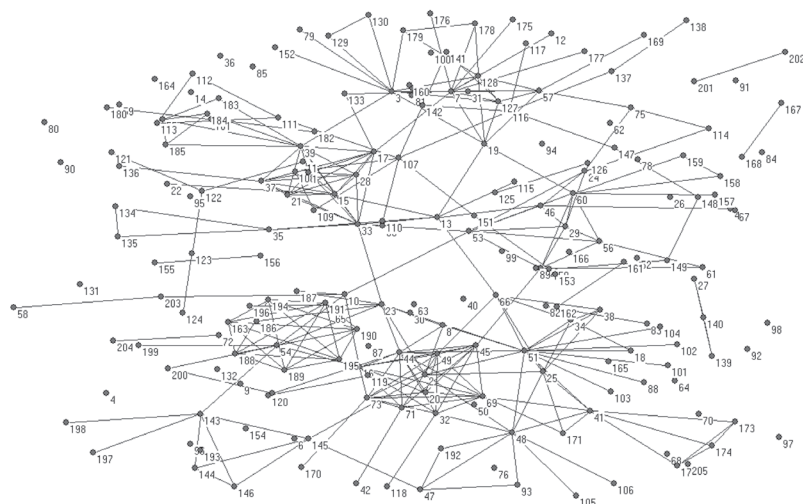
Diameter	12	9	14
Node with the highest betweenness degree	70 V́ctor Patiño	50 Don Berna	50 Don Berna
Fragmentation	0.988857006	0.991965567	0.99505022

Source: Authors' work based on *El Cartel de los Sapos*, and processed with Pajek Software.

Results about fragmentation, average degree and the emergence of weak components were within the expected bounds. However, the fall in average distance in the simulated network seems at first glance somewhat odd. Neither the real process, nor the simulated one yielded that type of result. Quite the contrary, in both cases the average distance increased –to 3.716 in the real process, and to 4.595 in the alternative simulated process. However, there is a very intuitive explanation. As high betweenness nodes disappeared from the network, the remaining nodes resulted eventually at shorter distances one from each other. An open question is still how they would act in a deeper small-world context.

As expected, the removal of nodes and the destruction of links through violence induced a larger average distance between nodes in the final real network, but still within the boundaries of small-worlds networks. The fact of substituting Don Berna through V́ctor Patiño as the node with the highest betweenness degree does deserve deeper consideration. It has to be considered firstly that the fact that a node has the highest betweenness coefficient does not necessarily mean that it is the most vulnerable of all. Having chosen a deal with the US justice, V́ctor Patiño left the scene and Don Berna emerged as the node with the most paths linking pairs of traffickers passing through him. Was he in fact the arbiter and supreme matchmaker in the world of traffickers? In a way, he was, for he was able of connecting organizations otherwise isolated and belonging to separate worlds within the criminal world at large.

**Graph 2. Network after the iterated removal of nodes with highest betweenness degree (23 iterations)**



Source: Authors.

The resilience of the largest component is impressive, given the huge clustering of violence in the trafficking network. Even if the external force was a US government's agency, and all drug lords with highest betweenness were to be removed from the network, traffickers would still belong to a huge large component and the network would remain a small-world one. This suggests both that traffickers' networks are largely resilient and difficult to destroy by means of direct attacks on their nodes and architecture, and that even the most aggressive anti-drug policy has to come to terms with the resilience of trafficking networks.

#### **4.2 Cut-Points Removal Routine**

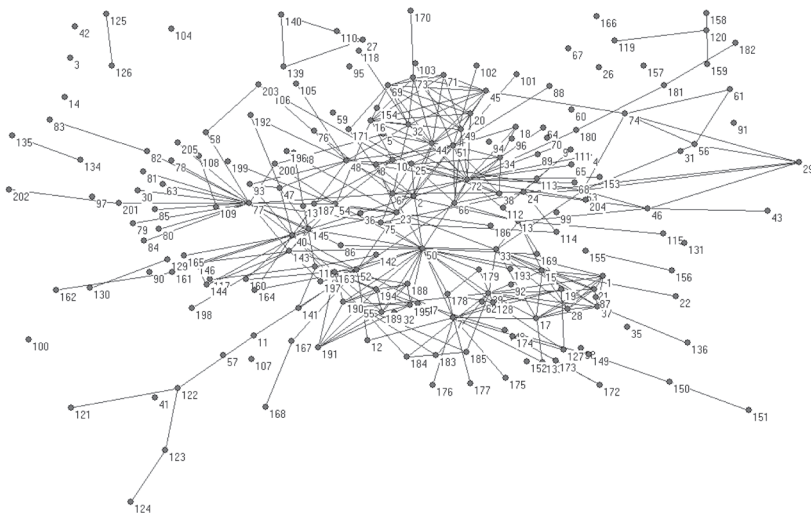
A natural path towards the destruction or full fragmentation of traffickers' network is the removal of all available cut-points and bridges<sup>9</sup>. We tried that routine but rapidly bump into a major structural obstacle: as we hit the third iteration, cut-points literally vanished. The reason

<sup>9</sup> A bridge is a link which, if removed, increases the number of components in the network.

is straightforward. As we are dealing with a large component and high betweenness degree network, transitivity and triadic closure dominate cut-points: there are too many paths between nodes for a node to be the only one connecting two otherwise isolated components. With this restriction it is no wonder that only nodes located at the periphery of the network were removed by means of this routine. In structural terms, the only way of fully fragmenting the whole network is through the global destruction of the largest component.

Perhaps that is what the US negotiation strategy was looking for when coalitional negotiations seemed to be at the top of its priorities by the end of the last century. However, it was never successful and was quickly replaced by a strategy of strong individual pressing over Colombian traffickers in situations of need.

**Graph 3. Network after the iterated removal of cut-points**



Source: Authors.

It is pretty obvious that the cut-point routine is highly inefficient in small-world, high betweenness degree networks. At the end of the third iteration, 160 nodes were still in the large component, and the

average distance was somewhat smaller than the one belonging to the original network. The efficiency of the real process ends up in an intermediate position between the more efficient high betweenness removal routine and the less efficient cut-point removal.

## 5. Conclusion

Even if the fragmentation of the original network was not –and could not– be the main objective of traffickers or state agencies, the observed drug trafficking network resilience (under all processes) is an important outcome for state agencies and researchers. Both generalized violence and conceptual routines of removal failed to fully undermining the activity and connectivity of a trafficking network attacked both from within and from outside. Huge head counting does not translate into the destruction of the networks that produce, distribute and sell illegal drugs into the US and Europe.

And generalized violence pays –with a twist. All the powerful drug lords that rose to dominance during the 90s and in the first years of this century are now dead, in jail or trying to arrange a deal with US justice. Both their prestige and their money conspired against their survival. Within such an environment, violent, small-time operators may have an edge in the silent battle for the control of what is left. *Comba's* vertiginous rise into the Colombian trafficking world is a good remainder of the strange logic at work in small-world drug trafficking networks.

The policy of negotiated surrender promoted by US agencies and independent intermediaries exploited, without a consciousness about it, the fact that drug trafficking networks are small-worlds, with average distances smaller than 4 between its members. Closeness proved to be lethal for most drug lords and their associates. But the unbelievable resilience of the largest component of those very same networks points out that organized drug trafficking is here to stay, at least until the rules of the game are not radically changed.



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