Poisonous connections

Diviák, Tomáš; Dijkstra, Jan Kornelis; Snijders, Tom A. B.

Published in:
Global Crime

DOI:
10.1080/17440572.2019.1645653

Publication date:
2020

Global Crime

ISSN: 1744-0572 (Print) 1744-0580 (Online) Journal homepage: https://www.tandfonline.com/loi/fglc20

Poisonous connections: a case study on a Czech counterfeit alcohol distribution network

Tomáš Diviák, Jan Kornelis Dijkstra & Tom A.B. Snijders

To cite this article: Tomáš Diviák, Jan Kornelis Dijkstra & Tom A.B. Snijders (2020) Poisonous connections: a case study on a Czech counterfeit alcohol distribution network, Global Crime, 21:1, 51-73, DOI: 10.1080/17440572.2019.1645653

To link to this article: https://doi.org/10.1080/17440572.2019.1645653

GLOBAL CRIME
2020, VOL. 21, NO. 1, 51–73
https://doi.org/10.1080/17440572.2019.1645653

Routledge
Taylor & Francis Group

ARTICLE

OPEN ACCESS Check for updates

Poisonous connections: a case study on a Czech counterfeit alcohol distribution network

Tomáš Diviák[a,b], Jan Kornelis Dijkstra[a] and Tom A.B. Snijders[a,c]

[a]Department of Sociology, University of Groningen, and Interuniversity Center for Social Science Theory and Methodology, Groningen, The Netherlands; [b]Department of Sociology, Faculty of Arts, Charles University, Prague, Czech Republic; [c]Emeritus Fellow, Nuffield College, University of Oxford, Oxford, Great Britain

ABSTRACT

Using data on 32 actors and ties among them drawn from available court files, we combine analytical sociology with statistical models for networks in order to analyse a case of a counterfeit alcohol distribution network from the Czech Republic. We formulate a theory of action and identify relational mechanisms which could explain how the structure of the network emerged and describe. We use the exponential random graph model to test these mechanisms. The analysis reveals that the two actors capable of manufacturing the poisonous mixture were considerably though not optimally proximate to others enabling fast distribution of the mixture. Our model results that the structure was formed by mechanisms of triadic closure, negative tendency to concentrate ties, and tie translation of pre-existing ties into operational ties. We conclude with the discussion of the implications our approach for the study of criminal networks.

ARTICLE HISTORY
Received 17 May 2018
Accepted 14 July 2019

KEYWORDS
Social network analysis; organized crime; exponential random graph models; analytical sociology; criminal networks; Methanol affair

Introduction

In recent years, social network analysis (SNA).[1] has become popular among criminologists, who apply it to different types of organised crime, ranging from gangs, smuggling and trafficking of illegal commodities, political corruption, to terrorism.[2]

Studies about trafficking and smuggling of illegal commodities have aimed to unravel the overall network structures. In comparison to co-offending networks and also to their legal counterparts, these networks tend to exhibit a lower numbers of ties (density) and lower concentration of ties around key actors (centralisation). Moreover, these networks also reveal stronger centralisation than terrorist networks.[3] For instance, Natarajan[4] found that the network of heroin distribution in New York City was composed of small compact groups which were loosely interconnected. There is also evidence that drug trafficking networks may be evolving over time in response to supply/demand, and to the activity of law enforcement agents.[5] Hughes, Bright, and Chalmers[6] map the functional and structural differentiation of poly-drug distribution networks operating

CONTACT Tomas Diviak t.diviak@rug.nl University of Groningen/ICS, Department of Sociology, Grote Kruisstraat 2/1, Groningen 9712 TS, The Netherlands
Supplemental data for this article can be accessed here.

simultaneously with multiple types of drugs. This differentiation may take different forms, such as outsourcing production to another drug syndicate, accompanied by the emergence of clear management structures with centralised oversight. A study by Lord and colleagues[7] on a counterfeit alcohol distribution found that the network was considerably resilient and adaptive due to a number of brokers who managed and oversaw the processes associated with production and distribution.

Despite the wide application of SNA, it has been criticised, particularly for two issues. First, network research on organised crime often lacks proper theoretical foundations,[8] being driven by available data rather than by theory.[9] Second, research on criminal networks strongly relies on descriptive measures, neglecting complex interdependencies among actors and ties and more in-depth explanations of criminal network structures.[10]

This paper aims to overcome both issues by using the theoretical approach of analytical sociology[11] and analytical criminology[12] in combination with statistical models developed for network data.[13] The analytical approach is based on identifying micro-level mechanisms which result in outcomes at the macro level. Specifically, we aim to identify relational mechanisms that bring about the observed network structure. Statistical models for social networks synergize with this aim, as they allow to disentangle the network structure into micro-elements representing relational mechanisms. There are several examples of previous studies of criminal networks using mechanism-oriented theory and statistical models for networks.[14] We build upon this work by explicitly formulating a theory of action for criminal networks and deriving hypotheses on relational mechanisms. Subsequently, we test the hypotheses with a statistical network model. This way, we deduce explanations from the theory of action first and then compare them with the model results to see if there is empirical support for them or not.

We study a case of a counterfeit alcohol distribution network from the Czech Republic which has become publicly known as the methanol affair. This network was uncovered in the second half of 2012 after its activities resulted in numerous cases of deaths and permanent medical consequences for tens of victims due to drinking methanol-diluted spirits. The poisonous mixture had been efficiently distributed to a lot of consumers across the whole country in a process of cooperation and coordination among actors who manufactured, distributed, and sold it. We aim to shed more light on this specific case combining a general theoretical and rigorous methodological framework.

Background of the case: the methanol affair

The case studied in this paper is a network of actors involved in the production and distribution of illegal alcoholic beverages mixed with poisonous methanol. In September 2012, this affair was under widespread attention from police and media in the Czech Republic when series of deaths and serious health damages, most prominently poisoning induced blindness, occurred after consuming a poisonous mix of alcoholic beverages with methanol. In the aftermath, around 140 people suffered health damage and more than fifty died. Because of the rapid outbreak and increase in the number of victims, Czech state officials decided to impose temporary prohibition across the whole Czech Republic and temporary restrictions on alcohol export from the Czech

Republic. These restrictions together with tax evasions associated with production and distribution of untaxed spirits resulted in strongly negative economic consequences.

During the investigation, it became apparent that the whole affair can be divided into two branches. The first one was based in the Zlín region in the eastern part of the Czech Republic and consisted of a long-term active organised criminal group led by RB, an entrepreneur and local *éminence grise*. This group developed an organised division of labour, provided a cover for illicit activities with legal business, and some of the actors routinely used intimidation, coercion, or physical confrontation in order to protect their illegal profits. These profits were mostly coming from tax evasion via production and distribution of untaxed alcoholic beverages. The second branch was located around the city of Ostrava and revolved around manufacturing and distribution of the incriminated lethal mix of alcohol and methanol. This mixture was originally created by a pair of actors, TK and RF, from whom it was distributed by JV, previously a legal distributor of spirits. The actors involved collaborated on the mixing of the poisonous drinks, storage, and distribution to small convenience stores or to potential customers directly.

Analytical sociology and network mechanisms

In this study we build upon analytical sociology.[15] The three pillars of this approach are mechanism-based explanations, the micro-macro link, and a theory of action. Regarding the first pillar, analytical sociology seeks to identify micro-level social mechanisms by identifying a constellation of entities and activities, typically actors and their actions, that are linked in such a way that they regularly bring about the phenomenon under study.[16] This approach can be fruitful for SNA which concerns actors and relations among them. In SNA, the mechanisms of interest are the relational mechanisms connected to patterning ties in networks.[17] These mechanisms reflect tendencies of actors to act in the network in certain ways by creating, maintaining, or dissolving ties. However, actors in the network are seldom able to oversee the entire structure of the network as their information radius is limited mostly to their personal network, that is, the other actors to whom they are directly connected, with some further information about the connections of their connections. Hence, the macro-level network structure arises as a consequence of the accumulation, overlap, and collision of individual actions via relational mechanisms.[18] This is the core of the second pillar of analytical sociology – explaining how macro outcomes are brought about by their micro foundations.

The analytical distinction between micro-relational mechanisms and macro-level outcomes is crucial here, as a particular characteristic of the whole network (a macro outcome), such as centralisation, is not necessarily the consequence of one relational mechanism of concentration of ties because multiple mechanisms operate simultaneously either reinforcing or cancelling each other out.[19] A strong centralisation of a drug distribution network might suggest that the central actors mobilised resources and efforts into organising and coordinating this network. However, this explanation may be incorrect if we also consider another mechanism such as triadic closure, in which three actors all become directly connected to each other. Hence, the centralisation of the network might have arisen as an unintended consequence of creating closed triads which incidentally overlap due to the inclusion of particular individuals, making them in turn central. A descriptive analysis of the network does not allow to untangle these

competing mechanisms. Therefore, it is necessary to use suitable statistical models for social networks to separate the contribution of several relational mechanisms to the structure.[20] Such statistical network models employ computer simulations to effectuate the micro-macro link.

Theory of action

The third pillar of analytical sociology is a theory of action.[21] The theory of action specifies motives, constraints, and capabilities of actors, that is what happens at the micro level. For our case, we need to clarify our assumptions on how actors will act (i.e., create, maintain or dissolve ties) in certain ways (representing relational mechanisms). We assume that actors act purposefully in order to reach their goals.[22] The primary goal here is to make financial profit. In this illegal spirit distribution network, it is reasonable to assume, which is further supported by the court testimonies of the offenders themselves, that the actors attempted to reach financial profit by the sub-goal of decreasing the cost of production through mixing alcohol with cheaper methanol and, subsequently, selling the beverages to consumers.

However, this goal is accompanied by an additional sub-goal, which constitutes a definitional feature of criminal networks, namely, the aim of actors to avoid detection and remain concealed.[23] In general, creating and maintaining ties is costly as actors need to mobilise resources, such as time or cognitive capacity.[24] The additional constraint of trying to avoid detection in criminal networks places 'extra costs' on ties as each tie in a criminal network increases visibility and thereby comes with a larger probability of being detected. This is the most important imperative of actors in criminal networks; subject to this constraint, they try to achieve the goals they had for joining the network.

The tension between both goals is captured in the efficiency/security trade-off.[25] This trade-off refers to the fact that the more the network is efficiently structured towards reaching its goals by having numerous ties, the less it is secure because of the increased visibility introduced by the increasing amount of ties. Conversely, the more securely the network is structured, the less efficient it is in reaching its goals. This conflict between efficiently reaching the illicit goal while maintaining security introduces tension into individual action. Whenever there would be a conflict between remaining concealed and generating profit, we assume actors would prefer security. The argument for this claim is that the violation of security would lead to the inability to pursue any financial profit as being arrested actors cannot manufacture and distribute illicit alcohol in the market.

Network as a channel for flows

The network of the methanol affair raised public and law enforcement attention because of how quickly the poisonous beverages spread and killed or injured considerable numbers of victims. How is it possible that a network of 32 actors, with only one pair of them capable of manufacturing the mixture, was so deadly? Networks have been regarded as channels for flows of various types of resources.[26] From this point of view, one question is how the individual actors contributed to the distribution of poisonous spirits based on their position within the network and within the distribution flow. A major aspect of network position is actor centrality[27] – the more central actors are,

the more influential they are for the distribution. This does not necessarily overlap with the actors' position within the distribution chain, where the importance of actors is based on how close they are to the pair of manufacturers. The closer actors are to the manufacturers the sooner they may profit from selling a batch of poisonous spirits either to other involved actors or directly to consumers.

Next to individual actors, who can be assessed in terms of their contribution to flows in the network, the structure of the network as a whole can also be characterised in similar way. The longer path a batch of bottles has to travel in order to reach a consumer, the more time it takes and the more expensive it is and likely to be uncovered. Thus, an ideal distribution network from this point of view would have the shortest possible paths from the manufacturers to the remaining actors, which implies that the pair of manufacturers would have direct ties to all the other actors. In terms of the efficiency/security trade-off, this would maximise the efficiency, but it would maximise the vulnerability at the same time. The two manufacturers might have had some naïve conception of this, when they started to look for others to distribute the mixture. The question here is to what extent the observed network of this case optimised the closeness of the manufacturers to their co-offenders, enabling the quick distribution of the potentially lethal mixture. We subsequently aim to test which relational mechanisms can explain this overall network structure.

Structure of criminal networks

The structure of the network may arise from endogenous structural mechanisms, independent of any other exogenous factors, reflecting a process of network self-organisation. This simply means that creation or dissolution of ties depends on the existence and/or absence of other ties in the network.[28] The term 'flexible order' has been used in criminal networks with a similar meaning, denoting the proposition that there is no need for an architecture or plan for criminal network structure; rather, it emerges from interactions and relations among members of the network.[29] The most fundamental structural endogenous mechanisms are preferential attachment, closure, and brokerage. While these mechanisms are general, we argue how they might have specifically influenced our case.

Preferential attachment describes how initial differences between actors in their numbers of ties cumulate over time to produce a highly skewed degree distribution with a few highly central actors and a lot of marginal ones.[30] According to this mechanism, the initial number of ties triggers a cumulative self-reinforcing process, where the probability that an actor creates/receives a new tie depends on the number of ties actors have – the more ties an actor has, the more likely new ties will be made to this actor in the future, which in turn increases the probability of having even more ties. This accumulation happens when having many ties increases visibility to other members, or potential members in the network, and also when it signifies power or a lucrative position.

In criminal networks, however, accumulation of ties has a clear disadvantage as each tie also increases the risk of visibility of the actor to law enforcers, thus undermining the aim of remaining concealed. In other words, while preferential attachment may increase efficiency, it decreases security. While the profit returns from every new tie may diminish rapidly, the chance of exposure may actually grow faster with each new tie, and the costs of maintaining

ties in terms of time or effort are more or less constant. The literature on strategic positioning in criminal networks suggests that actors in criminal networks actively restrict their direct ties in order to avoid detection.[31] Furthermore, actors joining the network may not even be aware of who is the central actor, as they would need to see the whole network in order to fully assess this, which is a doubtful assumption in covert settings.

Hypothesis 1: Actors display tendencies against preferential attachment.

Closure is a tendency of actors to close open micro-structures or, in friendship terms, to befriend the friends of current friends. Closure is manifested in the network by the presence of triangles, that is, triads in which all ties are present. The creation of closed triangles is associated with increased social control, trust, and cooperation, because actors embedded within closed structures can oversee one another, control and support each other, and easily coordinate their efforts.[32] All these effects strengthen the security of the network as they help to prevent defection and infiltration. These advantages of closed micro-structures may be a reason why actors display positive tendencies towards closure, despite the fact that the proliferation of ties makes the network as a whole more susceptible to detection due to increased visibility. However, actors themselves may not be aware of macro structural consequences of strong closure as that would require them to have a 'bird's eye view' over the entire network and mutually coordinate ties in some network-optimal way. But even in organisations with clearly defined formal organisational structures, parallel networks of informal ties emerge which may sometimes greatly differ from the officially prescribed structures.[33] Hence, a much more realistic assumption about actors is that they try to improve their position within their network neighbourhood by forming ties in a way they see as sufficient to achieve their goals.[34] Because the advantages of closure at the micro-level are directly experienced by actors rather than the disadvantages at the macro-level and they add to the security of the network by fostering trust and social support while enabling cooperation (and thus efficiency), we expect positive closure tendencies.

Hypothesis 2: Actors display tendencies towards closure.

Closure in a network with a given density is highest for networks composed of small densely connected clusters of actors that are not interconnected. For interconnecting these subgroups and limiting the extent of closure, the mechanism of brokerage may be important, as it is the tendency of actors to bridge between closed regions.[35] Brokerage thus allows unimpeded flows in the network and it also provides the brokers with a competitive advantage, which has been repeatedly documented in networks legal as well as criminal. The reason is that whatever flows in the network needs to pass through the broker in order to get from one part of the network to another.[36] It is certainly possible to imagine the inclination towards brokerage in the counterfeit alcohol distribution network, because this would enable the generation of profit, which undoubtedly is of interest in profit-oriented organised crime. Nevertheless, such profit serves mainly the broker and not the brokered actors. Moreover, it does not necessarily translate into the profit of the whole group. The arguments for brokerage assume an opposition between the aim of the individual and those of the group, potentially leading to free-riding, decreased control,

and defection, which would violate the security of the group. Substantial free-riding or defection were arguably not viable alternatives for actors involved in this case, as they were not able to produce nor distribute any larger amount of counterfeit alcohol on their own; also many of them were embedded in the network by being tied to other actors not only in terms of the illicit activities in the methanol affair, but also by being legitimate business partners or employers/employees. For these reasons, we would not expect a tendency for brokerage among actors in the network.

Hypothesis 3: Actors display tendencies against brokerage.

Individual attributes of actors in criminal networks

In addition to considering endogenous relational mechanisms, it is also necessary to account for individual attributes of actors involved in this type of network, because attributes reflect differences between actors in their abilities to contribute to reaching their goals and the collective goal, which will influence which ties they create.[37] Specifically, for a case of illegal manufacturing and distribution of alcohol, tie formation might be influenced by previous experiences of actors in legitimate business with spirits. There is a theoretical stream in the literature which points out the similarities between organised crime and legitimate organisations such as firms.[38] In this light, such experience with legitimate organisations and skills acquired therein may be useful for criminal activity.

This projection of business experience and corresponding skills and resources into criminal activity may happen through two relational mechanisms – generalised social selection and homophily. generalised social selection designates a situation in which actors who possess certain attributes display the tendency to acquire certain network positions, such as being central or peripheral.[39] Actors with strategic skills and resources may be important for the successful operation of the whole network thanks to which they may hold specific positions in its structure.[40] In this case, it is possible that resources and know-how gained in entrepreneurship may predispose their bearers to more central positions. A case in point may be the ability to manage employees, translated into managing co-offenders in a criminal network. Furthermore, actors with an entrepreneurial background may be more economic in the way they profit from their ties, as success in legitimate business requires good micromanagement of one's ties. Thus, the returns from ties in criminal networks may be less diminishing for entrepreneurs than for actors without this background. Hence, we would expect the entrepreneurs to be more active in the network.

Hypothesis 4: Entrepreneurs tend to be more active.

Another mechanism based on attributes is homophily,[41] which has been consistently shown to be a powerful driving force in many different empirical contexts, including criminal networks such as gangs.[42] Homophily is frequently expressed with the saying that 'birds of a feather flock together' as it is a tendency of actors to form ties to those who are alike themselves – in other words, to those who share the same attribute. In organised crime and in crime in general, it is possible to make a case for an inverse mechanism to homophily: heterophily, the preference for choosing partners different

from oneself in certain respects. The shortcoming of homophily is that mutually similar partners may frequently share the same resources and information, but contacts and ties to different others may also enable access to new resources and new information.[43] This is particularly beneficial for collaboration networks where differences may be mutually complementary.[44] The overreliance on similar alters decreases efficiency, as access to unavailable resources, knowledge and skills. This works for both entrepreneurs and non-entrepreneurs. Whereas entrepreneurs may need actors with certain skills, such as operating machines or reliable drivers, to execute the production and distribution of illegal alcohol, non-entrepreneurs may rely on entrepreneurs to participate in the first place and to receive orders on storage and distribution of the mixture. Thus, we expect the network to exhibit signs of heterophily leading to ties between entrepreneurs and non-entrepreneurs.

Hypothesis 5: Entrepreneurs tend to associate with non-entrepreneurs.

Pre-existing ties

Pre-existing ties are legitimate or legal relations that were established between members of criminal networks prior to the criminal activity itself. In the case of the methanol affair, these ties take the form of kinship, prior friendship, being employees of the same firm, or being legitimate business partners. There are two reasons why pre-existing ties has been of interest among researchers of criminal networks for a long time. First, it has been argued that pre-existing ties are a basis for interpersonal trust, which is deemed to be crucial in criminal environment, where mistrust or untrustworthy partners may have fatal consequences.[45] Second, these ties represent the intertwining of the organised crime with legitimate business and legitimate social relations.[46] Smith and Papachristos[47] even argue that this overlap of pre-existing and criminal ties is a cornerstone of organised crime, as it compensates for the lack of formal institutions and organisations, which warrant enforceability of contracts and commitments in licit relations. While friendship or kinship may anchor criminal cooperation in shared commitments and experience, preceding collaboration in legitimate business or other legal activities may be seen as a sign of credibility and success of criminal collaboration. In this respect, social or physical settings in which criminals may find information, resources or accomplices for their illicit activities, so-called convergence settings, may facilitate or outright enable criminal organisation and collaboration.[48] Taken together, pre-existing ties have the potential to be translated into criminal ties.

Research on multiplex social networks considers the co-occurrence of ties of different types.[49] The observation that multiple ties of different kind overlap (e. g., friendship and mutual help) may be brought about by different mechanisms. We postulate a mechanism of tie translation, that is, the tendency of actors to create operational ties on the basis of pre-existing ties. The presence of a pre-existing tie may increase the probability of the creation of an operational tie, but not the other way around. In this way pre-existing ties increase interpersonal trust, reduce uncertainty and risk, and thus, decrease the cost of creating operational ties. Embedding operational ties in pre-existing ties does not only increase security, but it also adds to the efficiency by making such

connections more 'economic'. For this reason, we expect positive effect of tie translation in the network under study.

Hypothesis 6: Actors tend to create operational ties on the basis of pre-existing ties.

Data collection and processing

This study relies on court files from three different courts which were judging the studied case in the Czech Republic. Court files have been used in previous studies yielding a valid representation of given network and providing a source data which has been deemed valid.[50] However, court files are not without their limits. A specific weakness of summaries of court proceeding is the fact that offenders themselves are interested in withholding as much information as possible in order to obtain the best possible sentence. This yields systematically incomplete data, which may or may not be uncovered by the investigation, court, or fellow offenders. Actors on the side of law enforcement, however, focus on trying to prove the guilt of the offenders, and thus scientifically interesting aspects, such as the evolution of offenders' relations or their individual qualities, may be omitted unless they are of specific importance for the court.

The data file was extracted from nineteen court records provided by the courts themselves, which together add up to more than one thousand pages of text. We performed all the data coding manually identifying all actors associated with the case. For each actor, the name was noted and their experience with legitimate business. All actors who were reported to be involved in the affair (i.e., they knew they were collaborating in the distribution of illegal beverages) were included in the analysis. This yielded a total of 32 actors in the network. All mentions of interactions and relations among any pair of actors were recorded including the exact citation of the court file and a code for the content of that particular relation/interaction. By far the most frequent codes were cooperation on manufacturing the illicit spirits, cooperation on their storage or transport, and supplying or demanding some amount of the beverages. However, most of these codes were not distinguishable from one another (e.g., whenever actors exchanged alcohol, it also always entailed some instructions about logistics and planning). All the ties with these codes were eventually coded as operational ties, as they serve the purpose of cooperating on the organisation of the criminal activity. The only other type of ties that was distinguishable in the court files were pre-existing ties. These ties mostly referred to friendship, kinship, legal business partnership, or employment or cooperation within distilleries (convergence settings), in which incriminated commodities were manufactured or stored. All the pre-existing ties chronologically preceded the ties coded as operational. In sum, we analyse two undirected networks – one of operational ties and one of pre-existing ties together with a binary nodal attribute indicating entrepreneurship.

Methods

Cohesion measures are used in order to assess the properties of a network as a whole.[51] Density is a proportion of ties present in the network relative to the maximum number of possible ties in the network. Degree centralisation is the ratio of the dispersion of the number of ties compared to a network with maximally concentrated ties.[52] Closure was

measured by the clustering coefficient, which is a ratio of complete ('closed') triangles to all two-paths in the network, that is, to all triads connected only by two ties. All these measures have a range from 0 to 1, where the closer the value is to 1, the denser (resp. more centralised or closed) the network is. Density and centralisation can also be expressed by average degree and the standard deviation of degrees respectively, which are also directly interpretable from the actors' perspective.[53] The cohesion of a network can also be expressed by the average geodesic (i.e., the shortest path length between a given pair) and diameter (i.e., the longest geodesic in the entire network). The shorter the geodesics and the diameter, the more cohesive the network. A descriptive measure of observed homophily/heterophily is the E-I index,[54] which ranges from −1 to 1, where −1 indicates that all ties are homophilous, whereas 1 indicates that all ties are heterophilous.

Geodesic distances are also important for characterising the importance of actors within the flow in the network and the speed of flows in the network as a whole. We computed the geodesic distances from the two actors who manufactured the poisonous beverages to all other actors, which indicates how long distances the beverages had to travel in order to get to each actor. For interpretation purposes, we computed the reciprocal of all these values,[55] so that higher values indicate shorter distances, i.e., higher importance. We then averaged these reciprocal distances to have an actor-level measure. The larger this number, the less important the actor is as it takes more time until the batch of bottles reaches him/her. The network-level characteristic derived from this measure (based on its average) indicates to what extent the network is similar to an ideally structured one for distribution. As described above, distances of all actors to the distributors in such an ideal network are equal to one. If the observed reciprocal geodesic distances are divided by this number, the result indicates how similar the observed network is to an ideally structured one where a value of one means the observed network has the shortest possible geodesic distances from the manufacturers to all the other actors. To capture the centrality of each actor in the network, we computed their degree.

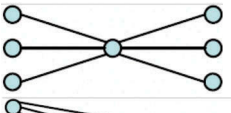
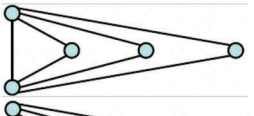
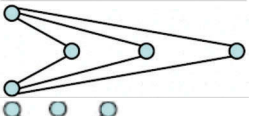
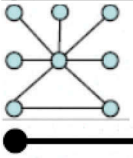
To disentangle effects of the micro-level mechanisms postulated in theory, it is necessary to apply statistical models designed for network data. Standard tools of statistical modelling and inference cannot be validly used for tie variables in networks for two reasons. The first reason for not using standard statistics is the fact that the latter is based on the underlying assumption of independence of observations. This assumption is principally violated in networks (further see e.g., Borgatti and colleagues' or Prell's textbook),[56] because tie variables are interdependent. The second reason is the contrast that, while standard statistical inference is oriented towards making inferences about a population based on the knowledge of a sample drawn from it under certain conditions, inference in networks is usually oriented towards making conclusions for a given data set about its representation by a model.[57] For both reasons, it is essential to apply network models which were developed to address the interdependence among observations.[58]

An important class of models used to represent micro-level mechanisms in networks is the exponential random graph model (ERGM).[59] ERGMs model the interdependence of tie variables with so-called configurations, which are basic building blocks of a network, for instance, closed triads of mutually interconnected actors or pairs of actors with the same value of a given attribute. The network structure is considered to be the result of accumulation, overlap, and collision of these configurations. Configurations can be used to represent theoretical local mechanisms and tendencies of actors to choose their ties, such as the

tendency to cooperate in closed triads or to bridge open micro-structures. The estimation of the ERGM parameters determines which of these mechanisms were significant for the formation of the network structure. This allows to consider several micro-social tendencies at the same time and to disentangle their effect in the resulting network. These models have already been used in studies of criminal networks.[60] Moreover, by explaining macro-level structures from their micro-level elements, ERGMs correspond with analytical sociology.

The dependent variables in ERGMs are the tie variables indicating the existence or non-existence of the ties in the observed network. These are binary variables like in logistic regression. The dependence between the tie variables is modelled by the aforementioned configurations, which capture many different ways in which the ties in the network may be dependent on each other. These configurations have a similar role as the explanatory variables in logistic regression. ERGMs are both computationally and conceptually considerably complex. Here, it is sufficient to say that first, the algorithm tries to find a distribution of networks which on average matches the observed frequencies of the configurations in the data. Based on the simulated distribution of networks, the model determines which of the configurations is statistically significant to explain the structure of the observed network. The output of the model is a list of parameter values, which express the conditional log odds of the probability of creating a tie in the observed network when, given the rest of the network, this tie would increase the frequency of the corresponding configuration by one. If the resulting parameter value is significant (in practice, at least twice as large as its standard error) and positive (negative), then the corresponding configuration is present (absent) more often than can be accounted for by the rest of the model. The configurations used to model the network of the methanol affair are summarised in Table 1 The accuracy of

Table 1. ERGM specification.

Exponential random graph model specification		
configuration	visual representation	interpretation
edges		Tendency to create ties (model intercept).
alternating star		Preferential attachment; H1 suggests negative effect.
alternating triangle		Closure; H2 suggests positive effect.
alternating two-path		Control configuration
alternating edge-triangle		Brokerage (Pattison & Snijders, 2013); H3 suggests negative effect.
attribute – activity		generalised social selection; H4 suggests positive effect.
attribute – interaction		Homophily; H5 suggests negative effect.
tie entrainment		Tie translation; H6 suggests positive effect.

estimates is judged by their t-ratios for convergence, which should be smaller than 0.1 in absolute value to consider the model being converged.

After the estimation of the model, it is also important to assess its goodness of fit to the data. In the ERGM framework, this is done by comparing the simulated distribution of networks with the observed network in terms of network characteristics that were not explicitly modelled, such as other configurations or global network properties. Specifically, for each of a set of such characteristics, its mean frequency in the simulated distribution is compared with its frequency in the observed network. If the absolute value of this difference divided by the standard error of the distribution is not too high (the usual cut-off is two), it can be said that the model has a reasonable fit to the data.

Results

Looking at Figure 1, it is apparent that the whole network is stitched together by the tie between actors SPj and JV. Without this connection, the whole network would fall apart into two mutually isolated components. Hence, it would be impossible to distribute the poisonous spirits among all actors as it was manufactured by a pair of actors (RF and TK), who both belong to the component around JV. According to the court files, JV had later become the main distributor of these illegal and poisonous alcohol drinks. Concurrently, JV started to cooperate with SPj, whom he knew from previous business activities and they considered each other to be good business partners (a case of tie translation, see Figure 2), thereby connecting both branches and getting the poisonous spirits to the group around RB. This group was previously focused on profiting from tax evasions by manufacturing untaxed spirits. Therefore, it appears that in this regard, the network perspective collates with the conclusions from the investigation and court proceedings.

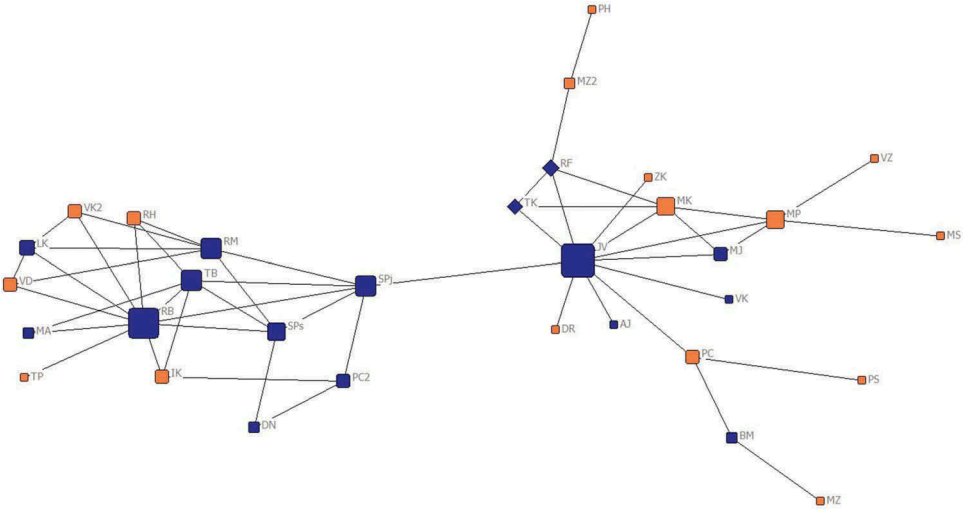


Figure 1. Sociogram of the network. Node size is based on degree. Colour of nodes represents attributes (entrepreneur = blue). The left hand side corresponds to the Zlin branch, whereas the right hand side corresponds to the Ostrava branch. The two diamond-shaped nodes in the Ostrava branch are the manufacturers.

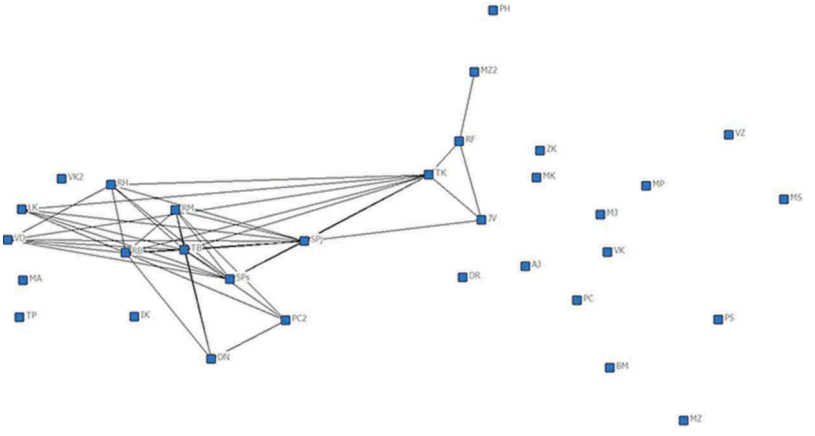


Figure 2. Sociogram of pre-existing ties. The positions of nodes in the visualisation is based on their position in Figure 1 for easy visual comparison.

Table 2. whole network measures.

Whole network descriptive measures	
statistic	value
number of nodes	32
number of ties	52
density	0.11
degree centralisation	0.27
average degree	3.25
standard deviation of degree	2.51
closure	0.28
average geodesic path length	3.15
diameter	6
number of entrepreneurs	16
E-I index (entrepreneur)	−0.04

Table 2 summarises the network descriptive measures. In total, there are 32 actors in the network connected by 52 ties, which together yields a density of 0.11. Hence, 11% of the theoretically possible ties are actually present in the network. While this number may not seem very high, we see from the sociogram that it is sufficient to keep the network connected in one component. Despite the fact that the network may appear centralised in the visualisation, there are multiple high degree actors and the centralisation is only 0.27. This information is complemented by the average and standard deviation of the degrees. On average, each actor has slightly more than three ties, but the degrees show non-negligible variability, which means that there are highly central as well as marginal actors in the network. Looking at the average geodesic path length and the diameter, the distances between actors are quite long considering the number of actors in the network. On average, information or resources flow between any pair of actors through more than three ties, while the longest distance is six 'steps'. The closure is 0.28, meaning that a bit more than one fourth of all potential triangles are closed, which means that the network is descriptively more open than closed. The value of the E-I index is −.04 indicating neither homophily nor heterophily.

Table 3. actor importance measures.

Network and flow positions			
actor	degree	actor	distance
JV	11	RF	source
RB	10	TK	source
RM	6	JV	1
SPj	6	MK	1
TB	6	MZ2	0.75
MP	5	SPj	0.5
MK	5	MP	0.5
SPs	5	AJ	0.5
LK	4	DR	0.5
RF	4	MJ	0.5

Table 3 displays the results of actor importance measures, capturing the top ten actors with highest degree centrality and shortest distances to the two manufacturers. As it can be seen, there is some overlap. The most prominent distributor JV and SPj have high values of both measures. An interesting fact is that while one of the manufacturers, RF, had above average degree and the other manufacturer, TK, had below average degree, neither of them was very central in the network. If they would have been more central, the speed of distribution of the poisonous beverages and thus the lethality of the network would be even higher. So while the distances from these two actors were short overall (2.8 on average, maximum of 4), the structure could have been even more efficient with regards to distribution of the lethal spirits. This is also reflected by the network-level measure, average reciprocal geodesic distance to the manufactures, which is 0.59, suggesting that the network reached 59% of its distributive potential. Other actors who combined considerable degree with closeness to the manufacturers were MK and MP. Again, when more actors would have had higher degrees and been in short distance to the manufactures, the network could have been more effective with the distribution.

Table 4 shows the results of the ERGM. T-ratios of each modelled parameter were < 0.07 in absolute value indicating good model convergence and thus sufficient accuracy of the estimates. A first conclusion is the remarkable lack of an effect of the two configurations related to entrepreneurship. Thus, there is no evidence that the network structure was systematically patterned by the experience of the actors in the sphere of legitimate business, which is in contrast with Hypotheses 4 and 5. The parallel between

Table 4. ERGM results. Statistically significant effects are bold.

Exponential random graph model results			
configuration	parameter	S.E.	t-ratio
structural effects			
edges	−1.240	1.256	−0.030
alternating star	**−1.060**	**0.493**	−0.041
alternating triangle	**0.726**	**0.310**	−0.045
alternating two-path	0.080	0.073	−0.039
alternatin edge-triangle	0.003	0.092	−0.037
individual effects			
entrepreneur – activity	0.829	0.575	−0.060
entrepreneur – homophily	−0.689	0.693	−0.049
dyadic effects			
pre-existing ties	**1.654**	**0.414**	0.013

Table 5. Goodness of fit results.

Goodness of fit for global network properties				
statistic	observed	simulated mean	simulated SD	t-ratio
standard deviation of degree	2.51	2.33	0.43	0.43
skewness of degree	1.48	1.25	0.56	0.41
clustering coefficient	0.28	0.28	0.05	0.07

organised crime and legal organisations[61] is not exhibited in this case. What does significantly shape the network, however, is the presence of pre-existing ties. The positive sign here indicates that a pre-existing tie between two actors increases the probability of an operational tie. This supports Hypothesis 6 and also the results from previous research.[62] Further, two structural effects are significant; alternating star and alternating triangle. Alternating star models the preferential attachment. A negative value of this parameter suggests that actors in the network display the opposite tendency, that is, they try to spread their ties evenly across alters in the network, as with every tie actors have, the probability that they will create another one decreases, in line with Hypothesis 1. The alternating triangle captures the tendency towards creating closed micro-structures. This parameter is positive in the network, so there is evidence for this tendency, which supports Hypothesis 2. If there is a triad of actors in the network with two ties among them, the probability that they will create the remaining tie is larger than if the two ties were not there. The alternating edge-triangle effect indicating brokerage from closed regions is not significant, hence there is no evidence to support Hypothesis 3. Overall, the formation of the network structure can be seen as the result of the combined operation of the mechanisms of triadic closure, tendency against preferential attachment, and the translation of pre-existing ties into operational ties.

As for the goodness of fit, all of the 25 statistics representing configurations implemented in MPNet show adequate fit of the model to the data (t-ratios < 1.2 in absolute value for effects not included in the model and < 0.1 for those included in the model). Additionally, Table 5 displays the goodness of fit of our model to the global properties of the network which are implemented in the MPNet software package – standard deviation of degree, skewness of degree and clustering coefficient. All the t-ratios are well below 1 in absolute value, indicating reasonable fit of the model to these global properties of the observed network.

We also re-analysed the two branches of the network separately to inspect whether there are differences between the two branches in terms of ERGM results. However, even though the models converged, none of the theoretically postulated effects were significant and standard errors were considerably high due to the lack of statistical power.[63] This is not surprising, as these two sub-networks are smaller than the networks usually considered to be well analysable by ERGMs.

Discussion and conclusion

This study revealed several findings from the analysis of the network of actors involved in the methanol affair. First, the structure of the network was quite specific in that it consisted of two components connected only through one bridging tie. At first sight, the

network does not show any obvious further structural features. That is, it is not remarkably dense nor sparse, heavily centralised nor decentralised, built on closed structures nor it is in any other way compartmentalised. Although the two manufacturers were not located particularly close to others, there are a few highly central actors in the network and some of them are also close to the two actors who manufactured the poisonous beverages. The ERGM results suggest that the structure of the network was brought about by the mechanisms of closure, inverse preferential attachment, and translation of pre-existing ties into operational ties. We also hypothesised a tendency to avoid brokerage and heterophily with respect to being entrepreneurs, but found no support for this.

We demonstrated the utility of combining analytical sociology with statistical models for social networks. Analytical sociology provides a theoretical framework for postulating relational mechanisms as explanations for the observed network structure, which can in turn be empirically tested with an appropriate statistical model for network data. Our results show strong effect of pre-existing ties on the creation of operational ties. Besides corresponding to extant theory,[64] the effect of pre-existing ties may have policy implications, as investigators may use this finding in an investigation and track potential co-offenders along the lines of already existing connections in legitimate spheres or personal domain, such as friendship. To our knowledge, police investigators already proceed this way frequently and thus our findings confirm the importance of such procedures. Despite the strong theoretical foundation,[65] brokerage, generalised social selection, or heterophily with regards to entrepreneurship did not systematically shape the network structure. In our view, this demonstrates the strength of our analytical approach. As we could have interpreted the sociogram showing an instance of brokerage (i.e., the bridging tie) or the prominence of entrepreneurs, these mechanisms tested within a coherent framework against other competing explanations turned out to not affect the network as much as it may seem upon first sight.

One mechanism worthy of further investigation might be propinquity.[66] Propinquity is a tendency to create ties based on physical/geographical proximity. Usually the closer actors are to one another, the more likely it is that they will share a tie, as the shorter the distance, the easier it is to create and maintain a tie. This mechanism is of obvious explanatory importance for distribution networks as distribution unfolds in physical space. The role of physical distances alongside network distances may bring new insights into how the distribution network is structured.

Another avenue of research would be to consider the temporal dynamics of the network. Criminal networks are adaptive and dynamic as actors involved respond to their changing environment and the opportunities and threats it poses,[67] which will be manifested by the changes of the structure or change in actors' attributes over time. The question is then what relational mechanisms drive the evolution of the network[68] and how do actors respond in the face of critical turns of events such as law enforcement crackdowns or the emergence of competing criminal groups.

However, neither propinquity, temporal dynamics, nor a more detailed distinction between different types of ties (multiplexity) could be incorporated in this study due to the lack of information in the court files that we used as a data source. Although there are previous studies extracting even this fine-grained information from court files,[69] the level of available detail may vary across jurisdiction. It is possible that court documentation in some countries will lend itself to extracting more detailed information, while this

may not be the case in other countries without reaching out to other sources of information (e.g., police investigation files). Even though court files bear higher face validity than data obtained, e.g., from media databases, data validity constitutes the greatest limitation of the present study; this is the case in research on criminal networks in general.[70] Yet, we are confident that no crucial actor is omitted from the court files and that all important connections were uncovered.

For the description of the network, we defined our own measure of actors' importance as the geodesic distance from the two manufacturers. In general, the choice of centrality measures for analysis should mirror the nature of the flow in the network.[71] For our case, the flow of poisonous beverages was substantively important. The identification of central actors is obviously interesting for criminal network analysis and thus the application of existing centrality measures or creation of new ones is likely to proliferate. In order to use existing measures and derive new in principled way, a common methodological framework for thinking about centrality measures may be helpful. A potential framework for this is proposed in the so-called positional approach.[72] This approach provides a way of conceptualising network measures with the aim to integrate the notion of position of an actor in a network (e.g., centrality) with the notion of position of that actor in social space (e.g., socioeconomic status). This opens the possibility to integrate centrality measures with the attributes of actors and capture the prominence of actors in the network as based on multiple dimensions such as centrality and skills or centrality in multiple different types of ties.[73] Similarly, the study of influential actors and outliers may be incorporated in the ERGM framework with newly developed methods.[74]

Notes

1. Borgatti, Everett and Johnson, *Analysing Social Networks*; and Robins, *Doing Social Network Research*.
2. Gerdes, *Illuminating Dark Networks*; Morselli, *Crime and Networks*; and Morselli, *Inside Criminal Networks*.
3. Bichler, Malm and Cooper, "Drug Supply Networks".
4. Natarajan, "Understanding the Structure of a Large Heroin Distribution Network."
5. Bright and Delaney, "Evolution of a Drug Trafficking Network."
6. Hughes, Bright and Chalmers, "Social Network Analysis of Australian Poly-Drug Trafficking Networks."
7. Lord et al., "A Script Analysis of the Distribution of Counterfeit Alcohol across Two European Jurisdictions."
8. Carrington, "Crime and Social Network Analysis"; and van der Hulst, "Terrorist Networks."
9. Bright, Hughes and Chalmers, "Illuminating Dark Networks."
10. Campana, "Explaining Criminal Networks"; and Carrington, "Crime and Social Network Analysis."
11. Hedström, *Dissecting the Social*; Hedström and Bearman, *The Oxford Handbook of Analytical Sociology*; and Manzo, *Analytical Sociology*.
12. Matsueda, "Toward an Analytical Criminology"; and Wikström and Sampson, *The Explanation of Crime*.
13. Robins, "A Tutorial on Methods for the Modeling and Analysis of Social Network Data"; and Snijders, "Statistical Models for Social Networks."
14. Bright, Koskinen and Malm, "Illicit Network Dynamics"; and Grund and Densley, "Ethnic Homophily and Triad Closure."

15. Hedström, *Dissecting the Social*; Hedström and Bearman, *The Oxford Handbook of Analytical Sociology*; and Manzo, "Introduction."
16. Hedström, *Dissecting the Social*, 2.
17. Rivera, Soderstrom and Uzzi, "Dynamics of Dyads in Social Networks."
18. Robins, Pattison and Woolcock, "Small and Other Worlds"; and Snijders and Steglich, "Representing Micro–Macro Linkages by Actor-Based Dynamic Network Models."
19. Hedström and Ylikoski, "Causal Mechanisms in the Social Sciences."
20. Campana, "Explaining Criminal Networks"; Robins, Pattison and Woolcock, "Small and Other Worlds."
21. Hedström, *Dissecting the Social*; and Manzo, "Introduction."
22. Coleman, *Foundations of Social Theory*; and Lindenberg, "Social Rationality, Semi-Modularity and Goal-Framing."
23. Morselli, *Inside Criminal Networks*; Oliver et al., "Covert Networks."
24. Snijders, "Network Dynamics."
25. Morselli, Giguère and Petit, "The Efficiency/Security Trade-off in Criminal Networks."
26. Borgatti, "Centrality and Network Flow"; and Borgatti et al., "Network Analysis in the Social Sciences."
27. Freeman, "Centrality in Social Networks Conceptual Clarification."
28. Robins, Pattison and Woolcock, "Small and Other Worlds"; and Robins, *Doing Social Network Research*.
29. Morselli, *Inside Criminal Networks*.
30. Barabási and Albert, "Emergence of Scaling in Random Networks"; and de Solla Price, "A General Theory of Bibliometric and Other Cumulative Advantage Processes."
31. Bright et al., "Networks within Networks"; and Morselli, "Assessing Vulnerable and Strategic Positions in a Criminal Network."
32. Bright, Koskinen and Malm, "Illicit Network Dynamics"; Coleman, *Foundations of Social Theory*; Erickson, "Secret Societies and Social Structure"; and Robins, "Understanding Individual Behaviors within Covert Networks."
33. Robins, "Understanding Individual Behaviors within Covert Networks."
34. See note 24 above.
35. Burt, *Structural Holes*; Burt, *Brokerage and Closure*; Robins, "Understanding Individual Behaviors within Covert Networks"; and DellaPosta, "Network Closure and Integration in the Mid-20th Century American Mafia."
36. Burt, *Structural Holes*; Burt, *Brokerage and Closure*; DellaPosta, "Network Closure and Integration in the Mid-20th Century American Mafia"; Morselli, "Assessing Vulnerable and Strategic Positions in a Criminal Network"; and Morselli and Roy, "Brokerage Qualifications In Ringing Operations*."
37. Coleman, *Foundations of Social Theory*; and Robins, 'Understanding Individual Behaviors within Covert Networks'.
38. Gimenéz Salinas-Framis, "Illegal Networks or Criminal Organizations"; Kenney, *From Pablo to Osama*; and Milward and Raab, "Dark Networks as Organizational Problems."
39. See note 33 above.
40. Bright et al., "The Use of Actor-Level Attributes and Centrality Measures to Identify Key Actors."
41. McPherson, Smith-Lovin and Cook, "Birds of a Feather."
42. Grund and Densley, "Ethnic Homophily and Triad Closure."
43. Granovetter, "The Strength of Weak Ties."
44. See note 17 above.
45. Erickson, "Secret Societies and Social Structure"; Krebs, "Uncloaking Terrorist Networks"; and Morselli and Roy, "Brokerage Qualifications in Ringing Operations*."
46. Felson, "The Ecosystem for Organized Crime"; Paoli, *The Oxford Handbook of Organised Crime*.
47. Smith and Papachristos, "Trust Thy Crooked Neighbor Multiplexity in Chicago Organized Crime Networks."

48. Felson, "The Ecosystem for Organized Crime."
49. Wang, "Exponential Random Graph Model Extensions."
50. See note 9 above.
51. Borgatti, Everett and Johnson, *Analysing Social Networks*; and Prell, *Social Network Analysis*.
52. See note 27 above.
53. Snijders, "The Degree Variance."
54. Krackhardt and Stern, "Informal Networks and Organizational Crises."
55. Gil and Schmidt, "The Origin of the Mexican Network of Power."
56. See note 51 above.
57. Snijders, "Statistical Models for Social Networks."
58. Snijders; Robins, "A Tutorial on Methods for the Modeling and Analysis of Social Network Data."
59. Lusher, Koskinen and Robins, *Exponential Random Graph Models for Social Networks*; and Robins et al., "An Introduction to Exponential Random Graph (P*) Models for Social Networks."
60. Grund and Densley, "Ethnic Homophily and Triad Closure"; Smith and Papachristos, "Trust Thy Crooked Neighbor Multiplexity in Chicago Organized Crime Networks."
61. Gimenéz Salinas-Framis, "Illegal Networks or Criminal Organizations"; and Milward and Raab, "Dark Networks as Organizational Problems."
62. Erickson, "Secret Societies and Social Structure"; Smith and Papachristos, "Trust Thy Crooked Neighbor Multiplexity in Chicago Organized Crime Networks."
63. These ERGM results together with further goodness of fit results are not shown here. However, they are available in the online supplementary information.
64. See note 62 above.
65. Kenney, *From Pablo to Osama*; Milward and Raab, "Dark Networks as Organizational Problems"; Morselli and Roy, "Brokerage Qualifications in Ringing Operations*"; and Morselli, "Assessing Vulnerable and Strategic Positions in a Criminal Network."
66. Daraganova et al., "Networks and Geography."
67. Bright and Delaney, "Evolution of a Drug Trafficking Network"; and Kenney, *From Pablo to Osama*.
68. Bright, Koskinen and Malm, "Illicit Network Dynamics."
69. Bright, Hughes and Chalmers, "Illuminating Dark Networks"; and Hughes, Bright, and Chalmers, "Social Network Analysis of Australian Poly-Drug Trafficking Networks."
70. Bright, Hughes and Chalmers, "Illuminating Dark Networks"; Morselli, *Crime and Networks*; and Morselli, *Inside Criminal Networks*.
71. Borgatti, "Centrality and Network Flow."
72. Brandes, "Network Positions."
73. Bright et al., "Networks within Networks"; and Diviák, Dijkstra and Snijders, "Structure, Multiplexity, and Centrality in a Corruption Network."
74. Koskinen et al., "Outliers and Influential Observations in Exponential Random Graph Models."

Acknowledgments

We are grateful to Miroslav Scheinost for his help with getting access to the data and to the two anonymous reviewers for their suggestions and comments.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Internal Grant of Faculty of Arts, Charles University in Prague [FF/VG/2017/72 "Networks of Organized Crime"].

Notes on contributors

Tomáš Diviák (https://www.researchgate.net/profile/Tomas_Diviak) is a PhD candidate in sociology at the University of Groningenand at Charles University in Prague. His research focuses on the application of social network analysis, particularly to the study of organized crime, and analytical sociology. He is one of the founders of informal association of network researchers in the Czech Republic called Czech Network for Social Network Analysis. His recent work appeared in Trends in Organized Crime and Social Movement Studies.

Jan Kornelis Dijkstra is an associate professor in the Department of Sociology at the University of Groningen, the Netherlands. His research interests include delinquency, risk behaviours, peer influence, peer relations, status, criminal networks, and social network analysis. He has published his research in, among others, Criminology, Social Networks, and Developmental Psychology.

Tom A.B. Snijders (http://www.stats.ox.ac.uk/~snijders/) is professor of Statistics and Methodology in the Social Sciences at the University of Groningen and emeritus fellow of Nuffield College, University of Oxford. His research concentrates on social network analysis and multilevel analysis. His work on developing statistical methodology for network dynamics is implemented in the software package RSiena (Simulation Inference for Empirical Network Analysis) in the statistical system R. With Roel J. Bosker he wrote Multilevel Analysis; An Introduction to Basic and Advanced Multilevel Modeling (Sage, 2nd ed., 2012). Combining these two research strands, together with Emmanuel Lazega he edited Multilevel Network Analysis for the Social Sciences; Theory, Methods and Applications (Springer, 2016).

ORCID

Tomáš Diviák http://orcid.org/0000-0001-7239-8466

Bibliography

Barabási, A.-L., and R. Albert. "Emergence of Scaling in Random Networks." *Science* 286, no. 5439 (1999): 509–512. doi:10.1126/science.286.5439.509.

Bichler, G., A. Malm, and T. Cooper. "Drug Supply Networks: A Systematic Review of the Organizational Structure of Illicit Drug Trade." *Crime Science* 6, no. 1 (2017). doi:10.1186/s40163-017-0063-3.

Borgatti, S. P., A. Mehra, D. J. Brass, and G. Labianca. "Network Analysis in the Social Sciences." *Science* 323, no. 5916 (2009): 892–895. doi:10.1126/science.1165821.

Borgatti, S. P., M. G. Everett, and J. C. Johnson. *Analyzing Social Networks*. London: SAGE publications, 2013.

Borgatti, S. "Centrality and Network Flow." *Social Networks* 27, no. 1 (2005): 55–71. doi:10.1016/j.socnet.2004.11.008.

Brandes, U. "Network Positions." *Methodological Innovations* 9 (2016): 2059799116630650. doi:10.1177/2059799116630650.

Bright, D. A., C. Greenhill, A. Ritter, and C. Morselli. "Networks within Networks: Using Multiple Link Types to Examine Network Structure and Identify Key Actors in a Drug Trafficking Operation." *Global Crime* 16, no. 3 (2015): 219–237. doi:10.1080/17440572.2015.1039164.

Bright, D., C. Hughes, and J. Chalmers "Illuminating Dark Networks: A Social Network Analysis of an Australian Drug Trafficking Syndicate." *Crime, Law & Social Change* 57, no. 2 (2012): 151–176. doi:10.1007/s10611-011-9336-z.

Bright, D., J. Koskinen, and A. Malm. "Illicit Network Dynamics: the Formation and Evolution of a Drug Trafficking Network." *Journal of Quantitative Criminology* (2018). doi:10.1007/s10940-018-9379-8.

Bright, D. A., and J. J. Delaney "Evolution of a Drug Trafficking Network: Mapping Changes in Network Structure and Function across Time." *Global Crime* 14, no. 2/3 (2013): 238–260. doi:10.1080/17440572.2013.787927.

Bright, D. A., C. Greenhill, M. Reynolds, A. Ritter, and C. Morselli "The Use of Actor-Level Attributes and Centrality Measures to Identify Key Actors: A Case Study of an Australian Drug Trafficking Network." *Journal of Contemporary Criminal Justice* 31, no. 3 (2015): 262–278. doi:10.1177/1043986214553378.

Burt, R. S. *Structural Holes: the Social Structure of Competition*. 1st Paperback edition. Cambridge, Mass.: Harvard University Press, 1992.

Burt, R. S. *Brokerage and Closure: an Introduction to Social Capital*. Oxford: Oxford University Press, 2005.

Campana, P. "Explaining Criminal Networks: Strategies and Potential Pitfalls." *Methodological Innovations* 9 (2016): 2059799115622748. doi:10.1177/2059799115622748.

Carrington, P. J. "Crime and Social Network Analysis." *The SAGE Handbook of Social Network Analysis* (2011): 236–255.

Coleman, J. *Foundations of Social Theory*. Cambridge, MA: Belnap Press, 1990.

Daraganova, G., P. Pattison, J. Koskinen, B. Mitchell, A. Bill, M. Watts, and S. Baum "Networks and Geography: Modelling Community Network Structures as the Outcome of Both Spatial and Network Processes." *Social Networks* 34, no. 1 (2012): 6–17. doi:10.1016/j.socnet.2010.12.001.

DellaPosta, D. "Network Closure and Integration in the Mid-20th Century American Mafia." *Social Networks* 51 (2017): 148–157. doi:10.1016/j.socnet.2016.11.005.

Diviák, T., J. K. Dijkstra, A. B. Tom, and Snijders. Structure, Multiplexity, and Centrality in a Corruption Network: the Czech Rath Affair"."*Trends in Organized Crime* (2018): 1–24. doi:10.1007/s12117-018-9334-y.

Erickson, B. H. "Secret Societies and Social Structure." *Social Forces* 60, no. 1, (1981): 188–210. doi:10.1093/sf/60.1.188.

Felson, M. 2006. "The Ecosystem for Organized Crime." *HEUNI 25th Anniversary Lecture*. http://www.heuni.fi.

Freeman, L. C. "Centrality in Social Networks Conceptual Clarification." *Social Networks* 1, no. 3 (1979): 215–239. doi:10.1016/0378-8733(78)90021-7.

Gerdes, L. M. *Illuminating Dark Networks: the Study of Clandestine Groups and Organizations*. Cambridge: Cambridge University Press, 2015.

Gil, J., and S. Schmidt. "The Origin of the Mexican Network of Power." *Proceedings of the International Social Network Conference*, Charleston, SC, 1996, 22–25.

Gimenéz Salinas-Framis, A. "Illegal Networks or Criminal Organizations: Power, Roles and Facilitators in Four Cocaine Trafficikng Structures." *Universidad Autonóma De Madrid* (2011).

Granovetter, M. S. "The Strength of Weak Ties." *American Journal of Sociology* 78, no. 6 (1973): 1360–1380. doi:10.1086/225469.

Grund, T. U., and J. A. Densley. "Ethnic Homophily and Triad Closure: Mapping Internal Gang Structure Using Exponential Random Graph Models." *Journal of Contemporary Criminal Justice* 13 (2014): 1043986214553377. doi:10.1177/1043986214553377.

Hedström, P. *Dissecting the Social: on the Principles of Analytical Sociology*. 1st ed. Cambridge: Cambridge University Press, 2005.

Hedström, P., and P. Bearman, eds. *The Oxford Handbook of Analytical Sociology*. 1 ed. Oxford; New York: Oxford University Press, 2011.

Hedström, P., and P. Ylikoski "Causal Mechanisms in the Social Sciences." *Annual Review of Sociology* 36, no. 1 (2010): 49–67. doi:10.1146/annurev.soc.012809.102632.

Hughes, C. E., D. A. Bright, and J. Chalmers. "Social Network Analysis of Australian Poly-Drug Trafficking Networks: How Do Drug Traffickers Manage Multiple Illicit Drugs?" *Social Networks* 51 (2017): 135–147. doi:10.1016/j.socnet.2016.11.004.

Hulst, R. C. V. D. "Terrorist Networks: the Threat of Connectivity." In *The SAGE Handbook of Social Network Analysis*, 256–270. London: SAGE Publishing, 2011.

Kenney, M. *From Pablo to Osama: Trafficking and Terrorist Networks, Government Bureaucracies, and Competitive Adaptation*. University Park, PA: Pennsylvania State University Press, 2007.

Koskinen, J., P. Wang, G. Robins, and P. Pattison "Outliers and Influential Observations in Exponential Random Graph Models." *Psychometrika* 83, no. 4 (2018): 809–830. doi:10.1007/s11336-018-9635-8.

Krackhardt, D., and R. N. Stern "Informal Networks and Organizational Crises: an Experimental Simulation." *Social Psychology Quarterly* 51, no. 2 (1988): 123. doi:10.2307/2786835.

Krebs, V. 'Uncloaking Terrorist Networks'. *First Monday* 7, no. 4 (2002). http://firstmonday.org/ojs/index.php/fm/article/view/941.

Lindenberg, S. "Social Rationality, Semi-Modularity and Goal-Framing: What Is It All About?" *Analyse & Kritik* 30, no. 2 (2008). doi:10.1515/auk-2008-0217.

Lord, N., J. Spencer, E. Bellotti, and K. Benson "A Script Analysis of the Distribution of Counterfeit Alcohol across Two European Jurisdictions." *Trends in Organized Crime* 20, no. 3–4 (2017): 252–272. doi:10.1007/s12117-017-9305-8.

Lusher, D., J. Koskinen, and G. Robins, eds. *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*. Structural Analysis in the Social Sciences 32. Cambridge: Cambridge University Press, 2013.

Manzo, G., ed. *Analytical Sociology: Actions and Networks*. 1 ed. Hoboken: Wiley, 2014.

Manzo, G. "Introduction." In *Analytical Sociology: Actions and Networks*, edited by G. Manzo, 1–52. 1 ed. Hoboken: Wiley, 2014.

Matsueda, R. L. "Toward an Analytical Criminology: the Micro-macro Problem, Causal Mechanisms, and Public Policy: toward an Analytical Criminology." *Criminology* 55, no. 3 (2017): 493–519. doi:10.1111/1745-9125.12149.

McPherson, M., L. Smith-Lovin, and J. M. Cook. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27 (2001): 415–444. doi:10.2307/2678628.

Milward, H. B., and J. Raab. "Dark Networks as Organizational Problems: Elements of a Theory." *International Public Management Journal* 9, no. 3 (2006): 333–360. doi:10.1080/10967490600899747.

Morselli, C. *Inside Criminal Networks*. Studies of Organized Crime. Vol. 8. New York, NY: Springer New York, 2009.

Morselli, C. "Assessing Vulnerable and Strategic Positions in a Criminal Network." *Journal of Contemporary Criminal Justice* 26, no. 4 (2010): 382–392. doi:10.1177/1043986210377105.

Morselli, C. *Crime and Networks*. New York: Routledge, 2014.

Morselli, C., and J. Roy. "Brokerage Qualifications in Ringing Operations*." *Criminology* 46, no. 1 (2008): 71–98. doi:10.1111/j.1745-9125.2008.00103.x.

Morselli, C., C. Giguère, and K. Petit "The Efficiency/Security Trade-off in Criminal Networks." *Social Networks* 29, no. 1 (2007): 143–153. doi:10.1016/j.socnet.2006.05.001.

Natarajan, M. "Understanding the Structure of A Large Heroin Distribution Network: A Quantitative Analysis of Qualitative Data." *Journal of Quantitative Criminology* 22, no. 2 (2006): 171–192. doi:10.1007/s10940-006-9007-x.

Oliver, K., N. Crossley, M. G. Everett, G. Edwards, and J. Koskinen. 2014. "Covert Networks: Structures, Processes and Types." *The Mitchell Center for Social Network Analysis working paper*. http://www.socialsciences.manchester.ac.uk/medialibrary/research/mitchell/covertnetworks/wp/working_paper1.pdf.

Paoli, L., ed. *The Oxford Handbook of Organized Crime*. 1 ed. Oxford: Oxford University Press, 2014.

Prell, C. *Social Network Analysis*. 1 ed. Los Angeles; London: SAGE Publications Ltd, 2011.

Rivera, M. T., S. B. Soderstrom, and B. Uzzi "Dynamics of Dyads in Social Networks: Assortative, Relational, and Proximity Mechanisms." *Annual Review of Sociology* 36, no. 1 (2010): 91–115. doi:10.1146/annurev.soc.34.040507.134743.

Robins, G. "Understanding Individual Behaviors within Covert Networks: The Interplay of Individual Qualities, Psychological Predispositions, and Network Effects." *Trends in Organized Crime* 12, no. 2 (2009): 166–187. doi:10.1007/s12117-008-9059-4.

Robins, G. "A Tutorial on Methods for the Modeling and Analysis of Social Network Data." *Journal of Mathematical Psychology, Social Networks* 57, no. 6 (2013): 261–274. doi:10.1016/j.jmp.2013.02.001.

Robins, G. *Doing Social Network Research*. London: SAGE publications, 2015.

Robins, G., P. Pattison, and J. Woolcock. "Small and Other Worlds: Global Network Structures from Local Processes." *American Journal of Sociology* 110 (2005): 4. doi:10.1086/427322.

Robins, G., P. Pattison, Y. Kalish, and D. Lusher. "An Introduction to Exponential Random Graph (P*) Models for Social Networks." *Social Networks* Special Section: Advances in Exponential Random Graph (p*) Models 29, no. 2 (2007): 173–191. doi:10.1016/j.socnet.2006.08.002.

Smith, C. M., and A. V. Papachristos. "Trust Thy Crooked Neighbor Multiplexity in Chicago Organized Crime Networks." *American Sociological Review* 81, no. 4 (2016): 617–643. doi:10.1177/0003122416650149.

Snijders, T. A. B. "Network Dynamics." In *The Handbook of Rational Choice Social Research*, edited by R. Wittek, T. A. B. Snijders, and V. Nee, 252–280. Stanford, CA: Stanford Social Sciences, an imprint of Stanford University Press, 2013.

Snijders, T. A. B. "The Degree Variance: an Index of Graph Heterogeneity." *Social Networks* 3, no. 3 (1981): 163–174. doi:10.1016/0378-8733(81)90014-9.

Snijders, T. A. B. "Statistical Models for Social Networks." *Annual Review of Sociology* 37, no. 1 (2011): 131–153. doi:10.1146/annurev.soc.012809.102709.

Snijders, T. A. B., and C. E. G. Steglich "Representing Micro–Macro Linkages by Actor-Based Dynamic Network Models." *Sociological Methods & Research* 44, no. 2 (2015): 222–271. doi:10.1177/0049124113494573.

Solla Price, D. D. "A General Theory of Bibliometric and Other Cumulative Advantage Processes." *Journal of the American Society for Information Science* 27, no. 5 (1976): 292–306. doi:10.1002/asi.4630270505.

Wang, P. "Exponential Random Graph Model Extensions: Models for Multiple Networks and Bipartite Networks." Structural Analysis in the Social Sciences 32. *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*. edited by D. Lusher, J. Koskinen, and G. Robins. Cambridge: Cambridge University Press, 2013. 115–129.

Wikström, P.-O. H., and R. J. Sampson, eds. *The Explanation of Crime: Context, Mechanisms and Development*. Cambridge: Cambridge University Press, 2006. doi:10.1017/CBO9780511489341.