5. The efficiency/security trade-off and beyond: testing a theory on criminal networks

5.1. Introduction

Actors in all organizations, overt and covert alike, need to act and cooperate in order to achieve their organizational goals. To this end, actors need to create ties with others for communication and cooperation, resulting in a network structure. However, a straightforward increase of activity and thus a higher number of ties may not simply result in better cooperation, especially not in criminal networks. A defining feature of criminal networks is the need of their participants to remain concealed (cf. Morselli, 2009; Oliver, Crossley, Everett, Edwards, & Koskinen, 2014). This puts constraints on interactions, because increasing activity becomes a liability as it comes with increased risk of being detected and consequently dismantled. Thus, criminal network participants must always oscillate between achieving their goals and keeping their activities hidden. Hence, Morselli, Giguère, and Petit (2007) postulate that “criminal network participants face a consistent trade-off between organizing for efficiency or security”; the so-called efficiency/security trade-off (Morselli et al., 2007, p. 143). Efficiency would imply that participants in criminal networks interact and communicate with each other frequently and have a large number of ties. At the same time, this undermines the security of the network as it increases visibility and thus susceptibility to detection and disruption. Morselli and colleagues subsequently deduce systematic structural differences between criminal networks oriented towards profit and towards ideology, as they require different temporal planning. Consequently, the trade-off is supposed to be different between these types of networks.

Although this idea has become widely accepted in the field of research on covert and criminal networks, it has been rarely empirically tested until recently (Crossley et al., 2012; de Bie, de Poot, Freilich, & Chermak, 2017; DellaPosta, 2017; Ünal, 2019). This paper aims to test this theory by examining the implications of the efficiency/security-trade-off for different network characteristics across nine ideology-driven and eleven profit-driven networks, using descriptive

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31 By security, we mean the absence of risk. This is different from resilience of the network, which is the ability of the network to withstand external shocks and attempts to disruption (cf. Bright, 2015; Duijn, Kashirin, & Sloot, 2014).
The efficiency/security trade-off

The idea that participants in criminal networks trade efficient achievement of their goals for security has been more or less explicitly articulated also before Morselli et al.’s seminal paper (2007). Baker and Faulkner (1993) stated that actors involved in criminal networks have two conflicting needs: maximizing concealment and maximizing efficiency. They showed that the need for concealment overrode the need for efficiency in three price-fixing conspiracy networks in heavy electrical industry. Similarly, Milward and Raab (2006) theorized a trade-off between the capacity to act and the capacity to persist. They related this tension to the theory of organizations and the processes of integration and differentiation, stating that “the structure will become more differentiated to make them (criminal networks) more difficult to find and destroy and thereby less integrated. This trade-off makes it more difficult for the network to maximize its destructive capacity but leaves it less vulnerable to attack” (Milward & Raab, 2006, p. 343). In a similar vein, Enders and Su (2007) talked about a trade-off between security and communication in terrorist networks.

A principal addition to this idea by Morselli et al. (2007) is that the trade-off does not occur uniformly in all criminal networks, but depends on the goal its members pursue. A distinction is made between two primary goals of criminal network participants: financial profit (e.g., traffickers of drugs or other goods) and ideological goals (typically terrorists). Whereas the efficiency is symptomatic for profit-driven networks, the security side of the trade-off is a domain of ideology-driven ones (Morselli et al., 2007).

The argumentation why profit-driven networks exhibit efficient structures, whereas ideology-driven networks exhibit secure structures, is based on the different time frames in which these network operate (Morselli et al., 2007). The time-to-task, that is, the interlude between time and action, is shorter in profit-driven networks as actors involved in them desire rapid pay-off. This shorter time-to-task requires the network to be designed for more efficient communication, while assuring as much security as possible. By contrast, the time-to-task is longer in ideology-
driven networks, as these operate within longer time frames, allowing the network to maximise security and assure as much efficiency as possible. Hence, ideology-driven network participants are supposed to aim particularly for assuring security to carry out a carefully planned action (e.g., an attack). To achieve this, they have to remain as secure as possible. The question is how the different time-to-task considerations affect the structure of the network. In other words, what are the structural implications of the efficiency/security trade-off. If the theory holds, we would expect that these two types of criminal organizations differ in their network structure.

Despite the prominence of this theory in research on criminal networks, two important issues deserve more attention. The first issue with testing the efficiency/security trade-off theory is its generalizability. Originally, the theory was proposed and illustrated using two cases of criminal networks (one profit-driven and one ideology-driven; Morselli et al., 2007). Other studies were also case studies of a single particular network. For instance, Crossley and colleagues (2012) studied a network of militant suffragettes and found support for the theory showing how the network becomes less dense and less centralized when it becomes more covert. DellaPosta (2017) studied a large-scale American mafia network, which exhibited a balance between efficiency and security by combining local closure and global openness. De Bie and colleagues (2017) studied a case of Dutch jihadists, showing that contrary to the theoretical expectations, the jihadi network was structurally more inclined towards efficiency, especially when its members aimed for dissemination of their ideology. The only study which went beyond analysis of one or two cases is Ünal's (2019) study which compares five illicit drug networks with five narco-terrorist networks within the Turkish context on their descriptive whole network and centrality measures, finding no systematic structural differences between these networks, especially in terms of clustering and path lengths between actors.

The second issue concerns the analytical level where the trade-off between efficiency and security takes place. The theory is formulated at the analytical level of the network. That is, it is the network, where the goal (profit or ideology) is defined and it is the overall network structure which is supposed to reflect it. However, intentions and goals are always properties of individuals, who may base their action on them (see e.g., Coleman, 1990; Hedström, 2005; Robins, 2009). Hence, network structures arise as a result of accumulation, intertwining, and crossing of individual interactions and relationships. This implies that, if the mechanism is located at the network level, actors are regarded as being quite rational and able to see the network from a “bird’s eye view” in order to adjust their actions (forming ties) in a way that serves the purpose of the network optimally. However, this is not a very realistic assumption as
the structure may not always correspond to the intentions of individuals that initially brought it about. In some cases, the structure may be even in contradiction with individual intentions and arise as an unintended consequence of individual actions (Boudon, 1982). For instance, actors aiming for security may rely on frequent cooperation and communication in order to prevent infiltration by their opponents or defection by their collaborators. Moreover, in the pursuit of security, they may prefer to create dense closed structures, aiming to promote trust (cf. Coleman, 1990; Kadushin, 2011). Trust is supposed to be important for cooperation in high risk activities, such as organized crime (Erickson, 1981; Robins, 2009; von Lampe & Ole Johansen, 2004). However, as an unintended consequence of this behaviour, structures with dense ties may become easily visible and detectible, thus undermining the original intentions of its creators.

We aim to overcome both issues as follows. First, we test this theory on a large number of profit-driven and ideology-driven networks by examining network characteristics of both types of networks. In so doing, we aim to obtain more general conclusions about differences between them. Second, to our knowledge previous studies only used whole-network descriptive measures to test the efficiency/security trade-off. However, networks are known for their complex structures, where similar structures may result from different underlying mechanisms (Robins et al., 2005). For instance, network-level centralization may be brought about by a variety of mechanisms, not only by a tendency to concentrate ties around several actors at the actor level. Thus, we apply statistical models for social networks to disentangle the network structures to their constituent elements at the actor level represented by configurations, such as triangles (i.e., three fully interconnected actors). In so doing we are also able to distinguish tendencies of actors from their consequences for network structures.

5.3. Network-level properties

We test hypotheses about four basic structural features of networks, that is, density, centralization, closure, and brokerage. Note that density and centralization are explicitly formulated in the original theory, whereas closure and brokerage are only implied. However, since not only density and centralization, but also closure and brokerage are important for patterning ties in networks and thus for making them efficient or secure, we also derive hypotheses from the efficiency/security trade-off about closure and brokerage. In the following section, we briefly review each of these four concepts. Because our aim is to test the
efficiency/security trade-off (formulated at the network level), we derive our hypotheses for the network level. To obtain greater clarity and understanding, we also explore the implications of the efficiency/security trade-off at the actor level in the following section.

Density

As a network property, density is the proportion of ties existing in the network compared to all potentially existing ones. High density facilitates the flow of information and resources and enables fast diffusion (Janssen et al., 2006). Dense ties also form a basis for social support and social control (Coleman, 1990; Kadushin, 2011). Nevertheless, high density may not always be beneficial, as both extreme density and extreme sparsity are disadvantageous. In all types of networks including criminal networks, higher density initially increases its flexibility and the potential for interaction among its members. However, beyond a certain point, increased cohesion may stifle these advantages (Everton, 2012, p. 141), as overly dense network structures are supposed to lead to too much social control among the actors (Janssen et al., 2006; McGloin & Kirk, 2010), which hampers their ability to perform complex tasks and adapt to changing conditions. By contrast, very low density results in insufficient cooperation, coordination, social control among the actors and thus the inability to reach goals. At the network level of the efficiency/security trade-off (Morselli et al., 2007), efficiency is associated with a high number of ties and thus with high density as this is supposed to help generate value for profit-driven networks, whereas security is associated with a loose structure and subsequent low visibility and vulnerability (Enders & Su, 2007). Because ideology-driven networks are assumed to maximize security and thus to avoid high visibility induced by high amount of ties, we expect profit-driven networks to be denser than ideology-driven networks.

Hypothesis 1: Profit-driven networks are denser than ideology-driven networks.

Centralization

High density is not the only way to assure efficiency. Actors in the network may also be efficiently connected if the ties are concentrated around a few central nodes, even though there is a low number of ties in total. Central actors in such networks directly exercise control over their neighbours and over a large proportion of flows in the network (Berardo & Scholz, 2010;}

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52 Different terms may be used to denote what we refer to as ‘density’ here, such as cohesion, density or average degree. We understand density as a concept referring to the number of ties in a network, which can be measured by a measure called density or by average degree.
Jackson, 2014; Janssen et al., 2006). These advantages are at the expense of dependence on the performance of the central nodes. In criminal networks, centralization comes with another drawback: high vulnerability to the removal of central nodes (Bright, 2015; Helfstein & Wright, 2011). Thus, increased centralization adds to the efficiency of the network, whereas decreased centralization adds to the networks’ security (Morselli et al., 2007). Hence, we expect profit-driven networks to exhibit more centralization than ideology-driven networks.

**Hypothesis 2:** Profit-driven networks are more centralized than ideology-driven networks.

**Closure**

Closure or transitivity reflects the existence of closed structures (triangles) as a network property. Unlike density, which is about creating ties in general, closure is about connecting those, who are not yet directly connected. At the network level, closure increases efficiency by shortening the distances among actors (Berardo & Scholz, 2012). By closing an open triplet, two actors reach each other with one tie instead of having to use an intermediary. However, closure introduces redundant ties as two ties are enough to connect three actors and hence the third closing tie is redundant (cf. Burt, 1992; 2005). This redundancy in turn increases the risk of being detected (Robins, 2009), which decreases security. Following the original proposition of Morselli and colleagues (2007), increasing the efficiency by shortening the distances may be more salient in profit-driven networks, whereas the increase in visibility may be avoided by ideology-driven networks. Therefore, we expect more closure in profit-driven networks than in ideology-driven ones.

**Hypothesis 3:** Profit-driven networks show more closure than ideology-driven networks.

**Brokerage**

At the network level, brokerage is manifested by the presence of open structures, also known as structural holes. Brokerage introduces structural differentiation into the network as in open triads, there are two structurally equivalent actors who are interconnected by the actor in the position of broker. Milward and Raab (2006) argue that such differentiation increases the security of the network, because while it reduces the ability of actors to coordinate their actions, it makes them more difficult to detect and target. Furthermore, structural holes imply a low number of redundant ties, making the network less visible and more secure. Therefore, in line with the efficiency/security trade-off (Morselli et al., 2007), we suppose that ideology-driven
networks exhibit more brokerage than their profit-driven counterparts, as that allows to maximize security.

Hypothesis 4: Ideology-driven networks display more brokerage than profit-driven networks.

Balance between efficiency and security

In addition to Morselli et al. (2007), we propose to take into account a balance between the conflicting ends of efficiency and security, which can be identified both at the actor-level and at the network-level. At the network level, this balance is similar to what is known as the small-world phenomenon (Watts & Strogatz, 1998). A small-world network is characterized by high closure and short geodesic distances, which provides actors both the advantages of closed local clusters associated with trust and cooperation, and at the same time access to resources and ideas from other clusters through bridging ties. Small-world networks have been thought to be the balance between efficiency and security (DellaPosta, 2017; Robins, 2015, p. 31). This is also supported in research on criminal networks by revealing so-called cell structures or compartmentalized structures (DellaPosta, 2017; Faulkner & Cheney, 2014). The cell structure resembles the small-world network model as it is also composed of a number of small dense subgroups (cells) interconnected by sparse bridging ties, the difference being that the bridging ties are produced by a moderate amount of randomness in the small-world model, whereas in compartmentalized cell structured networks, the bridging ties are assumed to be resulting from strategic considerations. This compartmentalization is supposed to protect against infiltration and disruption, while assuring connectedness among the actors in the network. As the efficiency/security trade-off does not explicitly mention the balance between the two ends, we do not test it at the network level. However, we argue that it is important to discuss this possibility.

5.4. Actor-level mechanisms

In this section, we argue that the loci of action are actors, whose tendencies to relate to others in specific ways are captured by different mechanisms. The basic tendencies for network structures that we investigate are propensity to create and accumulate ties, to close open triads, and to leave triads open. As none of these tendencies is explicitly postulated in the efficiency/security trade-off, we do not derive hypotheses. However, we aim to explore their implications. Note that there is a potential tension between motives of individual actors and the
purpose of the network and that as we said above, actor-level tendencies do not necessarily translate into corresponding network-level outcomes.

Tie creation

Actors in profit-driven networks may differ from actors in ideology-driven networks in their general propensity to create ties, that is in their propensity to cooperate and communicate with each other. Creation and maintenance of each tie has its cost in the form of time, effort or energy (Snijders, 2013). In criminal networks, there is an extra cost to each tie in the form of increased visibility. If the goal is profit, actors would probably be inclined to cooperate with others in order to make profit and achieve the desired good. If actors are involved in ideology-driven activities, only a few trusted contacts may suffice to get the necessary information and support. Thus, the actor level explanation aligns with the network level perspective.

Tie accumulation

The actor level mechanism associated with concentration or accumulation of ties is called cumulative advantage (also known as preferential attachment; Barabási & Albert, 1999; de Solla Price, 1976). This mechanism entails a self-reinforcing process making the probability that an actor creates or receives a new tie dependent upon the number of ties an actor already has. This may go together with disproportionately frequent activity of some members of the network (Milward & Raab, 2006), who may even try to organize the group to assure greater security. However, in doing so, they inadvertently undermine their own effort at the network level as they make the network centralized around themselves. If this is the case, intentions of individuals are counterproductive to the network level structural outcome. Centralization may also arise as an effect of popularity of central actors because of their highly demanded resources or skills (Robins, 2009). The accumulation of ties has diminishing returns (Rivera et al., 2010), which is more pronounced in criminal networks where it increases the visibility of central actors and their neighbours (Bright, Koskinen, & Malm, 2018) and provides the central actors with opportunities they may exploit for their personal advantage (Berardo & Scholz, 2010; Jackson, 2014). For both these reasons, actors in both profit-driven and ideology-driven networks may actively try to avoid accumulation of ties.

Closure

Closure refers to closing open triangles or, colloquially, to befriending friends of friends. Individuals form these structures to reinforce trust, control, and support as actors in the network
can check on how they deal with each other (Berardo & Scholz, 2010; Coleman, 1988; Jackson, 2014; Rivera et al., 2010). In doing so, they may reinforce norms, for instance, pertaining to coyness and loyalty. Actors embedded in these closed network structures are thus less likely to defect (Jackson, 2014). As trust is supposed to be crucial in criminal networks (Erickson, 1981; Robins, 2009; von Lampe & Ole Johansen, 2004) and together with the fact that closure helps prevent defection and infiltration (Bright et al., 2018; Helfstein & Wright, 2011), actors may close triads to increase security rather than efficiency in contrast to the network level proposition. Consequently, this may result in increasing visibility by creating redundant ties and as an unintended consequence, it may expose the network to detection.

**Brokerage**

At the actor level, brokerage is the tendency of actors to create structural holes, to bridge between unconnected actors. From the perspective of individual actors, the closed structures may be disadvantageous because actors who are embedded within them constrain each other, as they have access to similar resources and capabilities (Burt, 1992, 2005). Brokerage over structural holes provides a competitive advantage, because it allows reaching out for new resources and ideas (Burt, 1992, 2005; Kadushin, 2011, p. 63). This tendency to exploit structural holes serves the profit of the brokers, sometimes captured by the notion that “brokers do better” (Morselli & Roy, 2008). The role of brokers and their competitive advantage is well documented in criminal settings, showing that more sophisticated criminal organizations display more brokerage (DellaPosta, 2017; McGloin & Kirk, 2010; Morselli, 2010; Morselli & Roy, 2008). From the actor’s perspective, the intention to broker may also be driven by the motivation to obtain material profit and as such will be more salient in profit-driven networks.

**Tendencies to balance efficiency and security**

From the actor level perspective, the aim to balance efficiency and security has been described in both overt and covert settings. For instance, Uzzi (1996) showed that entrepreneurs in legitimate business in the apparel industry try to keep a mix of both weakly tied contacts to access innovation, and strongly tied contacts for situations which require trust and coordination. This is further supported by Burt (2005, p. 164), who claimed that while brokerage enables to create value, closure enables to deliver it. Brokerage provides access to new information and resources, whereas closure creates opportunities to make use of them. Actors may also try to balance centralization and decentralization. Related to this, the concept of strategic positioning has gained considerable attention in the study of criminal networks in recent years (Morselli,
Strategic positioning is the tendency of actors in criminal networks to limit their direct connections (i.e., below average degree), while seeking network positions on important flows (i.e., high betweenness). In this way strategically positioned actors decrease their visibility but retain some control over flows of information and resources in the network.

5.5. Data

We tried to find as many criminal networks as possible which were available for re-analysis and in which the content of ties as communication or cooperation can be clearly distinguished from other tie contents; this was required as it reflects the kind of ties the efficiency/security trade-off is referring to. This resulted in twenty networks: nine ideology-driven and eleven profit-driven. The profit-driven networks consist of cases of human trafficking, drug trafficking, and illicit vehicle resale, whereas ideology-driven networks contain terrorist networks. Networks where communication/cooperation ties were impossible to clearly distinguish from other tie contents were not included in the analysis.

Because most of the networks were undirected, we symmetrized the directed networks by making all the ties undirected (whenever there was a tie in at least one direction, it was considered to be in both directions) to allow for comparison between networks. Similarly, most of the networks were initially binary, so we dichotomized the remaining networks as well. All the networks, their sources, brief description, and the way we processed them prior to the analysis are summarized in the appendix. Table 5.1 provides the descriptive statistics for each network and the appendix provides further information on the datasets we used.

5.6. Methods

Descriptive analysis

To test our hypotheses, we compared the network characteristics of density, centralization, closure, and brokerage between ideology-driven and profit-driven networks. To account for the differences in size of the networks, ranging from 17 to 86 nodes, we used measures which are not sensitive to these differences.
Density. We used the average degree as an indicator of density instead of density itself. The reason is that network’s density is inversely related to its size (Everton, 2012; Snijders, 1981). Moreover, average degree is directly interpretable in terms of activity of the actors in the network. The higher the average degree, the denser is the network.

Centralization. We used the variation coefficient of degrees as a measure of centralization of the network. Similar to density, centralization measures are sensitive to the size of the network. The variation coefficient is defined as the standard deviation divided by the mean, which allows for comparison of networks with different number of nodes as variation coefficient is by its definition dimensionless. The higher the variation coefficient of degrees, the more dispersed the degree distribution, indicating that there are a few high-degree and many low-degree nodes (cf. Snijders, 1981).

Closure. To measure closure, we started with the frequently used clustering coefficient. This coefficient is the ratio of closed triplets to three times the number of connected open triplets, so-called two-paths. This measure ranges from 0 to 1, where 0 indicates no closed triangles and 1 indicates no open two-paths. However, the clustering coefficient is sensitive to the density, because the expected value of random networks with a given size and density is just the density itself. Thus, we subtracted the density of the network from its clustering coefficient to take out the potential distortion caused by different densities.

Brokerage. As an inverse measure of brokerage, we used Burt’s (1992, p. 55) measure of aggregate constraint averaged across actors within each network. This measure expresses the extent to which an actor is tied to others who are themselves interconnected. If an actor’s neighbours are not mutually interconnected, the actor is unconstrained and sits atop of a lot of structural holes. Well interconnected neighbours imply a small amount of structural holes, i.e., high constraint, and thus leave little opportunities for the focal actor to exploit. Higher values of this measure indicate higher constraint and thus less brokerage.
In order to compare the ideology-driven networks to their profit-driven counterparts, we conducted a two-sample one-sided Wilcoxon-Mann-Whitney permutation test for each of these measures using the coin package in R (Hothorn, Hornik, Wiel, & Zeileis, 2008). Note that our sample of networks is not a random draw from a well-defined population, but rather a set of available cases with the content of ties corresponding to the theory. Therefore, inferences based on our permutation tests pertain only to our set of networks and differences between the two types of networks therein.

Statistical models

As stated above, the efficiency/security trade-off has been originally proposed only with regard to descriptive network statistics. Although these measures provide a good basis for testing the efficiency/security trade-off on the network level, they do not capture the actor level. In order to explore the mechanisms at the actor level, we use exponential random graph models ('ERGMs'; Lusher, Koskinen, & Robins, 2013). These models represent global network
structure in terms of local network configurations, that is, micro-level network patterns. By estimating and testing such models we assess which configurations contribute significantly to the overall structure of the network. In this way, ERGMs allow to capture the actor level elements which bring about the observed network structure.

We fitted an ERGM with a configuration for each of the discussed network mechanisms. As the efficiency/security trade-off is concerned only with structural effects, we did not include any node attribute parameters or dyadic covariates. We employed the alternating statistics in our models (Snijders, Pattison, Robins, & Handcock, 2006). Alternating statistics progressively weight down higher-order multiples of their corresponding configurations, which prevents the distribution of networks to be highly concentrated at a combination of nearly complete and nearly empty graphs, the so-called near-degeneracy problem. We fitted the models using the MPNet software for estimation of ERGMs (Wang, Robins, & Pattison, 2009).

We included the following effects in the model. The edge parameter models the overall propensity of actors to create ties. The alternating star parameter models the tendency of a few actors to have many ties, reflecting accumulation of ties. The alternating triangle parameter captures the tendency of actors to form closed structures (triangles), whereas the alternating two-path parameter captures the preconditions for closure. A positive two-path effect alongside a positive triangle effect in the model may be interpreted as brokerage as it suggests there is a tendency toward creating connected structures which are not part of closed triads (Garry Robins, personal communication). Finally, the alternating edge-triangle parameter, defined by a triangle in which one of the nodes has multiple other ties, models the tendency to combine efficiency and security, as it captures both closure and openness (see Figure 5.1; Pattison & Snijders, 2013). If the resulting coefficient is at least twice as high in absolute value as the corresponding standard error, we consider parameters significant (Lusher et al., 2013). Positive values of significant parameters indicate, that the given configuration is significantly more present given other parameters in the models, while negative values of significant parameters indicate they are significant less present.

![Figure 5.1: Alternating edge-triangle configuration](image)

Many of the networks are too small to be analysed separately according to an ERGM in this specification. Therefore, all networks of the same type (profit-driven and ideology-driven) were
combined in one large network, using structural zeros between individual networks representing that ties between networks are impossible to (Kalish & Luria, 2013)\textsuperscript{33}. For the two combined networks, parameter estimation was iterated until satisfactory model convergence was obtained (convergence t-ratios for all fitted parameters < 0.1 in absolute value). We also checked the goodness of fit of each model to see whether it represents the data adequately by the method of Hunter, Goodreau, and Handcock (2008) as implemented in the MPnet software.

Modelling all networks of one type together with one model assumes that the model is homogeneous across all the networks, neglecting within-group differences. This is not tested by the standard goodness of fit checks for the ERGM. To investigate the homogeneity across networks, we did an additional goodness of fit check. This used three statistics that are not systematically dependent on number of nodes, applied to each network separately: average degree, variation coefficients of degrees, and clustering coefficients minus density\textsuperscript{34}. To apply this to each network separately, we included dummy variables indicating the membership of a node in particular network. These statistics were also used in the goodness of fit procedure according to the method of Hunter, Goodreau and Handcock (2008). A poor fit (t-ratios > 2 in absolute values) suggests that the specific network is far from the model “average” in terms of the statistic in question. If this happens for many networks, it indicates internal heterogeneity within the given type of criminal networks.

5.7. Results

Descriptive measures comparisons

Table 5.1 contains the results of descriptive analyses. The comparison between profit- and ideology-driven networks in terms of the relevant descriptive measures is displayed by violin plots in Figure 5.2. In terms of the number of nodes, both the largest and smallest network are ideology driven, that is, the Turkish terrorist network Ergenekon (N = 86) and the Indonesian terrorist group Jemaah Islamiyah (N = 17). In general, ideology-driven networks in our dataset tend to be larger than profit-driven networks (p = 0.06 in a two-sample permutation test).

\textsuperscript{33} We initially started with case-by-case modelling with the intention to subsequently summarize the results with a meta-analytic technique (Lubbers & Snijders, 2007). However, this approach resulted in problems with poor convergence or degeneracy with a number of cases, which eventually rendered this approach inapplicable.

\textsuperscript{34} These three statistics can be calculated with the simulation output from MPNet.
Hypothesis 1: Looking at cohesion, the densest network in the dataset is the Al-Qaeda pre-War on Terror network (average degree = 10.96), whereas the sparsest is a Dutch women trafficking network E (average degree = 1.9). There is considerable variability among ideology-driven networks, whereas the average degree varies less in profit-driven networks, as evidenced by Figure 3. We found no support for the hypothesis that profit-driven networks are denser than their ideology-driven counterparts ($p = 0.99$), however the $p$-value implies a significant difference opposite to Hypothesis 1, that is, ideology-driven networks have a higher average degree instead of profit-driven networks.

Hypothesis 2: The variation coefficient of degree, capturing the dispersion of the average number of ties among actors, is highest in the case of the European branch of the Islamic State terrorist network (1.43), and lowest in the Jemaah Islamiyah network (0.4). Similar to average degree, we found considerable variance in ideology-driven networks for this network measure. We found support for Hypothesis 2 ($p = 0.04$), which states that profit-driven networks are more centralized.

Hypothesis 3: The network which exhibits the highest clustering coefficient minus density (0.33) is the Jemaah Islamiyah, while the lowest value is for the European branch of the Islamic State network (0.02). Again, there is high variability among ideology-driven networks, but also among profit-driven networks. The difference between ideology-driven and profit-driven networks is not statistically significant in the predicted direction ($p = 0.96$). However, similar to average degree, this finding contradicts the efficiency/security trade-off as the $p$-value implies the opposite difference to what the theory predicts. Hence, we found no support for Hypothesis 3.

Hypothesis 4: Looking at brokerage captured by average constraint, the Malian-Tuareg terrorist network has the highest value (0.73), whereas the lowest value is displayed by a Spanish drug trafficking network JAKE (0.19). Both these networks are outliers of their respective types. Overall, the ideology-driven networks are not exhibiting statistically significantly more brokerage than profit-driven networks ($p = 0.45$). This is in contrast with the assumption at the network level of the efficiency/security trade-off that ideology-driven networks have a lower number of redundant ties. Hence, there is no support for Hypothesis 4.

In sum, only we found support for the trade-off theory only in Hypothesis 2 about network centralization. In the case of density and closure, our results are in the opposite direction to what the theory would imply.
Exponential random graph model results

Table 5.2 displays the results of the exponential random graph models with one model for each type of network. In general, profit-driven and ideology-driven networks are rather similar in terms of ERGM results. First, the edge parameter is statistically significant and negative in both cases, meaning that networks are sparse: actors do not have the tendency to proliferate their ties. Second, in both types of networks we found a significant, negative star parameter. This is consistent with general expectations about criminal network participants, who are supposed to avoid vulnerable centralized network structures. The triangle parameter capturing triadic closure is significant and positive in both types of criminal networks. Although closure results in more visibility and at least actors in ideology-driven networks should avoid it according to the trade-off theory, actors in both types of networks display tendencies towards it. The last similar feature is the positive and significant edge-triangle parameter. This can be seen as evidence for tendencies of actors in both types of criminal networks to balance brokerage and closure.

The only parameter that is not in the same direction for profit-driven and ideology-driven networks, is the alternating two-path. This effect is positive and significant in the case of profit-
driven networks, but non-significant in ideology-driven networks. The positive two-path effect together with the positive triangle effect suggest that actors in profit-driven networks tend to create more open structures than actors in the ideology-driven networks, where the alternating two-path effects is not statistically significant. The non-significant effect in ideology-driven networks is contradictory to the expectation from the efficiency/security trade-off, which suggests that leaving two-paths open assures security while maintaining connectivity.

In terms of goodness of fit, the model for ideology-driven networks fits the data acceptably on 16 out of all 17 structural effects implemented in MPNet, with the exception of clustering coefficient (t-ratio = 8.35). The model for profit-driven networks slightly misfits five structural effects (goodness of fit t-ratio in all cases a bit above 2 in absolute value), but in the case of skewness of degrees, the t-ratio is -4.02 suggesting misfit.

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<th>effect</th>
<th>Profit-driven networks</th>
<th>Ideology-driven networks</th>
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<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>SE</td>
</tr>
<tr>
<td>edge</td>
<td>-1.97</td>
<td>0.24</td>
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<td>alt star</td>
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<td>0.09</td>
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<tr>
<td>alt triangle</td>
<td>0.63</td>
<td>0.09</td>
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<tr>
<td>alt two-path</td>
<td>0.09</td>
<td>0.01</td>
</tr>
<tr>
<td>alt edge-triangle</td>
<td>0.04</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 5.2: Exponential random graph model results. Statistically significant effects are bold. Note: one network (pre-War on Terror Al Qaeda) has been excluded, because its inclusion caused problems with convergence of the model.

Figure 5.3 shows the comparison of goodness of fit for average degrees, variation coefficients of degrees and clustering coefficients minus density for each network. The bars represent t-values, which indicate the (dis)similarity between the mean counts of given statistics in the simulated sample of networks and the count of that statistic in the observed network. If the bar exceeds 2 or −2, this is an indication that the model does not adequately capture the corresponding network statistics. The statistics of the majority of networks in our sample are captured adequately by the model. However, we see different networks being highly over- or underestimated in each studied statistic. This is most clearly visible in the case of average degree, which the model overestimates in six profit-driven networks (one is underestimated) and three ideology-driven networks (one is underestimated). In terms of variation coefficient of degree, the results are similar to average degree, although the deviations occur for different networks. Again a number of values are overestimated by the model, and one ideology-driven
network is underestimated. In terms of clustering coefficient minus density, most of the networks are captured adequately by the model, but the outliers here are the farthest away from them (the t-ratio for the Ergenekon network is almost 60).

These results indicate two things. First, the efficiency/security trade-off theory as a structural theory does not yield a model which adequately explains criminal networks structures as indicated by its poor fit to a number of networks in our sample. Second, the post-hoc goodness of fit procedure reveals within-group differences which question whether the distinction between profit- and ideology-driven network is meaningful in terms of their actor-level relational mechanisms.

Figure 5.3: Goodness of fit t-ratios for average degrees, variation coefficients of degrees and clustering coefficients minus density in each network (upper row: profit-driven networks) based on 10,000 simulated networks of the same size and model parameters obtained from models in table 2.

Overall, the results of the ERGMs suggest that both profit-driven and ideology-driven networks are driven by the same underlying structural mechanisms; negative propensity to create ties, negative tendency towards centralization, positive closure, and positive tendencies towards balance between open and closed structures. The only clear difference is the positive brokerage tendency in profit-driven networks, which is absent in ideology-driven networks. The post-hoc goodness of fit analysis reveals that there are large within-group differences.
5.8. Discussion

The efficiency/security trade-off (Morselli et al., 2007) is an influential theory about the structure of criminal networks. We proposed several consequences of this theory on the network level, which we tested. However, we also argued that it is necessary to investigate the implications of the theory on the level of individual actors as network structures may not always align with individual intentions and even result in unintended, contradictory consequences. As such our study tries to respond to criticism for a lack of theoretical foundation in the field of criminal network studies (Carrington, 2011).

We focused on four properties of networks on which we tested the theory and, subsequently, explored the actor level mechanisms with exponential random graph models. Even though our tests found some differences between profit-driven and ideology-driven networks, these differences were only in one case in the direction predicted by the theory. Some differences were even opposite to the theory: ideology-driven networks displayed higher density (as measured by average degree) and closure than their counterparts. Our models suggest that both types of networks are brought about by similar actor level mechanisms with the exception of brokerage, for which there is statistical evidence only in profit-driven networks. Furthermore, the post-hoc comparisons based on these models reveals considerable within-group differences.

We attempted to approach the profit-driven and ideology-driven networks as sets of criminal networks that, in spite of the size differences between individual networks, are internally homogeneous to a sufficient extent to allow a "collective" treatment and comparison at the group level. Our results show that the two groups are too heterogeneous internally for an unequivocal comparison, and that as far as clear-cut comparisons could be made, some of the differences found between the groups were opposite to the prediction of the efficiency/security trade-off theory.

Although there are some differences both descriptively and in terms of model parameters, these cannot sufficiently and satisfactorily be explained by the goal (profit or ideology) of the networks, as these differences do not align with the direction the trade-off theory would suggest. Moreover, there is also high variability within both types of criminal networks. These findings call into question the distinction between ideology-driven and profit-driven networks in the first place. Some cases have been documented where terrorist networks opted for drug dealing or other profit-driven activity as a part of their strategic toolkit (Asal, Milward, & Schoon, 2015; Ünal, 2019). This may also happen the other way around, when profit-driven networks try to
intimidate their opponents by performing terrorist acts, for instance narco-mafias. Furthermore, it is certainly not impossible to imagine a profit-driven network in which actors sacrifice immediate profit for maximal security leading to a higher profit in the long-term, such as in the case of long-term planned bank robberies.

This is not to say that actors in criminal networks do not face the efficiency/security trade-off. Rather, there is little support in our data that this trade-off is fundamentally different in profit- and ideology-driven networks. Theoretically, there are some inconsistencies between the analytical levels of actors and networks. One way in which the theory may be extended is the further conceptual clarification of the central concepts – security and efficiency. Currently, security is conceptualized as a need to stay away from detection. However, as suggested by theoretical arguments underpinning the mechanism of closure (e.g., Coleman, 1988), there may be another, and at least equally relevant, notion of security for actors in criminal networks, specifying security as the need to cooperate with trusted others. Similarly, efficiency is conceptualized as the amount of communication among actors. Some network theoretical literature suggests (cf. Snijders, 2013), that efficiency may also be thought of as trying to minimize the costs of creating and maintaining ties, which could motivate some actors to actually prevent the proliferation of ties or to be rather selective about which ties and with whom to create or maintain. Another way for extending the theory is explicitly theorizing the balance between efficiency and security. We have outlined several different forms this balance can take such as strategic positioning or balancing openness and closure. Furthermore, our model results suggest that actors have these balancing tendencies in both profit- and ideology-driven networks, which calls for further research on how these balancing tendencies unfold at both actor and network levels.

In the light of our findings and the theoretical issues discussed above, it is important to find some factors that might be better suited to explain variations between criminal networks. The dynamics and evolution of criminal networks over time is an intensively debated issue (see e.g., Bright et al., 2018; de Bie et al., 2017; Duijn, Kashirin, & Sloot, 2014; Stevenson & Crossley, 2014). It is possible that the efficiency/security trade-off happens over time rather than across different types of activity. Actors observe their environment and they respond to perceived threats or opportunities. For instance, if actors feel threatened by law enforcement or by a competing criminal group, they may try to maximize security, while when they feel unthreatened or have plenty of opportunities to reach their goals, they may want to maximize efficiency. Studies by Crossley and colleagues (2012) and de Bie and colleagues (2017) point
in that direction, when they show how the structures of ideology-driven networks change over time in response to change in the broader social context, whereas Bright and colleagues (2018) focused on changes at the actor level in a drug-trafficking network.

The efficiency/security trade-off as it is formulated now is a purely structural theory. Although endogenous self-organizing mechanisms may be critical parts of the explanation of emergence of criminal networks, it is unlikely that they will be sufficient explanations. The study of individual attributes and psychological predispositions of actors has been rather neglected in criminal networks (Robins, 2009). Nevertheless, motivation and intentions are properties of individuals, which intersect with their abilities and personal traits when actors create, maintain, or dissolve ties. The obvious question is how this happens, and to what extent it is modified by the attempts of actors to remain concealed. For example, there is some evidence suggesting that actors with high social status, such as politicians, have high self-confidence that they will not be detected or prosecuted, and thus create numerous ties which may result in high visibility and their eventual downfall (Demiroz & Kapucu, 2012; Diviák et al., 2018b).

More research on both the dynamics and individual attributes requires available data. However, the data availability, validity, and reliability is the greatest limitation of our study and perhaps of the entire research field of criminal networks. The comparison we conducted relies on clear and comparable content of ties, which discards much of the available data. Moreover, what was beyond our control was the definition of boundaries of the networks in our sample. Both these issues are frequently under insufficient consideration in the studies of criminal networks, yet the plausibility of conclusions from these studies directly depends on how the boundaries of the networks and the content of ties are defined. Morselli’s (2009) criminal justice rings approach to boundary definition and the graph database framework for data collection proposed by Gutfraind and Genkin (2017) are promising in this regard. Transparent and unified schemes for data collection could enable more systematic comparison and generalization of findings across studies and in turn deepen our understanding of criminal networks.

We conclude that although there are structural differences among criminal networks, these differences cannot be accounted for by profit-driven or ideological motivation, as the differences between these groups are not marked and differences within the groups are non-negligible.
5.9. Appendix to chapter 5

Analysed networks:

Noordin Top – taken from the covert networks database of the Mitchell Centre for SNA (2019; available at: https://sites.google.com/site/ucinetsoftware/datasets/covert-networks), originally collected by Roberts and Everton (2011). N = 79; ideology-driven; only the ties in the dimension of communication are analysed. Indonesian jihadist terrorist network responsible for multiple acts of terrorism in South-East Asia.

November 17 - taken from the covert networks database of the Mitchell Centre for SNA (see above), originally collected by Rhodes and Jones (2009). N = 22; ideology-driven. Greek radical left-wing urban guerrilla.


Al-Qaeda pre-War on Terror – originally collected by Ouellet and colleagues (2017). N = 83; ideology-driven. Network of cooperation among members of Al-Qaeda prior to the War on Terror. Nodes do not overlap with Al-Qaeda War on Terror network.

Al-Qaeda War on Terror – originally collected by Ouellet and colleagues (2017). N = 35; ideology-driven. Network of cooperation among members of Al-Qaeda during the War on Terror. Nodes do not overlap with Al-Qaeda pre-War on Terror network.

Ergenekon - originally collected by Demiroz and Kapucu (2012). N = 86; ideology-driven. Symmetrized. Turkish political conspiracy and terrorist organization.

Jewish Underground – originally collected by Asal, Nagar, and Rethemeyer (2014). N = 26; ideology-driven. Ties based on recruitment analysed. Israeli terrorist network which planned attacks on Muslim targets.


JUANES - taken from the covert networks database of the Mitchell Centre for SNA (see above), originally collected by Giménez-Salinas Framis (2011). N = 51; profit-driven. Cocaine smuggling network between Mexico and Spain.


Ciel - taken from the covert networks database of the Mitchell Centre for SNA (see above), originally collected by Morselli (2009). N = 25; profit-driven. Drug smuggling network from Jamaica and Canada.

Siren - taken from the covert networks database of the Mitchell Centre for SNA (see above), originally collected by Morselli (2009). N = 44; profit-driven. International network of stolen vehicle transportation.


Togo - taken from the covert networks database of the Mitchell Centre for SNA (see above), originally collected by Morselli (2009). N = 33; profit-driven. Stolen vehicle resale network from Canada.

WomenTrafiB (N = 18), WomenTrafiC (N = 19), and WomenTrafiE (N = 20) – three cases of woman trafficking in the Northern part of the Netherlands, which were investigated by the police in 2013-2014 and analysed by Oosting (2016).
Despite the broad-based claim that criminal networks are dynamic, flexible, and adaptable, empirical research on dynamics of these networks is scarce (Bright, Koskinen, & Malm, 2018; Campana, 2016). One reason for this lack of evidence might be the scarcity of longitudinal data about criminal networks. While it is difficult to collect data on criminal networks in the first place, incorporating the temporal aspect is even more complex. However, the change of criminal network structure over time is an important aspect, as the ability to adapt and respond to internal and external changes is crucial for their functioning (Bright & Delaney, 2013; Bright et al., 2018; Duijn, Kashirin, & Sloot, 2014; Kenney, 2007).

The dynamics of criminal networks is especially relevant in relation to activities of law enforcement agencies to disrupt these networks. Observational and simulation studies comparing the performance of different disruption strategies showed that removal of actors in various types of central positions is among the most immediately efficient strategies (Bright, 2015). What is necessary, though, is to assess how disruption of criminal networks affects their evolution over time (Fielding, 2016). Interestingly, disruption attempts, such as arrests, do not usually lead to the complete dismantlement of the network, but only to partial damage. In response, actors may change the way they create, maintain, or dissolve ties, which, in turn, leads to changes in the network structure.

Considering network disruption in dynamic criminal network analysis allows to empirically assess the effect of disruption on network structure and actors' responses to disruption. Understanding how disruption strategies affect criminal networks is crucial considering the fact that even a carefully planned network intervention may result in contradictory unintended consequences (Duijn et al., 2014; Morselli & Petit, 2007).