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ARTICLE

The Building Blocks of a Euroregion: novel Metrics to Measure Cross-border Integration

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ABSTRACT The article explores how the notion of European integration at the local level can be conceptualized and measured. Based on a process-oriented inclusive understanding of integration and using relational datasets that maps both domestic and cross-border communication ties among political representatives in four Euroregions along the borders of Hungary–Slovakia and Sweden–Norway, we begin by applying and theoretically dissecting network-analytical metrics based on frequency of ties. Despite finding that such measures capture analytically relevant properties of political cross-border networks, we argue that they are less than ideal for capturing the notion of political integration. Instead, with inspiration from the blockmodeling tradition in network analysis, we propose two novel metrics—*cross-border connectivity* and *integrational overfitting*. These metrics not only enrich our understanding of political integration in cross-border settings but also can serve as useful mapping tools for policy-makers. A software client enabling the analysis of these measures supplements this article.

KEY WORDS: Cross-border cooperation, Euroregions, network analysis, blockmodeling

1. Introduction

The starting point for this article is the empirical observation that local and regional governments located close to a national border in Europe increasingly tend to form or join organizations with local or regional governments located on the other side of that border. Following Perkmann (2002, 104), such organizations will here be referred to as 'Euroregions', defined as

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formalized cooperation initiatives between sub-national authorities, often including private and non-profit actors located close to a border in two or more countries. The rise of Euroregions has attracted the attention of scholars and policy-makers alike, as it is linked to debates on European integration, new regionalism, and to multi-level governance as a new mode of policy-making (e.g. Brunet-Jailly 2012; Herrschel and Tallberg 2011, 8; Johnson 2009, 177; Koff, 2007a, 13–30; Scott 2007, 53).

Euroregions have been seen as 'self-confessed "laboratories of European integration"' (Kramsch and Bohdana 2008:31), lending themselves to addressing questions related to political integration. Is the development on the macro-political EU level mirrored in local contexts as well? Can processes in local cross-border spaces illuminate mechanisms and even predict developments on the national and EU level? Does political integration lead to more efficient policy outcomes? While these constitute big questions in the context of the European project, it is not possible to answer these in a comparative fashion without first conceptualizing and, if possible, operationalizing the notion of integration. Whereas there are previous such attempts at assessing integration (e.g. Blatter 2000; Deas and Lord 2006; Koff 2007b; Perkmann 2003, 2007a, 2007b; Scott 1993, 2007, 2012), we argue that most of these attempts do not problematize or fully capture the fundamental meaning of the concept of integration per se.

This article will propose novel relational metrics designed explicitly to measure the degree of political integration. Although we argue that these proposed metrics are better than existing formal approaches at capturing the most relevant aspect of cross-border political integration, as well as implicit connotations of the concept of 'integration' as such, they are seen as a complement rather than a replacement of existing approaches used in cross-border studies. Using example data consisting of communication patterns among political actors in four Euroregions, the suggested index of cross-border integration differs from the network-analytical metrics used so far in the mapping of cross-border political networks. Moreover, it claims applicability beyond the communicational aspect of such political networks.

The article is structured as follows. It begins with a discussion on the integration concept in European studies and provides a justification for why relational approaches provide added value. We then present the Euroregions from which the data is derived that is used to demonstrate the metrics. The core of the article follows in which different metrics are applied, beginning by looking at the network-analytical tools and metrics that have previously been applied in the cross-border context: visualizations, density measures, and the so-called External-Internal (E-I) index. Although such metrics reflect structural features that are of interest in the study of Euroregions, we argue that they are less than ideal for capturing relational features that we deem to be characteristic of cross-border political integration. Instead, we propose and specify two novel metrics—cross-border connectivity and integrational overfitting—that we subsequently apply to our four example datasets.

2. The Meaning of Integration and the Added Value of Relational Approaches

Central to this methodologically focused inquiry is the concept of integration, which has a variety of meanings and connotations in different social-scientific contexts. 'European integration' has been used as a catch-all label for studies related to the European 'Project', understood as the European Union, even though occasionally effort has been made for an inclusive interpretation, such as in the declaration of this journal that European integration is understood as 'pan-European rather than as merely the EU' (Taylor & Francis Online 2014). However, as noted by Murray (2009) and Kirchner (2009), the word integration is frequently taken as something 'that does not require explanation' (Murray 2009, 228). When scholars do work explicitly with the concept, one frequent understanding is that of European integration as a process (Christiansen 1998; Chryssochoou 2000; Murray 2009; Van Ham 2001; Wiener and Diez, 2009, 3). This perspective on the integration can also be read into the original statement of this journal to seek scholarship on questions of European unification (1977, 5). This process can in turn refer to different phenomena. As expressed by Van Ham (2001) it may, 'refer to a process of long-term socio-economic convergence among European societies; a careful and premediated process of cooperation among European nation-states and regions on a variety of levels; as well as a process of constructing (or 'growing') of European identity' (Van Ham 2001, 58). What these have in common is that they all consist of acts of inter-linkage, i.e. we see integration as a process of increasing and intensifying relations among entities that leads to the emergence and expansion of an inclusive integral whole. These flows can consist of goods, services, and information, take place within different realms (economic, social, political) and entities can be anything from individuals to firms, organizations, and countries.

In our definition, a Euroregion is an organizational institution, but also a territory, a border region that is 'a special area of fluxes and exchanges of a social, cultural, economic and political nature, a space where the development of multiple activities takes place and where the type and intensity of transactions have evolved in time' (Sousa 2013, 671). It is this area that lends itself so well for observing integration as a process increasing inclusive flows/relations and testing related theories. Thus, the Euroregion as an institution can be seen both as a network of actors (local or regional governments), and as a policy actor within a broader network of actors (other organizational players relevant to policy-decisions taken in the cross-border landscape). In other words, representing one layer in a multi-level political and geographic conceptual structure, the study of Euroregions (and regionalism in general) needs to be connected to the adjacent levels to better grasp the particularities of the studied Euroregion. This perspective is in line with the multi-level governance view (Hooghe and Marks 2001; Kohler-Koch 1998) of Europe and the existing emphasis on the role of policy networks in policy-making.

For many research questions, such as those mentioned in the beginning of this article, it is important to assess how far the process of integration

has reached within a Euroregion, that is to measure the level of cross-border integration within different realms, which could be economic (e.g. infrastructure, firms, labor commute), social (e.g. friendships, marriages) or political (e.g. policy communication, policy cooperation, policy coordination). This article uses cross-border political ties as test data (elaborated on in the next section), focusing on communication between political entities falling into two (possibly more) distinct subsets based on national belonging. With cross-border integration, the emphasis is thus on the integration of entities between different subsets and the particularities that makes the system as a whole integral. Integration in this sense is related to whether actors on either side acquire ties to actors on the other side. Fundamentally, therefore, integration is about relations, justifying our network-analytical approach.

With an explicit focus on the sets of relations that tie individual social entities (actors in network terminology) into grander systems, social network analysis provides formal tools for studying systemic structures and relational patterns. With its genesis in sociology and the behavioral sciences, network analysis has permeated the social sciences, providing an alternative approach for understanding system complexity and interrelatedness that stretches beyond the traditional cross-comparisons of properties of, assumed independent, units of analysis. It should be emphasized here that although network analysis and the emergence of a would-be science of networks are currently experiencing a significant boom in academia, the study of relations between social entities is not without precedent in human geography. Inspired by the call of McCarty (1940), post-war-geographers such as Schaefer (1953) sought to advance a more 'scientific' geography, which led to the quantitative revolution in human geography in the 1960's. This entailed the development of several formal methods for the analysis of systems of interconnected spatial units (e.g. Haggett and Chorley 1969; Sheppard and Barnes 2008, 22), many of which are still in use in today's social network analysis. The counter-quantitative revolution in human geography of the 1970's and 1980's meant a setback for relational approaches, but over the past two decades there has been renewed interest in the study of the micro-level foundations of socio-spatial systems. Recent applications of network-analytical tools in the context of Euroregions can be seen as examples of this. For instance, two European research projects that utilize a network-analytical approach have recently concluded or will shortly do so. The Metronet project addressed the effect of policy networks concerned with transportation and regional marketing in four western cross-border regions.[1] In the EU Border Regions project[2] border regions are explicitly seen as complex governance systems and a preliminary mapping of cross-border networks has been carried out at the Ukrainian–Hungarian–Slovak border (Gerő and Micsinai 2012).

To sum up, integration is a concept that is ubiquitously used and (too) rarely defined. We see it as the process of increasing and intensifying relations among entities that leads to the emergence and expansion of an inclusive integral whole. We claim, and as we hope will be shown, that relational approaches are well suited to capture this. As the aim is to

capture and operationalize political integration in the cross-border context, we begin by presenting the example datasets used in this paper.

3. Four Euroregions as Example Data

The data used in this study consists of communication patterns between members of four Euroregions located at two national borders: Hungary–Slovakia and Sweden–Norway. Even though these cases are not used to test hypotheses, and issues like case selection therefore plays a minor role, knowing the basic facts of these Euroregions and how the data was derived will be of help when moving into the substantial parts of this article.

None of the cases represent 'famous' cross-border cooperation areas, such as the Dutch–German Euregio, which in 1958 was the first Euroregion to be established, or the Øresund Committee driving the metropolitan cooperation across the Danish–Swedish Øresund strait. Instead, with the possible exception of the Hungarian–Slovak Ister-Granum EGTC, their relative anonymity is typical for the around 150 Euroregions that today exist at Europe's internal and external borders (Association of European Border Regions 2013; Perkmann 2003; Svensson 2013). The oldest, Granskommitten Ostfold-Bohuslan-Dalsland (OstBoh),[3] was established in 1980 and has 22 Norwegian and Swedish local governments as members and two regions. To its immediate north, another Euroregion comprising 15 local governments is located, Granskommitten Varmland–Ostfold (VarmOst), which was founded 10 years later. At the West Central part of the Hungarian–Slovak border, Hidvero and Ister-Granum were founded in the late 1990s and early 2000s when dozens of Euroregions were formed in Central and Eastern Europe, but differ in size. Whereas one is a large agglomeration of more than 80 local governments (albeit most of small size), the other has 18 members. As seen in Table 1, these Euroregions do display differences in terms of the number of local governments that are members, the population, and when they were founded. However, in terms of having good pre-conditions for cooperation they are similar, since

Table 1. Overview of Euroregions included in the study

	OstBoh	VarmOst	Hídverő	IsterGranum
Official name	Gränskommitten Østfold-Bohuslän-Dalsland	Grensekomiteen Värmland-Østfold	Hídverő Ister-Granum	EGTC association
Founded	1980	1990	1999 (Association) 2003 (Euroregion)	2003 (Euroregion) 2008 (EGTC)
Population 2010	470,000	210,000	30,000	175,000
Local governments (actors)	22 14 Swedish +8 Norw.	15 10 Norw.+ 5 Swedish	18 13 Slovak+ 5 Hung.	82 42 Hung.+ 40 Slovak

participants share cultural-linguistic similarity (they can communicate in the same language since Norwegians and Swedes in these area understand each other without difficulties, and for historical reasons the Slovak local governments in the study are Hungarian-speaking) and operate in administratively and economically relatively homogenous areas. They all strive to be multi-purpose policy cooperation and coordination bodies, although the level to which that is fulfilled varies.

Of the multitude of relations that possibly exist between these local governments, including affiliation data such as would-be shared memberships in regional organisations, we will here use data on communication between local government offices. This focus is motivated by communication between policy actors being both a condition for and a result of coordination and cooperation on policy in different forms. It can therefore be a strong indication of political integration, although of course many other types of relations can matter as well. For the purpose of this article the cases presented above are useful examples since due to the good preconditions they could be expected to have some communication, but nonetheless are different enough to give variation on the investigated and proposed metrics.

In this dataset, communication constitutes all inter-personal forms, such as face-to-face contact, telephone, and email, i.e. similar to 'information exchange' as defined by Walther and Reitel (2012). In a series of interviews carried out 2010–2011 with the mayors of these local governments, who are also the ones who represent the local governments in the Euroregion, the highest political representatives of these were asked to rate the frequency of contacts with other local governments within their particular Euroregion. In this article, a tie is defined as when one part indicates at least monthly contact.

The response rate was high for all four networks. Three were complete, i.e. with a 100% response rate, whereas the fourth, Ister-Granum, had a response rate of 82%. This is important, as missing data is a more serious issue in network analysis than in cross-comparative sample-based statistical analysis. Samples can generally not be used (with exceptions for certain measures) and the effect of missing data is often multiplied throughout the network. The most common causes for missing data are ill-defined networks, respondent inaccuracy or non-response (Kossinets 2005).

4. Network Analysis in Cross-border Settings

A rudimentary understanding of network cohesion is provided by the density measure, calculated as the quota between the number of existing ties and the total number of possible ties. The density can refer to the whole network, or, as we shall return to later on, for subsets of actors. Another index previously used in Euroregional studies is the E–I index. In this section, we will first examine how density for the whole network works out as an integration metrics (or not), followed by the E–I index and a modified version of subset densities. Establishing the deficits of these, the following section will then introduce the two novel indices, which draw on the

blockmodeling tradition in network analysis and constitute the core contribution of this article.

4.1. Density

Visualizing our networks allows a quick assessment of the overall density and local variations thereof in our networks of political communication (Figure 1). In Euroregions OstBoh and VarmOst, white nodes indicate Norwegian local governments and black nodes indicate Swedish ones. In Euroregions Ister-Granum and Hidvero, Hungarian local governments are white and Slovak black. The overall density value based on monthly communication is added to each Euroregion. Moreover, larger nodes correlate to the closeness to the national border.

Starting with the Swedish–Norwegian Euroregions, we see that the networks are clearly divided into separate national clusters. The establishment

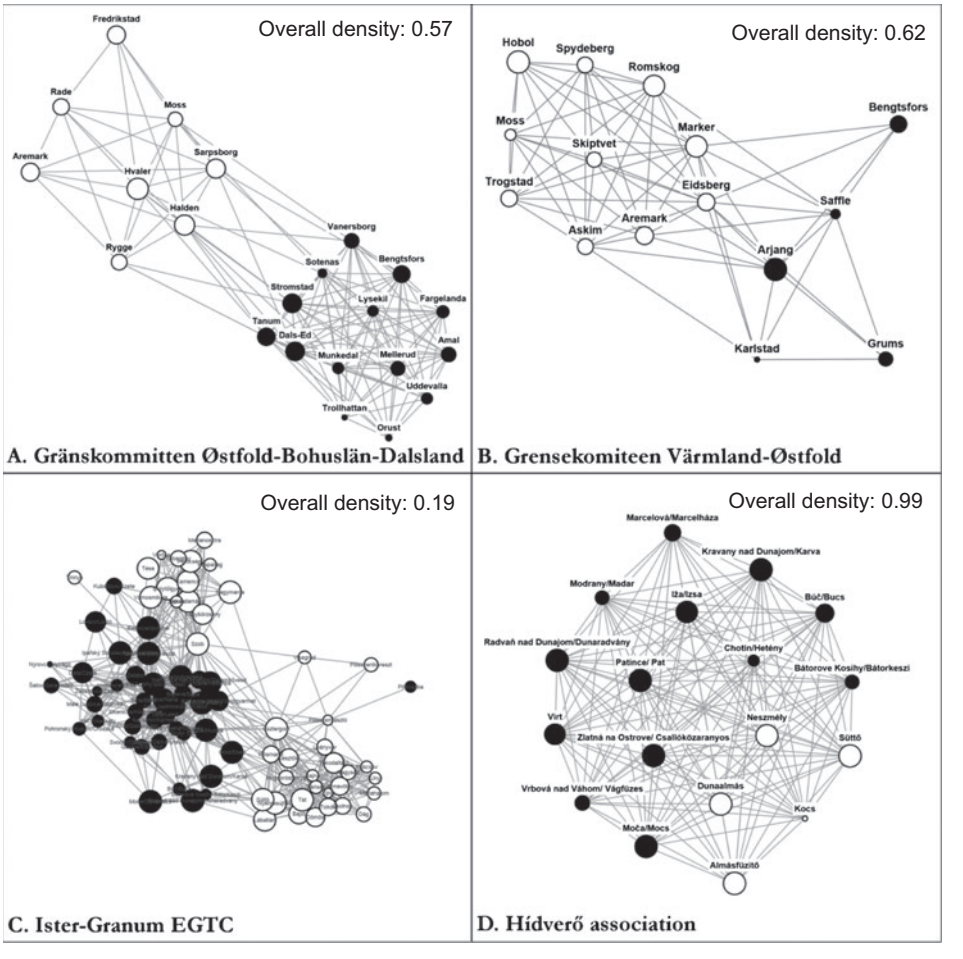

Figure 1. Visualization of communication patterns

of these Euroregions have evidently not led to the creating of integrated political cross-border spaces.[4] Even though the network-wide density values of the networks may be over 0.50, these numbers obfuscate the obvious density differences within and across national borders.

This impression is overall supported when comparing the Swedish–Norwegian networks with the Slovak–Hungarian ones. The primacy of the state border is again apparent, even though Hídverő seems to be a much more integrated political communication network than the others. This suggests that density differentials between domestic and cross-border ties are a characteristic feature of Euroregions. A particularity is how the Hungarian side of the Ister-Granum network is further divided into two separate cohesive subgroups. These follow geographic and internal administrative divisions, with one subset mainly consisting of local governments located south-west of the Danube river, where remaining Hungarian actors are found east of the Danube and the border river to Slovakia, Ipoly/Ipel, belonging to different administrative regions. This shows how it is not only state borders that can impede political communication in Euroregions, but also domestic administrative borders can matter.

These visualizations of the Euroregions as cross-border political spaces are probably not surprising. It is well known that the performance of many Euroregions has been below initial expectations (e.g. Perkmann 2003), and few would have expected administrative borders to stop mattering.[5] However, what is important is that when state borders evidently act as significant inhibitors of political communication, network-analytical metrics applied in the cross-border context has to take such properties into account. We see how calculations of overall density of Euroregions can be misleading, since entities can be well connected with each other on each side of the border, driving up the overall density, although there are few links across the border. It might therefore be better to measure and compare subset densities, which for instance can be only those that cross the border. However, before doing that we will first examine an index that is explicitly designed to measure relative tie frequencies occurring within and between pre-specified subsets.

Table 2. External-Internal index values for partial (domestic) and overall networks per Euroregion

Euroregion (total number of actors)	Partial network		Overall network	
	Country 1	Country 2	Non-normalized	Rescaled
OstBoh (22)	−0.837 (S)	−0.529 (N)	−0.758	−0.939
VarmOst (15)	−0.032 (S)	−0.709 (N)	−0.552	−0.842
Ister-Granum (81)	−0.724 (H)	−0.746 (SK)	−0.735	−0.735
Hídverő (18)	0.524 (H)	−0.418 (SK)	−0.158	−1[a]

[a]The rescaled value of Hídverő is misleading, since the network has a density of nearly 100% and the rescaled value therefore is calculated on only a couple of 'missing' links.

4.2. E–I Index

The E–I index was developed by Krackhardt and Stern (1988, cited in Hanneman and Riddle 2005), and is an intuitive way to grasp whether actors tend to interact with actors like themselves (in this context someone on the same side of the border) or with actors that are different. In the cross-border context, Walther and Reitel (2012) and Durand and Nelles (2012) used this index in their studies of communication (information exchange) within policy networks on transports and public transit at the Basel cross-border region and the Lille-Kortrijk-Tournai Eurometropolis.

The index compares how many ties a group has between themselves with how many it has with actors outside this group, which is calculated by subtracting the number of internal ties of a given subset from the number of ties to actors outside this subset, divided by the total number of ties. Negative values indicate that most ties are within subsets, whereas positive values indicate an emphasis on ties outside the group. Table 2 displays the E–I index values for all four Euroregions and demonstrates that actors tend to have more domestic than cross-border ties. This contrasts sharply against the findings in the studies mentioned above. In the study of the Basel region, Swiss actors had a moderately negative E–I index of −0.271, whereas German and French actors actually had positive values of 0.63 and 0.03, respectively (Walther and Reitel 2012, 15). Likewise, based on the E–I index, it was found in Lille-Kortrijd-Tournai that 'the border effect is not a factor for French actors whereas it appears to play a minor role for Belgian organizations' (Durand and Nelles 2012, 31).

Apart from possible substantive factors, we see two possible methodological explanations for the divergence in our results compared to the studies mentioned above. First, the studies by Walther and Reitel (2012) and Durand and Nelles (2012) pertain to a specific policy area of high cross-border relevance. Reflecting this, further biasing those findings, some actors were removed from the dataset as they 'had no cross-border activity' (Walther and Reitel 2012, 6). The datasets analyzed in this article, on the other hand, contains all local governments that are *formally* involved in cross-border cooperation organizations, irrespective of how active they actually are in these initiatives.

Secondly, the E–I index does not take the size of subgroups into account. As all networks except Ister-Granum have different sizes of their domestic subgroups, this distorts the raw (non-rescaled) E–I values and make them misleading for comparisons. Rescaling is not readily available in all standard network analytical softwares.

Table 3. Cross-border and overall densities of the four Euroregions

Euroregion	Cross-border density	Overall density
OstBoh (22)	0.14	0.57
VarmOst (15)	0.30	0.62
Ister-Granum (81)	0.05	0.19
Hídverő (18)	0.98	0.99

4.3. Cross-border Subsets

If the primary interest is the amount of ties that exist across the borders, we therefore advocate neither using overall density values nor the E–I index, but instead look at the densities of cross-border links only. That is, of all possible cross-border links, how many are present? This does not lend itself so well for visualization, but the numbers are telling. The density values of cross-border ties in the four Euroregions (see Table 3) are considerably lower than overall density values, indicating the constraining impact of state borders. The exception, once again, is Hídverő whose cross-border ties on a monthly basis are practically the same as the exceptionally high overall density.

These formal metrics confirm the intuitive results from the earlier graphs, i.e. the extent of cross-border communications between these political actors is generally low even though there are differences between the cases. However, even though this adjusted density measure seems to be a more apt measure than the overall density measure or the E–I index, it still measures only an aggregated tendency. Due to their focus on overall amount of ties, they hide finer details of the actual patterns of ties that exist in these networks and which would be important for assessing the degree to which they are integrated. In addition, one can assume a limitation to the number of ties, cross-border as well as domestic, which can actually be upheld by an actor. Density assumes an infinite 'relational capacity' of actors.

Borrowing concepts from the blockmodeling tradition in network analysis, the following section introduces two novel metrics that capture such details and better reflect what cross-border integration means in this context.

5. Inclusive Integration

Following the definition of integration as a process of increasing and intensifying relations among entities that leads to the emergence and expansion of an inclusive integral whole, integration is not just about the number of ties, but also about the extent to which an important share of actors are included. Moreover, it would fit when applied to the political realm of a cross-border region as indicated by the communication between actors therein.

To do this, we draw on blockmodeling, a hands-on tool in role-analysis that implies partitioning the actors of a network into subsets ('positions' in network terminology) based on a meaningful definition of equivalence that are deemed to fulfil similar structural roles in the network. Stemming from a series of articles in the 1970s (Breiger 1976; Lorrain and White 1971; White 1974; White, Boorman, and Breiger 1976), role-analysis and the associated technique of blockmodeling have occasionally been seen as a possible foundation for a theory of social structure (e.g. Snyder and Kick 1979, 1103; White, Boorman, and Breiger 1976, 732).

A blockmodel is created by sorting the original data matrix in accordance with a given partition of subsets. In the context of Euroregions this could mean partitioning the network into subsets based on the function of

the mayors of the local governments such as Chairs, board members, regular members etc.

After having outlined the sub-matrix 'blocks' within and between positions, the underlying functional anatomy of a network is established by comparing emerging block patterns with a set of ideal blocks. In *structural equivalence* studies, two actors are deemed equivalent if they have *identical* ties to the same alters. In such a case the two basic ideal blocks are 1-blocks (corresponding to a fully connected block) and 0-blocks (no ties). In *regular equivalence* studies, role-similarity means having *similar* ties to other actors that in turn are equivalent. This adds an additional ideal block type where there is at least one tie on each row and column, respectively. Following the example above, Chairs of Euroregions might be expected to have a similar pattern of connections to local governments on their own side of the border and to the other side, respectively. Having found partitions and blocks reflecting such ideal types, the blockmodel is then typically reduced to a block image/graph depicting general relationships between and within such positions.

Importantly, we did not conduct such a role-equivalence analysis per se of these geo-political networks in the present study, although doing so may be well worth doing in future research. Since we are instead interested in the patterns of cross-border ties, actors were partitioned into positions based on national belonging, followed by subsequent partitions based on the existence of cross-border ties. This means that we do not apply role-equivalence here but instead use this technique of generalized blockmodeling and its set of ideal blocks to conceptualize and measure integration in this particular disciplinary context.

We will now use the OstBoh dataset to walk through how this is done, which will conclude in the introduction of the measures connectivity and overfit. The visuals above demonstrated that domestic ties are relatively cohesive, indeed having a higher density than cross-border ties. Expressed as a 2-positional blockmodel, the density differential in OstBoh is clearly visible in Figure 2 where the intra-national blocks are almost ideal 1-blocks.

In a fully integrated Euroregion, the non-diagonal blocks would also constitute 1-blocks. As the density calculations revealed, they are not: the cross-border blocks in Figure 2 are significantly less dense than the two intra-positional blocks.

In the OstBoh dataset, five out of eight Norwegian actors have cross-border ties, connected with eight out of 14 Swedish actors, i.e. 13 actors have 16 cross-border ties that yield a cross-border density of 0.14. Additional cross-border ties would increase density, but would not necessarily result in more actors with cross-border ties. We can theoretically add 24 more cross-border ties, increasing the density to 0.36, while still remaining at these five Norwegian and eight Swedish actors with cross-border ties. Similarly, we can theoretically remove half of the cross-border ties in Figure 2, lowering the block density by half, while still having the very same amount of actors with cross-border ties. That is, even though density measures of domestic and cross-national ties provide an overview of

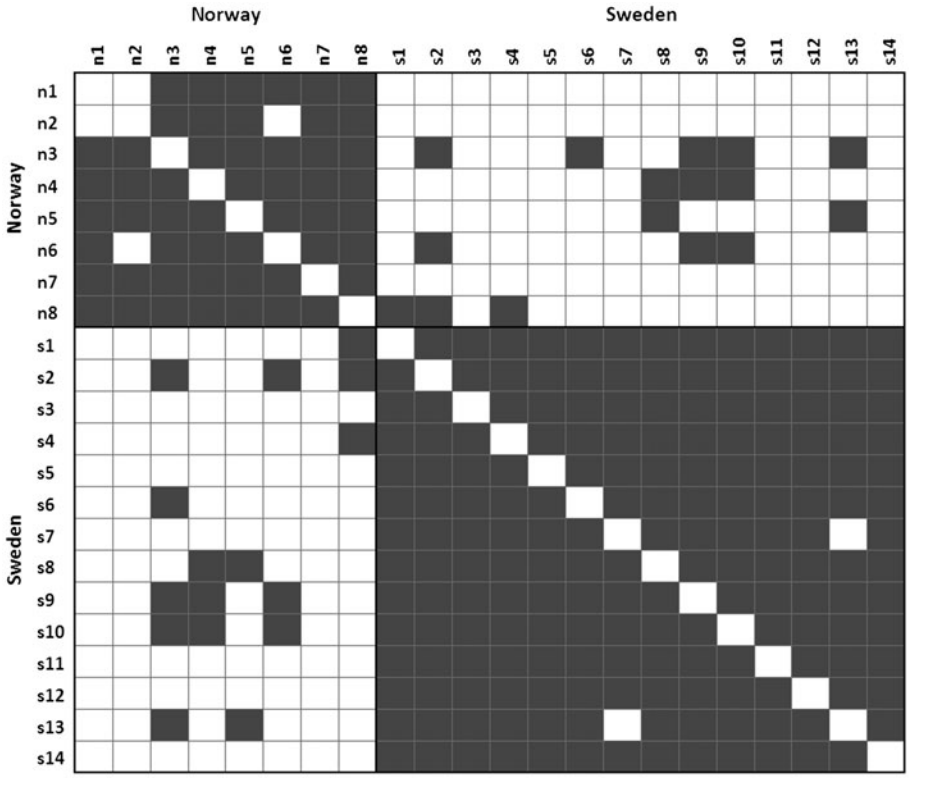

Figure 2. Positional (country-based) blockmodel of OstBoh monthly dataset

Euroregional communication patterns, such measures do not necessarily reflect an inclusive understanding Euroregional integration.

Rather than using densities, we work with the ideal regular block mentioned above defined as a block with at least one tie in each row and column. Here, this implies that each local government has at least one cross-border tie.

Subsequently partitioning the two national positions in Figure 2 based on cross-border connectivity, we arrive at positions with and without cross-border ties. These positions are displayed in Figure 3, where positions N1 and S1 contain actors with crossborder ties and N0 and S0 those without.

Collapsing this blockmodel into a generalized block image allows us to conceptualize domestic and cross-border ties of any possible Euroregion (Table 4). This table hence constitutes our suggested structural template for mapping ties in any conceivable cross-border setting.

Based on these partitions and the number of actors found in each of these, we suggest a normalized connectivity index that reflects the share of actors with cross-border connections:

$$\mathrm{conn}_{\mathrm{cb}} = \frac{(N_{\mathrm{A1}} + N_{\mathrm{B1}})}{N}$$

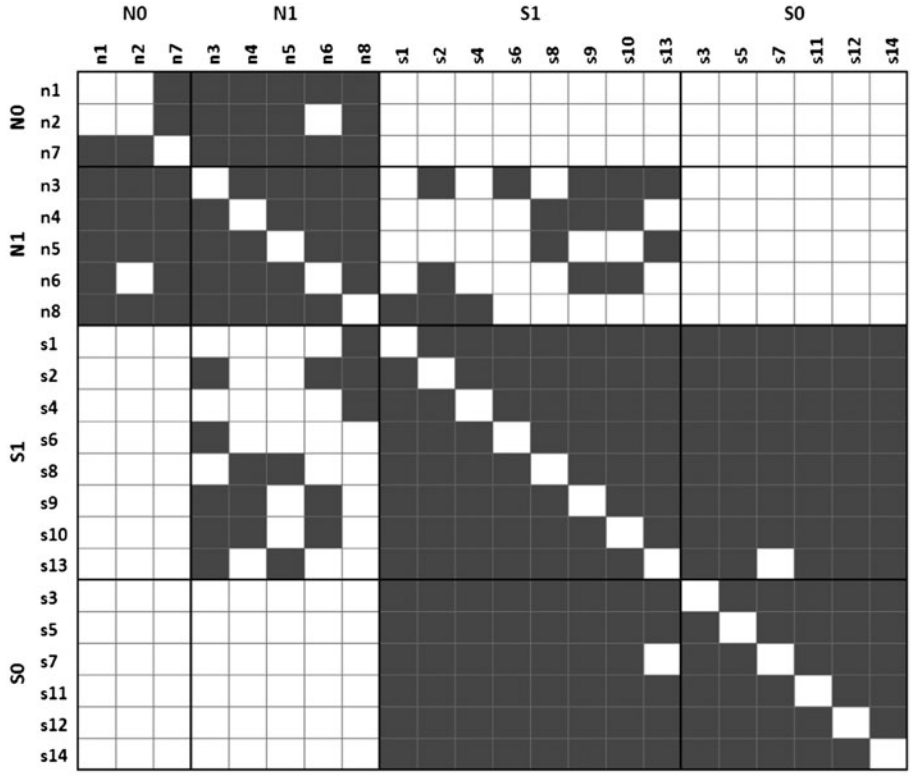

Figure 3. Positional (country- and cross-border-based) blockmodel of OstBoh monthly dataset

Table 4 Generalized block image of communication patterns within a Euroregion

	A0	A1	B1	B0
A0	(Imperfect) 1-blocks		0-block	0-block
A1			Regular	0-block
B1	0-block	Regular	(Imperfect) 1-blocks	
B0	0-block	0-block		

where A1 contains all actors with cross-border ties, N_{A1} is the number of actors in position A1, and N is the total number of actors.

We can also calculate a more rudimentary directional connectivity index, i.e. the share of actors on one side that has cross-border ties:

$$\text{conn}_A = \frac{N_{A1}}{N_{A1} + N_{A0}}$$

where N_{A1} and N_{A0} are the number of actors in position A1 and A0, respectively.

The above connectivity index for the OstBoh dataset is 0.59, indicating that 59% of local governments in this Euroregion have cross-border connections. However, there are more cross-border ties than is functionally necessary to arrive at this percentage.

Contrasting the number of existing cross-border ties with the minimum ties necessary for the given degree of connectivity, we get a measure of overfit for regular blocks:

$$\text{overfit} = \frac{\text{blocksum}(\text{A1}, \text{B1}) - \max(N\text{A1}, N_{\text{B1}})}{\max(N_{\text{A1}}, N_{\text{B1}})}$$

where blocks um(A1,B1) is the total number of ties in the A-to-B block, N_{A1} is the number of actors in position A1.

Expressed as a percentage of redundancy, the OstBoh example has an overfit value of 0.5, meaning that half of the existing cross-border ties are theoretically redundant in terms of adding anything to the connectivity value.

The two suggested measures can thus be summed up as follows:

Connectivity: indicates the share of actors with cross-border connections. The directional connectivity measure indicates the share of actors on one side with cross-border connections.

Overfit: indicates the number of ties that are not necessary in order to maintain a given connectivity.

These two metrics were implemented in *CrossborderBlocker*, a Windows software client[6] we developed for the explicit study of cross-border ties. Applying this tool on the four Euroregional networks of this article, the results are presented and discussed in the subsequent section.

6. Comparing Metrics: Results from Four Euroregions

This article has used communication links within four Euroregions as examples to discuss how scholars can assess European integration in micro-regional spaces. Even more concretely, we wished to establish the extent to which communication between local governments, as an indicator of political integration, takes place across borders as compared to within-country communication. Section 4 did so by using the tools of density and the E–I index. In section 5, the measures cross-border connectivity and overfitting were introduced. The key question is now whether these measures will change our perception of what constitutes an 'integrated' Euroregion in terms of having access to efficient cross-border communication ties.

Let us first return to what density is a measure of. When measuring communication ties using density, one could argue that 'the more, the better': the more communication that took place across the border, and the smaller the difference to the density of domestic ties, the more integrated would the overall network seem to be. In reality, many actors lack cross-border ties altogether, whereas others have many links. One actor could be 'sitting on' most of the cross-border ties, which hardly would constitute integration. An example is Eidsberg in the VarmOst dataset: as one out of 10

Norwegian municipalities, Eidsberg commands five out of the 15 cross-border ties to Sweden, whereas Trogstad, Spydeberg, Hobol, and Moss lack cross-border ties altogether.

However, our suggested index of cross-border connectivity captures the spreading of ties among several actors at both sides of the border, with fewer 'redundant ties' (i.e. one actor sitting on all cross-border ties). In Table 5, we provide the connectivity and overfitting indices for our four studied Euroregions, including rescaled overall E–I indices for reference.

As evident from the table, connectivity captures different properties of cross-border ties than density does. In combination with the measure of overfitting, the image of integration in the studied Euroregions becomes more nuanced. The table demonstrates that whereas Hidvero and VarmOst still stand out as networks with many cross-border connections, it is clear from this new measure that Ister-Granum can rely on a broader network base than the density measure would indicate. Two thirds of all actors in Ister-Granum have cross-border ties, even though the density is hardly noticeable.

Evidently, the measure of connectivity and overfitting is more independent of 'relational capacity' and network size than what is the case for density metrics. The directional connectivity can be useful for two purposes. First, it may give researchers a hunch regarding who dominates policy agenda setting, as the involvement of a higher proportion on one side can be an indication of that side taking the lead in developing cooperation proposals. Secondly, it can serve as a tool for studied Euroregions to see where resources to improve integration should be directed. For example, if additional resources are to be invested to increase regional connectivity, the *CrossborderBlocker* software client helps identify which local governments are in sections with little communication and policymakers can then take steps to find out why communication is lacking here, and what could be done to improve cross-border connectivity.

To sum up, the advantage of using connectivity vs. density values or the E–I index in the context of a cross-border region is that a network where a

Table 5. Properties of cross-border ties in the four Euroregions

		Cross-border properties			
Euroregion	E-I-index (rescaled) Overall network	Density	Connectivity	Directional connectivity	Overfitting
OstBoh	−0.94	0.14	0.59	S-to-N: 0.57 N-to-S: 0.62	0.50
VarmOst	−0.84	0.30	0.73	S-to-N: 1.00 N-to-S: 0.60	0.60
Ister-Granum	−0.74	0.05	0.67	SL-to-H: 0.67 H-to-SL: 0.67	0.67
Hidvero	−1.00	0.99	1.00	1.00 (both ways)	0.80

few actors 'own' most ties cannot be categorized as integrated despite of potentially high density values. The benefit of the Overfit measure is that in contacts where communication represents a cost it can detect whether resources are used wisely if the overall aim is to increase integration. Therefore, these new measures has the potential to change our perception of an 'integrated' Euroregion from one where much communication takes place across the border to one where communication takes place between many actors, or from a Euroregion with many links to one with more evenly distributed links.

7. Conclusion

We started this article by pointing out how the increasing number of subnational cross-border cooperation institutions in Europe has been linked to debates on European integration, new regionalism, and multi-level governance. Euroregions have been seen as laboratories where these phenomena can be studied. This article focused on how the notion of European integration can be measured in micro-regional cross-border political spaces. This opens up for important applications, since it can be assumed that efficient cross-border communication helps policymakers realize what issues could benefit from policy cooperation, as well as to enhance the capacity to come up with new ideas on how to tackle them. Enhancing people-to-people contacts among politicians as well as civilians can also be a goal in itself for Euroregions, and making informed assessments of the extent to which this happens is then a clear advantage.

It should be emphasized that the measures discussed in this article are not confined to communication data or political integration. The method would be the same for assessing other types of relations between entities and whether these are increasing or intensifying. For instance, infrastructure in the form of railways and bus connections, or cooperation links between civil society or corporate organizations would be another type of data that could be used. The key contribution of this article is therefore that it has demonstrated that the somewhat diffuse concept of integration is perhaps not captured by existing network analytical tools. The specific metrics on cross-border *connectivity* and *integrational overfitting* that we have proposed is not necessarily a replacement but rather complementary tools to density and the E–I index. We do believe them to be of use to both academics and policy makers in the study of integration in cross-border regions and beyond.

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Notes

1. The 'Cross-border Metropolitcan Governance in Europe' project is a three-year project led by the Centre for Population, Poverty and Public Policy Studies (CEPS/INSTEAD), Luxembourg, funded by the National Research Fund of Luxembourg (See e.g. Dörry and Decoville 2012).
2. 'EU Border Regions' is a four-year project led by the University of Eastern Finland, funded by the EU FP7 research program.
3. This Euroregion has recently changed name to "Svinesundskommittén".
4. As a control question, mayors in OstBoh were also asked to write down the name of the highest political representatives of other local governments in the region. On average, the OstBoh members could name 10.6 of their 21 potential alters. Out of these, 9.2 were from the same country, i.e. the average mayor knows only 1.5 mayor by name on the other side of the border.
5. It can here also be noted that the visualizations indicate that closeness to the border is important but not decisive for cross-border communication. While this is not key to the argument of this paper, it is a detail that my interest those with a more keen interest in Euroregions.
6. The CrossborderBlocker Windows software is freely available for download at http://cnslabs.ceu.hu/

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