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Beyond 'periphery': a detailed and nuanced taxonomy of the Norwegian regions

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ABSTRACT

Increasing attention is being paid towards the influence of regional contexts on innovation activities within regional development studies. Some of the literature in economic geography tends to consider the various peripheral areas as being homogenous and partly characterized by their remote location, weak innovation inputs and lack of knowledge exchange. This paper questions this approach by examining the role of innovation activities in peripheral regions. We offer a detailed and multifaceted taxonomy of the Norwegian economic regions. From an empirical viewpoint, the adoption of cluster analysis and a broad set of innovation, economic and territorial indicators allowed us to provide a nuanced picture of the current fabric of Norwegian innovation and economic-production. With the benefit of insights from relevant strands of literature (e.g. regional development, innovation systems and multi-scalar innovation networks), the case of Norway presented in our paper contributes to the scholarly debate on the role of structural preconditions for the innovation of firms in diverse peripheral areas.

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1. Introduction

The debate on firms' innovation activity in peripheral regions has recently attracted increasing scholarly attention (Doloreux and Dionne 2008; Eder 2019; Fritsch and Wyrwich 2021; Glückler, Shearmur, and Martinus 2022). Conversely, in economic geographical studies there has traditionally been a principal view of innovation as an urban phenomenon (Florida, Adler, and Mellander 2017; Feldman and Kogler 2010; Hall 1999). Based on this approach, density between firms and people is important for the diffusion of learning and creativity, which means that innovation dynamics thrive best in core or urbanized areas, thereby leading to economic growth. The idea behind this argument is that innovative activity flourishes in contexts where there are high levels of geographical, cognitive and organizational proximity between different types of co-located actors (e.g. private companies, research establishments and supporting agencies; see Boschma 2005). In peripheral areas, the literature highlights how contextual dimensions (i.e. regional characteristics such as depopulation, low proximity between knowledgeable actors, small firms, and organizational 'thinness' and remoteness) are factors that inhibit learning and innovation.

More recent evidence nuances the above argument – for example, by showing how rurality can also drive interactive innovation processes (Schmidt, Díaz-Puente, and Bettoni 2022), and how

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collaboration with different types of actors located outside peripheral regions can lead to beneficial innovation outcomes. Moreover, it is demonstrated how innovators within knowledge-intensive business services (KIBS) tend to locate away from more densely populated areas (Shearmur 2012). In this paper, we adopt recent conceptual advances in the field by arguing that peripheries are heterogeneous in terms of opportunities and challenges (Nilsen, Grillitsch, and Hauge 2022), thus underlining that not all peripheries are the same (Calignano 2022). In other words, we challenge the way in which peripheral areas have been traditionally characterized in terms of innovativeness in the academic literature by backing the scholars in economic geography and regional development that have started to treat these areas as diverse in terms of size, skills, competences, geographical remoteness, etc. (see Eder 2019; Pugh and Dubois 2021).

Our paper contributes to this discussion and aims to explore and differentiate peripheries by introducing a more nuanced view of innovative activity in peripheral regions (see Pugh and Dubois 2021). We seek to understand more about how different regions, with their own peculiar territorial, structural and socioeconomic characteristics, perform along the 'innovation path', thereby contributing to a detailed understanding of the differences and variations between them.

Using a cluster analysis, we are able to present a detailed taxonomy of the various regions that comprise a given national context. We can also reveal the degree of innovativeness of core and differentiated peripheral areas, based on a combination of selected indicators that measure various regional aspects and dynamics (e.g. status with regard to geographical core/periphery, networking and openness towards external sources, sectoral specialization, human capital and policy support), which are widely used in relevant strands of literature, such as economic geography and innovation studies (in this regard, see Sections 2 and 3, where we discuss how the variables we employed are anchored to the main theoretical approaches to regional development, and contribute to building our analytical framework).

The geographical context for our analysis is represented by the Norwegian regional areas known as 'economic regions', which approximately correspond to the Nomenclature of Territorial Units for Statistics – NUTS 4. The reasoning for using this context is the need for the Norwegian economy to renew and break out of its path-dependent natural resource economy, in particular the strong dependency on the oil and gas sector. Being highly dependent on income from extractive industries creates a vulnerability for the specialized industry in Norway, because fluctuations in exogenous factors (such as raw material prices, sustainability issues, and supranational pressure on greening the economy) increase the need to diversify into new sectors and industries. There is therefore a need for a more nuanced and detailed understanding of the current situation regarding firms' innovation performance in order to be able to create a 'baseline' and a knowledge-based starting point for the transition process.

Our study is informed by evolutionary economic geography (EEG) and regional innovation systems (RISs), which are two strands of literature that tackle the topic of path development by focusing on endogenous and exogenous factors such as knowledge density, competence development and geographical centrality (Martin and Sunley 2006; Binz and Truffer 2017; Frangenheim, Trippl, and Chlebna 2020; Njøs, Sjøtun, and Jakobsen 2020). In addition to this, we discuss considerations regarding the sectors that characterize each targeted industrial-productive fabric (Malerba 2005; Nilsen and Njøs 2022), with the aim of supplementing our territorial perspective and presenting a comprehensive regional representation of the national context under analysis. In this regard, in a country such as Norway, whose economy is characterized by a few dominating economic sectors, taking the sectoral characteristics of the targeted regions into consideration seems to be necessary.

To summarize, our study maps 88 functional regions (i.e. the 'economic regions' we mentioned above) and provides a detailed taxonomy of the current Norwegian innovation and economic-production fabrics. Our empirical analysis benefits from combining the 2018 Community Innovation Survey (CIS-2018) and data from the national register, and is based on a large number of innovation, territorial and socioeconomic indicators (i.e. innovativeness, multi-scalar knowledge flows, industrial structures, geographical and demographic statistics, institutional support and human capital).

This background creates the basis for our research question: What is the main distribution of firms' innovation activities in the Norwegian economic regions (with particular focus on the peripheral regions)? Answering this empirical question enables us to contribute to the theoretical debate on regional development processes in peripheral regions. By means of the methodological approach briefly illustrated above, our ambition is to transcend the targeted Nordic country and contribute new insights and interesting points of reflection to the current scholarly debate on the spatial, relational and economic dynamics and mechanisms that may possibly lead to innovativeness and regional development in differentiated peripheries.

The remainder of this paper is structured as follows. In Section 2, we briefly review the main literature on the topics primarily tackled in our paper (i.e. core and peripheral areas; innovation systems and multi-scalar networks; sectoral characteristics, socioeconomic conditions and policy support) and, based on this, we introduce the indicators used to perform our empirical analysis. In Section 3, we describe in detail the variables used when conducting our empirical analysis, and illustrate the method we adopted to create a taxonomy of the Norwegian economic regions (i.e. K-means clustering). We present our main findings in Section 4, and discuss them in Section 5. Finally, Section 6 features the conclusion of our paper.

2. Theoretical and analytical background

In the next four sub-sections, we illustrate the main theoretical concepts that inform our empirical analysis, and briefly introduce the related indicators that enabled us to provide a detailed taxonomy of the Norwegian regions under analysis (for further information on the indicators and variables used, see Table 1). We begin with innovation and regional development in core and peripheral areas (Section 2.1), followed by RISs (Section 2.2) and the importance of sectoral characteristics and policy support (Section 2.3). Finally, we discuss differentiated regional preconditions in the peripheries (Section 2.4) with the aim of creating the adequate background from which our paper will inform the extant literature.

2.1. The geographical framework: from core regions to peripheries

The term 'core regions' traditionally refers to more dominant, powerful, prosperous and prestigious regional areas to which 'peripheral regions' are hierarchically subordinated (Azaryahu 2008). Theories of innovation and regional development tend to focus on structural barriers in order to explain how innovation is inhibited in rural and more central areas, respectively (Grillitsch and Sotarauta 2020). Much of the work to stimulate regional development at the policy level has been devoted to facilitating the system, i.e. the collaboration between actors within a region, such as industries, applied research establishments, small firms and universities (Asheim, Isaksen, and Trippl 2019). The notion of geographical proximity and the view that knowledge and learning tend to be diffused more effectively in densely populated environments have promoted a strong belief in agglomerations in policy environments, particularly in large metropolitan regions (Tödtling and Trippl 2005; Isaksen and Trippl 2016).

More recently, several studies have questioned this view and have called for more nuanced descriptions of such peripheries. More specifically, this approach to the study of regional development 'has led to the implicit assumption that peripheries are seemingly uniform, characterized by low accessibility and low population density' (Eder 2019, 43). In addition, all of these regional areas seem to be equally poorly equipped in terms of innovation inputs, such as low research and development intensity, the presence of traditional sectors and limited knowledge exchange (Isaksen, Tödtling and, and Trippl 2018). According to Eder (2019), just such an alleged uniformity has made the various existing peripheries barely comparable. The recent 'rural turn' in the literature on regional development (Doloreux and Dionne 2008; Eder 2019; Eder and Trippl 2019) has prompted the view that alternative means are needed to promote development in rural regions.

Table 1. Detailed description of the variables and indicators adopted.

Variable	Indicator	Description
Product innovation, Process innovation	Innovativeness	Proportion of firms reporting product or process innovation (average). Municipality data aggregated at the economic region level. Source: CIS-2018. Reference years: 2016–2018
Agriculture, forestry and fishing; Mining and quarrying; Manufacturing; Construction; Transportation and storage; Information and communication; Financial and insurance activities; Real estate, professional, scientific and technical activities; Administrative and support service activities	Sectoral specialization	Proportion of employed persons in each listed sector (place of work). Municipality data aggregated at the economic region level. Source: Statistics Norway. Reference years: 2016–2018
Regional clients and suppliers, National clients and suppliers, International clients and suppliers, Regional research organizations, National research organizations, International research organizations	Openness/External knowledge sources	Proportion of firms reporting collaborations with clients/suppliers and/or research organizations. Municipality data aggregated at the economic region level. Source: CIS-2018. Reference years: 2016–2018
Financial support (regional authorities), Financial support (national authorities)	Institutional support	Proportion of firms that received institutional financial support. Municipality data aggregated at the economic region level. Source: CIS-2018. Reference years: 2016–2018
Upper secondary education, Higher education (short), Higher education (long)	Human capital	Proportion of persons with different degrees of education: Upper secondary education, Higher education – short (up to 4 years in duration), Higher education – long (more than 4 years in duration). Municipality data aggregated at the economic region level. Source: Statistics Norway. Reference years: 2016–2018
Centrality index, Population density	I) Centrality/ peripherality, II) Urbanization	I) Standard Classification of Municipalities. Municipality data aggregated at the economic region level. Source: CIS-2018. Reference years: 2016-2018. II) Number of individuals per square kilometre. Municipality data aggregated at the economic region level. Source: Statistics Norway. Reference year: 2018

Subsequent studies demonstrate that there is no general tendency for innovators in large cities to be more productive than those in rural areas (Fritsch and Wyrwich 2021).

These concepts are strengthened by Pugh and Dubois (2021), according to whom economic geographers have not been fully able to capture the socioeconomic complexity of territorial development in peripheral areas. In this regard, a simplistic and negative discourse prevails when scholars tackle the topic of development in peripheral regions, while a shift from the unfavourable concept of 'peripherality' to the more neutral concept of 'diversity' seems to be necessary.

Peripheries are not static entities: they evolve over time and, in some cases, seem to show socioeconomic dynamics that are increasingly similar to those observed in core and urbanized regional areas. In this regard, we support the argument that empirical analyses such as ours should aim at revealing 'what is special, unique and different about peripheries' (Pugh and Dubois 2021, 270). In this paper, we aim to answer the call to contribute to the scholarly debate about development in peripheries by examining them in a more interconnected, multifaceted and holistic way (Eder 2019; Pugh and Dubois 2021). In this endeavour, we follow Grillitsch et al. (2021), according to whom economic studies with a geographical background should seek to open the 'black box' of regional development in peripheral areas by providing a more nuanced and complex scenario.

There are two different approaches to the study of regional development that help us to provide a detailed taxonomy of the Norwegian context under analysis. The sociological perspective refers to a continuum between the core and the periphery, in which the existence of a 'semi-periphery' may be hypothesized and identified, whilst a geographical perspective suggests that, although peripheral regions seem to share some given characteristics (e.g. spatial distance to core regions, relatively

weak economies and migration), their degree of 'peripherality' depends on where they are situated (Eder 2019; Hall et al. 2013). In other words, this latter approach emphasizes the 'relativization' of the concept of periphery by stressing how a given region can only be considered to be central or peripheral in comparison with another region (see Pezzi and Urso 2017, for a more detailed examination of the sociological and geographical approaches). This is in line with the argument of Pugh and Dubois (2021) regarding the existence of 'cores within peripheries', i.e. dynamic cities or sub-regional areas within generically defined peripheral regions. This is a peculiar and less studied phenomenon, which has recently been observed in other Nordic and non-Nordic countries (e.g. rural Sweden (Carson, Carson, and Lundström 2021) and peripheral Canada (Shearmur and Doloreux 2021)), and that we expect to discover in the Norwegian context under analysis (by benefitting from the level of disaggregation we are using, equivalent to NUTS 4). We will discuss this in more detail in the following sections.

In our paper, we use the centrality index developed by Statistics Norway and population density to determine key territorial and demographic characteristics of the targeted regions. In particular, the centrality index is a spatial variable that enables us to determine the degree of centrality and to distinguish between (I) very central regions, (II) central regions, (III) relatively peripheral regions and (IV) peripheral regions. We define the degree of centrality (and related peripherality) on the basis of the functional parameters upon which the index is built (see Section 3.1 and Table 1 for details), by assuming that these may have a significant impact on innovativeness and socioeconomic development. Of similar importance, how the index is built contributes positively to the identification of the abovementioned four levels of centrality, which allows us to provide a nuanced taxonomy of the targeted Norwegian economic regions. Moreover, population density is used to indicate the size of the local economic system and how it affects innovativeness and development in the groups of regions identified through our cluster analysis (see De Siena and Calignano 2019; Ciccone and Hall 1996; Isaksen and Trippl 2016; Paci and Usai 2008).

2.2. Innovation systems, less advanced regions and knowledge sourcing

Various combinations of knowledge-exchange dynamics involving different actors (i.e. research establishments, clients and suppliers) are observed in different types of regions. In particular, the RIS approach highlights actors, networks and institutions as constituting factors for an innovation system. This approach refers to a classification introduced by Isaksen and Trippl (2016) – 'thicker' regions are generally technologically advanced metropolitan areas, which are characterized by a variety of industries and, supporting research institutions. Ideally, these regions may benefit from both localized knowledge exchange (engendered by a critical mass of co-located organizations) and long-distance knowledge flows. The former may involve various actors (including local universities and research centres), whilst the latter are potentially fostered by a high level of absorptive capacity (Cohen and Levinthal 1990) and the exchange of codified knowledge between local science-based organizations (characterized by an analytic knowledge base, see Asheim and Gertler 2005), extra-regional firms and research organizations (see e.g. Herstad, Wiig Aslesen, and Ebersberger 2014). In addition to the typical territorial perspective, RISs can be interpreted as geographically open systems. One example in this regard is represented by the so-called regionalized national innovation systems (see Asheim, Isaksen, and Trippl 2019). Moreover, the work of Asheim and Isaksen (2002) focuses on the integration of both local 'sticky' and global 'ubiquitous' knowledge. This leads us to believe that the ideal-typical RISs, in which exclusively regional knowledge and environments are critical in development processes, are rather uncommon in Norway.

On the other hand, less advanced or 'thinner' regions are characterized by one single dominant or a few industries, which are generally specialized in lower technology sectors and have a narrow (engineering-based/synthetic) knowledge base. In these geographical contexts, local interactions between some specific actors – primarily customers and suppliers – are possible, but they are

not particularly intense. Local firms should therefore aim to source their knowledge from extra-regional partners, but this is complicated by the limited absorptive capacity shown by the less-well equipped local firms (see e.g. Martin and Moodysson 2013). However, this typology does concentrate on organizational 'thinness', and does not nuance peripheral regions, or the differences between them, in greater detail when it comes to their innovative activity.

As argued by Coenen et al., the typology of old industrial regions is typically considered to concern regions that are overspecialized in 'mature technologies and industries experiencing decline. Innovation activities in these regions often follow mature technological trajectories mainly of an incremental character' (Coenen, Moodysson, and Martin 2015, 853). Their efforts to introduce radically new products into the market tend to be limited, compared with process optimization and other efficiency-oriented activities. The key problem in this regard is related to lock-in, but it is important to note that lock-in does not necessarily need to be negative if it is in an industry or cluster with a high impact on the regional industry (Grabher 1993). Nonetheless, the typology remains unresolved when it comes to differentiating innovation in specific peripheries.

In this paper, we use CIS-2018 to refer to collaboration between research organizations, clients and suppliers located on various geographical scales (from regional to international), in order to map the openness of each regional economy and the extent to which local firms benefit from different external knowledge sources.

2.3. Sectoral characteristics, socioeconomic conditions and policy support

The role of sectoral composition in regions is one additional relevant factor (although not always adequately taken into consideration) that we use to classify the targeted Norwegian regions based on their characteristics. As mentioned before, the RIS approach emphasizes how both various territorial dimensions and more extra-regional resources can be found in regional contexts characterized by different levels of innovativeness and development (Asheim 1999; Isaksen and Trippl 2016). We strengthen this viewpoint by explicitly arguing that sectoral characteristics – in addition to geographical location, openness towards external knowledge sources and the ability to benefit from multi-scalar networks – may add important insights into why regions perform differently.

In this regard, our considerations of the importance of sectoral and industrial mix are supported by various studies that refer to sectoral innovation system (SIS) literature. According to this approach, a sectoral system may contribute to regional innovativeness and development by means of a set of agents at various levels of aggregation (e.g. individuals or organizations) possessing 'specific knowledge base, technologies, inputs and demands', and who 'interact through processes of communication, exchange, co-operation, competition and command […] shaped by institutions' (Malerba 2002, 247). With this in mind, we use seven key sectors to map regional sectoral specialization (see Table 1 in Section 2 for details).

Finally, we use two variables, i.e. human capital and public financial support, to provide a comprehensive taxonomy of the regions that comprise the targeted national context. For more information on the critical role played by human capital in fostering regional development, see Rodríguez-Pose and Crescenzi 2008; and Faggian, Modrego, and McCann 2019; for the importance of public funds in regional development policy, see Albrecht, Grundel, and Morales 2021; and Wood 2016. More specifically, we adopt a widely used indicator, i.e. the level of education, in each Norwegian economic region as a proxy of human capital (Mellander and Florida 2014; Schlegel, Pfister, and Backes-Gellner 2022) and the share of firms that received institutional financial support as reported in CIS-2018, respectively.

2.4. Differentiated regional preconditions

Until recently, there had been few attempts in the literature to differentiate how and why regions, and particularly peripheral regions, differ when it comes to innovation and development

trajectories. This omission overlooks the differentiated actor composition and the role of regional preconditions that exist in regions, even though they are classified as peripheral. The relevant question in this regard is how differences between regions in the periphery can push forward different innovation outcomes.

With regard to discussing how to balance regional inequality between the alleged dynamic cities and the peripheral regions, the work of Nelson and Winter (1982) on the challenges of renewing fundamental and well-established organizational routines and practices is of interest. Regions outside the major metropolitan areas often face challenges regarding endogenous capabilities, since they lack the necessary knowledge or capital to undertake change processes (Isaksen and Trippl 2016) and to diverge from existing development paths.

Nuancing such an approach, Glückler, Shearmur, and Martinus (2022) seek to understand the role of periphery in innovation by introducing three different narratives concerning the relationship between innovation and geographical peripheries. By distinguishing between the 'no innovation' narrative, 'innovation despite' narrative and 'innovation because' narrative, different mechanisms in the literature on peripheries are highlighted. Anchored in the literature on innovation in this specific geographical context, they discuss dependency, absorptive capacity (Doloreux and Dionne 2008), external connections to the world outside (Doloreux 2004; Dubois 2015), the anchoring of foreign subsidiaries (Nilsen 2017) and the role of particular types of innovation processes (Grabher 2018; Doloreux and Porto Gomez 2017) in understanding why regions differ when it comes to innovation in the periphery.

Moreover, Nilsen, Grillitsch, and Hauge (2022) advances this understanding by means of a conceptual analysis of the varieties of peripheries, and connects four distinct regional types of periphery to the role of local agency in regional development. In this work, regional preconditions are understood as the pre-existing, historically developed structures that local actors can reproduce and transform, and that therefore play an active role in regional development processes. These structures are differentiated within and between sectors, and differ between industries and different levels of education, and between municipal, regional and national authorities (Nilsen, Grillitsch, and Hauge 2022). The role of actor composition in regions will therefore give rise to a variation in opportunities to draw on certain types of knowledge, networks and resources in regions. Peripheral regions with a high differentiation of actor composition have the potential to access a greater variety and depth of knowledge, networks and resources, whilst peripheral regions with low differentiation will create more vulnerability and dependency on actors that can easily monopolize labour markets. Therefore, the differentiation of the actor composition is a crucial dimension for distinguishing peripheral regions.

By summarizing the more recent theoretical contributions on the topic (e.g. Calignano 2022; Eder 2019; Nilsen, Grillitsch, and Hauge 2022; Pugh and Dubois 2021), it can be confidently argued that the narrative according to which peripheral areas are hardly innovative places seems to be outdated. RISs can be 'thin' or weaker in many peripheral regions, even though more open and nationally or globally connected systems may drive innovation processes, leading to a sizable number of innovative products and services (Asheim 1999; Asheim, Isaksen, and Trippl 2019). One of the main goals of our analysis, therefore, is to explore how innovation, collaboration and funding patterns (both at the regional and national levels) are related to different regions and their dimension of centrality/peripherality (the four levels we identified and mentioned above; see Section 2.1). In addition to this, other key regional characteristics, such as type of innovation (product/process), level of education and industrial composition, were also taken into consideration in our model.

3. Methodological strategy

We approached the existing knowledge gaps discussed in the theoretical section by mapping the 88 Norwegian economic regions. To do this, we used a large dataset comprising many indicators, and we also used K-means clustering to create a taxonomy of the targeted Norwegian regions, based on

a broad set of innovation, demographic and economic-production indicators, with the ultimate aim of proposing a stratified and nuanced taxonomy of the targeted regional areas.

3.1. Geographical units of analysis and variables employed

We used 88 Norwegian economic regions as the units of analysis.[1] According to Statistics Norway (2021b), such regional areas combine various municipalities, based on their actual economic conditions (e.g. labour market and trade). These functional parameters, which transcend rigid administrative boundaries, together with an optimal level of disaggregation between the (too large) county level and the (too narrow) municipality level, led us to consider the economic regions to be the ideal geographical context in which to conduct our empirical exercise (for information about the advantages of adopting a functional approach to the study of geographical and socioeconomic dynamics, see e.g. Castells-Quintana, Royuela, and Veneri 2020; ESPON 2020; Faggian et al. 2018; NORDREGIO 2016).

All of the indicators used to perform our statistical analysis are listed in Table 1, which provides further details of each of the variables employed. By adopting these variables, we were able to capture the degree of innovativeness, structural preconditions (industrial structure) and multi-scalar knowledge flows (collaboration with regional, national and international partners), as suggested by EEG (Martin and Sunley 2006; Boschma and Iammarino 2009; Neffke, Henning, and Boschma 2011), RIS (Asheim and Coenen 2005; Nilsen and Karlstad 2016; Schulze-Krogh and Calignano 2020) and SIS (Malerba 2002; Nilsen and Njøs 2022), when studying regional development. Similarly, critical elements, such as institutional support, human capital, geographical centrality and urbanization were taken into account in order to provide a comprehensive, detailed and multifaceted taxonomy of the Norwegian situation.

We used a set of standardized variables, which were reconstructed through the CIS-2018 or Statistics Norway databases, to conduct our research. In particular:

- We determined innovativeness by calculating the proportion of regional firms reporting product and business process innovation.
- We used the proportion of selected economic sectors (aggregated based on the Standard Industrial Classification 2007; see Eurostat 2021) to determine the structural characteristics of each economic region. The sectors through which we mapped the various regional economic-production fabrics were: I) Agriculture, forestry and fishing; II) Mining and quarrying; III) Manufacturing; IV) Construction; V) Transportation and storage; VI) Information and communication; VII) Financial and insurance activities; VIII) Real estate, professional, scientific and technical activities; and IX) Administrative and support service activities.
- We considered how 'open' each economic region is towards external knowledge sources. In particular, we captured such multi-scalar knowledge flows by calculating the proportion of regional firms that collaborate with different types of partners (clients/suppliers and university/research institutions) located in different geographical areas (regional, national and international collaborators).
- We calculated the proportion of firms in each region that received financial support from regional or national public authorities (what we defined as institutional support).
- We used the level of education (i.e. the proportion of the resident population with upper secondary or higher education – short and long duration) as a proxy for the human capital possessed by the targeted economic regions.
- We applied a specific index, named the 'Standard Classification of Centrality' (Statistics Norway 2021a), to measure how central or peripheral a given region is. Based on this index, the centrality of a municipality is determined by its geographical position in relation to a centre where the higher-order functions can be found (e.g. banks and post offices). As with all the other variables, we calculated the average scores of the municipalities comprising each economic region, and aggregated them at the geographical scale of interest.

- Finally, we used population density (i.e. the number of individuals per square kilometre) to classify economic regions based on the average degree of 'urbanization' shown by their respective municipalities.

3.2. K-means clustering: definition and procedure for validation

We used K-means clustering to create a detailed taxonomy of the Norwegian economic regions, based on the standardized variables described above. K-means clustering is an unsupervised machine learning algorithm that allows one to identify a set of 'K' clusters in a given dataset. By the application of such a clustering approach, it is possible to determine the degree of separation between clusters and to classify the objects (i.e. the Norwegian economic regions, in our case study) based on high intra-cluster and low inter-cluster similarity.[2]

More specifically, the K-means algorithm attributes a certain object to a given cluster when the distance of the object from the centroid (i.e. the cluster centre) is minimal. K-means clustering uses an iterative process to identify the various centroids and the related objects making up each cluster. This is a step-by-step procedure through which the designated algorithm seeks to find different centroids until, iteration after iteration, convergence is reached (or, to put it differently, the values in the subsequent iterations remain the same) and the results can thus be considered stable.

We carried out some preliminary and post hoc analyses that are generally used to validate the results of K-means clustering. Initially, we conducted an analysis of variance (ANOVA) to determine the variables that had an actual impact in the classification of the Norwegian economic regions (see Appendix A for the results of ANOVA, and Section 3.1. for a detailed description of all the variables we adopted). The statistical significance of the variables originally considered – together with knowledge of the Norwegian socioeconomic reality – enabled us to retain a good number of variables and to exclude from the final dataset others that were not deemed to be particularly useful for the purposes of our empirical analysis.

Secondly, it must be considered that there is no shared theoretical approach to the determination of the optimal number of 'K' clusters. The final clusters are defined by single analysis on a subjective basis, and they largely depend on the knowledge of the detected reality. However, the validity of the selected number of clusters can be tested by conducting a preliminary hierarchical cluster analysis and inspecting the related dendrogram (in this regard, among many others, see Calignano and Vaaland 2018, and with regard to the combination of hierarchical and non-hierarchical methods, see Ejdemo and Örtqvist 2021). In particular, we conducted hierarchical cluster analysis using Ward's method (Euclidean distance), and were able to identify nine clusters (see Appendix B), which – based on our knowledge of the Norwegian reality – seem to appropriately group the Norwegian economic regions on the basis of their characteristics and levels of similarity in terms of innovation and economic production.

The stability of the clusters we identified by the inspection of the dendrogram was confirmed by the iteration history shown in Table 2, according to which the cluster algorithm reached convergence in correspondence to the sixth iteration.

Table 2. Step-by-step progress of the clustering process – Iteration history table.

Iteration history									
Iteration	Change in cluster centres								
	1	2	3	4	5	6	7	8	9
1	4.390	3.757	4.549	4.260	0.000	4.139	4.277	3.333	3.332
2	1.244	0.000	0.334	0.582	0.000	0.386	0.474	0.000	0.000
3	0.818	0.000	0.431	0.000	0.000	0.271	0.615	1.436	0.000
4	0.000	0.000	0.165	0.000	0.000	0.000	0.227	0.000	0.000
5	0.000	0.000	0.188	0.000	0.000	0.000	0.000	1.711	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Finally, use of the Kruskal–Wallis post hoc test allowed us to reject the null hypothesis that the distribution of our standardized variables was the same across all the nine identified clusters, thus further supporting the appropriateness and validity of our K-means cluster analysis. The boxplots in Appendix C show in detail the variance observed within and between the nine identified clusters (excluding Cluster 5, which comprises a single economic region; see Figure C1).

4. A taxonomy of the Norwegian economic regions

The number of economic regions grouped in the various clusters shows some differences. In particular, we identified four relatively large clusters and five relatively small clusters (see Table 3 for details, and Table 5 for the complete list of economic regions in each cluster). Although the four larger clusters represent 83% of the regions surveyed, the smaller ones allowed us both to capture all of the complexity of the Norwegian situation and to highlight some critical, and perhaps little known, aspects of the various regional innovation and economic-production fabrics. The following section includes a description of each cluster. To give the reader a more distinct picture of each cluster, the descriptions are also supplemented with other insights besides the quantitative data regarding some of the regions in the clusters, e.g. key firms or industries.

Cluster 5 comprises a single economic region that corresponds to Stavanger/Sandnes. This is a strongly specialized region in the oil and gas industry (i.e. the main industry of the country of Norway, which is one of the largest exporters of oil worldwide; e.g. Deegan, Broekel, and Fitjar 2021; Gjelsvik 2011). This feature is fully captured by the graph shown in Figure 1, which shows the strong predominance of the mining and quarrying sector, both in the targeted region and in comparison to the regions that make up the other clusters. In addition, Stavanger/Sandnes is a central and densely populated region that shows a high level of human capital (proxied by the high proportion of the resident population with tertiary education) and whose regional firms are moderately innovative. These firms report frequent collaboration with regional clients and suppliers (an element that could be determined by the knowledge base primarily characterizing an engineering-based sector, such as oil and gas; see Asheim and Gertler 2005, in this regard).

Similarly, just two economic regions make up Cluster 8. Although located far away from each other (i.e. in Viken and Trøndelag counties, respectively), the Ullensaker/Eidsvoll and Stjørdalshalsen regions share some important similarities. In particular, both have an airport within their borders, both represent junctions of the main European routes (i.e. E6, E16 and E14), and both are important hubs in the national railway network. These advanced infrastructures and their key positioning in terms of logistics make Ullensaker/Eidsvoll and Stjørdalshalsen central regions (based on the centrality index we adopted; see Table 1) that are specialized in transportation and storage and related administrative and support service activities.

Finally, Cluster 9 includes two economic regions, and essentially comprises the southwestern metropolitan and capital area of Oslo. The capital of the country and the geographically proximate

Table 3. Number of economic regions in each identified cluster.

Cluster	No. of economic regions
1	4
2	6
3	18
4	15
5	1
6	26
7	14
8	2
9	2
Valid cases	88
Missing cases	0

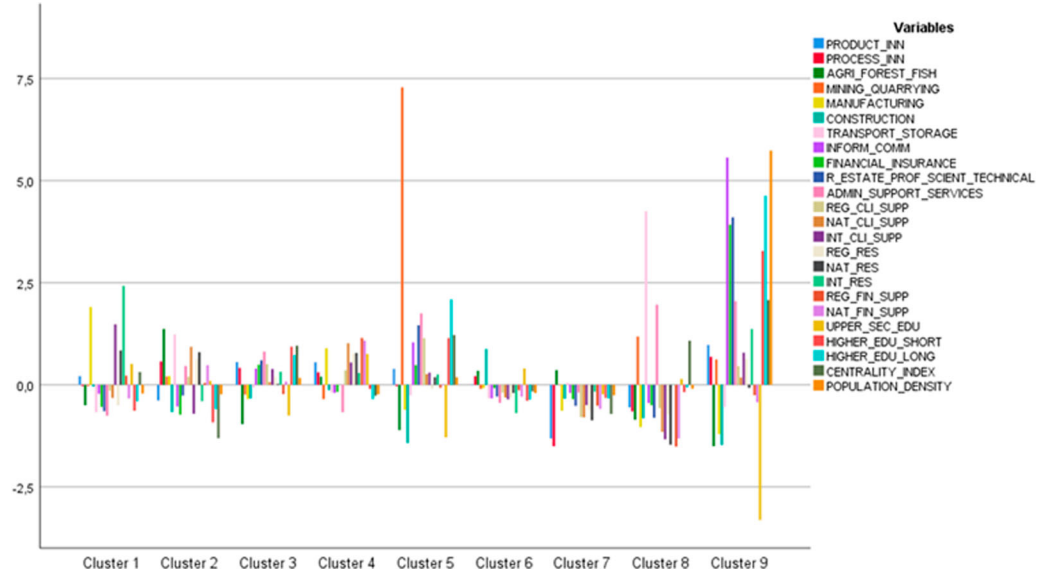

Figure 1. Cluster means and the related contributions of each variable to the formation of the identified clusters.

Bærum/Asker region represent the most innovative (both product and process innovation), the most central and the best educated economic regions of Norway (Isaksen and Karlsen 2013). Moreover, Cluster 9 is characterized by a high level of openness towards external knowledge sources and a high concentration of knowledge-intensive services (information and communication, finance, scientific activities, etc.).

In addition to the three smallest clusters, we identified two clusters consisting of a slightly greater number of economic regions (four in Cluster 1, and six in Cluster 2). These two clusters differ in many respects.

Cluster 1 is characterized by the presence of economic regions located along the southern coast, with the apparent exception of Kongsberg, which is located in Viken county and is primarily known for its advanced weapons system industries and offshore and maritime sector, including space technology (Isaksen and Karlsen 2013). The regions in Cluster 1 can be considered to be relatively central and densely populated, while showing a moderate degree of innovativeness in the manufacturing sector (primarily product innovation) and strong engagement in the fishery, maritime and petroleum sectors. Strong firms located in these economic regions include, for example, the fabrication yard of Aker Solutions in Egersund and Alcoa Norway in Farsund. The regional firms in Cluster 1 show a high degree of interaction with different national and international partners and a lower level of human capital compared to other more advanced clusters in this specific regard.

Cluster 2 similarly shows a relatively low level of human capital, but is characterized by high innovativeness (process innovation) and centrality in functional terms (i.e. high values on the centrality index). The clustered regions are sparsely populated, and are characterized by a large number of firms operating in the primary sector, as well as in supply industries and transportation (this latter result is supported by the existence of a large proportion of firms operating in the maritime and petroleum sectors in the economic regions that comprise Cluster 2). The central supply base of the petroleum industry for mid-Norway is located in Kristiansund (Berg-Nilssen et al., 2012). Rising industrial activity in Brønnøysund and the presence of the renowned firm Kleven in Florø are seen as important drivers of economic activity in the economic regions in Cluster 2 (Berg-Nilssen et al., 2012). Moreover, the recent positive economic development path of the aquaculture sector in these regions also contributes to their high level of process innovation (Bullvåg et al., 2018).

The four remaining considerably larger clusters show differences in innovation, economic production and demographics between each other, as well as the smaller clusters already described.

Cluster 3 includes 18 economic regions, with three of the regions playing a strategic role in the Norwegian context as a whole or in their reference county (e.g. Trondheim, Bergen and Tromsø). All of these regions have large universities, highly differentiated business sectors, varying sets and levels of skills, and rich research institutions, all of which contribute to a mix of important knowledge bases. Tromsø is known for its efforts to develop a science-technology-innovation (STI) route within marine biotechnology (Isaksen and Karlsen 2010). In addition to these three regions, there are also regional city centres, such as Ålesund (highly influenced by the maritime sector), Bodø (influenced by the tourism sector, in addition to the public sector), Moss, Hamar (strong service, ICT and public sector) and Lillehammer (tourism and public sector), that play important roles for their hinterlands. Arendal, which is located in the south-eastern part of Norway, is a leading region within engineering, ICT and machinery (Isaksen and Trippl 2017). Although different in many respects, the economic regions in Cluster 3 are highly innovative (both process and product innovation), they are specialized in services, and they are regionally and internationally connected with clients/suppliers and research organizations. They are central and densely populated regions, and show a high level of human capital. Moreover, the firms operating in the economic region making up Cluster 3 generally receive financial support from national authorities.

The economic regions in Cluster 4 are mostly mature manufacturing areas, and several of them have a long tradition of energy-intensive manufacturing, e.g. the aluminium industry in Odda (Cruickshank et al., 2013), Årdal and Mosjøen. The 15 regions making up this cluster are similarly characterized by a high degree of innovativeness and multi-scalar knowledge flows engendered by collaborations with clients and suppliers (national and international) and research organizations (regional and national). One of the regions, Ulsteinvik, lies on the coast of Sunnmøre and hosts one of the world's leading firms in ship design (Ulsteinvik Group), and is a leading cluster within the maritime sector (Grillitsch et al., 2022). Mosjøen and Gjøvik play important roles within global production networks in the manufacturing of automotive parts and weapons systems (Raufoss) (Johnstad and Hauge 2009), as well as in the process industry, with Elkem and Celsa in Mosjøen. Conversely, these economic regions are relatively peripheral, they are not densely populated, and they are characterized by a comparatively lower level of human capital. Interestingly, these elements do not hinder effective knowledge exchange with external partners and innovation outcomes.

Cluster 6 shows the largest quantity of economic regions in absolute terms (26) and primarily comprises smaller economic regions. In particular, there are a number of sparsely populated rural areas, which are quite evenly distributed throughout the country. Despite their peripheral location, the concentration of relatively isolated firms specializing in the primary sector and construction industries serving their 'home markets', and the low level of engagement with external partners, the firms located in the economic regions comprising Cluster 6 perform moderately well in terms of innovation outcomes (mainly process innovation).

Finally, the 14 economic regions grouped in Cluster 7 are analogously peripheral, are not densely populated, and are specialized in the primary sector, but they show a very low degree of openness towards external knowledge sources and, above all, only modest levels of innovativeness. As observed above for other clusters, the economic regions in Cluster 7 are located in various Norwegian counties scattered throughout the country, i.e. Innlandet, Vestland, and other counties primarily situated in the northern part of Norway.

In general, it should be stressed that our empirical analysis clearly confirms how national, regional and even sub-regional areas are complex and multifaceted realities that should be treated as such. We realize that the empirical reality is far more complex and variegated than the aggregated information from the statistics in this context might suggest.

By means of our methodological strategy and the adoption of a large set of indicators, we were able to demonstrate empirically that, in many cases, the rigid administrative boundaries (such as the county level in Norway, corresponding to the NUTS 3) do not fully capture the variety of

Table 4. Counties in the identified clusters. Legend – Yellow cell: No economic regions from the county in the respective cluster. Blue cell: At least one economic region from the targeted county in the respective cluster.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Cluster 9
Oslo									
Rogaland									
Møre og Romsdal									
Nordland									
Viken									
Innlandet									
Vestfold og Telemark									
Agder									
Vestland									
Trøndelag									
Troms og Finnmark									

innovation and economic-production environments that typify a given geographical area. Perhaps even more importantly, our detailed taxonomy shows how innovation is not exclusively a prerogative of the core, or most central, regions, and that there is a relatively high, although not uniform, level of innovativeness that can be observed in the various peripheries (primarily, but not exclusively, process innovation). These findings seem to support what the EEG and RIS literature suggests, i.e. that structural preconditions are more important than geographical location alone, and that they go hand in hand with regional innovation and possible differentiated development paths (Nilsen, Grillitsch, and Hauge 2022).

This latter concept is exemplified in the next table and figures, which graphically illustrate how the Norwegian counties actually contribute to the formation of each identified cluster. In particular, the blue cells in Table 4 highlight the presence of at least one economic region (NUTS 4) from a given county (NUTS 3) in a given cluster. It is immediately clear that the Norwegian counties

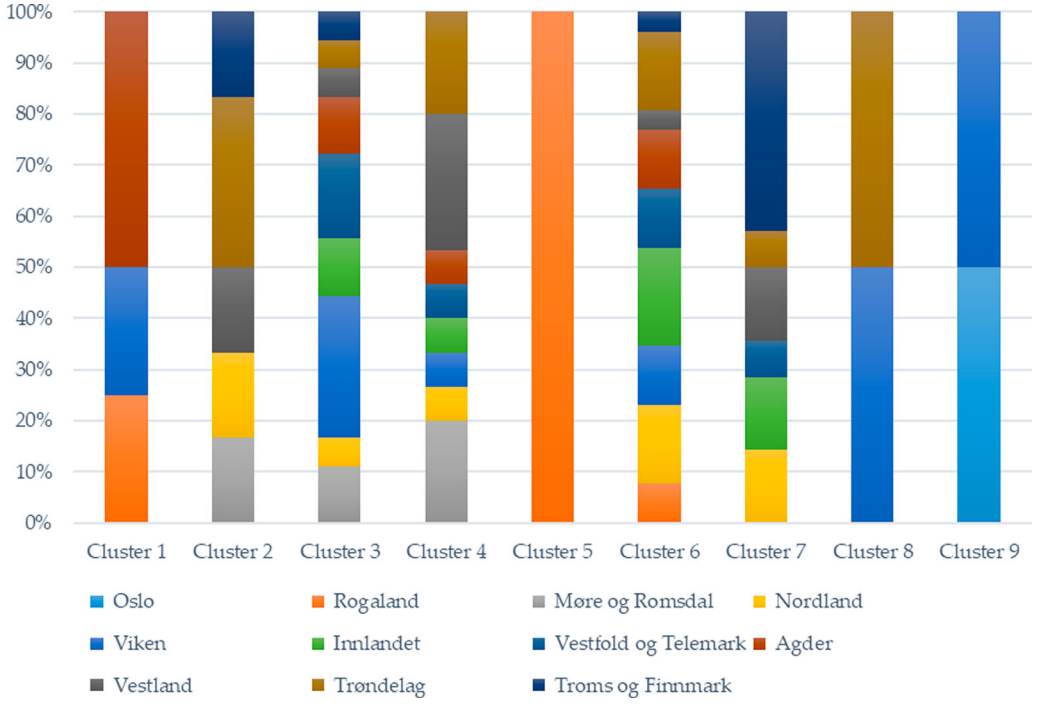

Figure 2. Share of economic regions aggregated at the county level in each cluster.

Table 5. Taxonomy of the Norwegian economic regions based on the selected innovation, economic and demographic indicators.

Cluster	Economic regions	Centrality	Densely populated	Education	Institutional support	Type of innovation	Main economic sectors	Level of cooperation	Knowledge sources	Level of innovation
1	Kongsberg, Lillesand, Lyngdal/Farsund, Egersund	Relatively central	Yes	Upper secondary education	Regional	Product	Manufacturing	High	Clients and suppliers (international)/ Research organizations (national and international)	Moderate
2	Florø, Kristiansund, Brønnøysund, Finnsnes, Frøya/Hitra, Rørvik	Peripheral	No	Upper secondary education	National	Process	Agriculture, forestry and fishing/Transportation and storage	Moderate	Clients and suppliers (national)/ Research organizations (national and international)	High
3	Moss, Fredrikstad/ Sarpsborg, Follo, Lillestrøm, Hamar, Lillehammer, Drammen, Tønsberg/Horten, Sandefjord/Larvik, Skien/ Porsgrunn, Arendal, Kristiansand, Bergen, Ålesund, Ørsta/Volda, Bodø, Tromsø, Trondheim	Central	Yes	Higher education (short and long)	National	Product and process	Information and communication/ Financial and insurance activities/Real estate, professional, scientific and technical activities/ Administrative and support service activities	Moderate	Clients and suppliers (regional and international)/ Research organizations (regional and international)	High
4	Halden, Gjøvik, Vest-Telemark, Mandal, Odda, Sunnhordland, Sogndal/ Årdal, Nordfjord, Ulsteinvik, Sunndalsøra, Surnadal, Mosjøen, Røros, Steinkjer, Namsos	Relatively peripheral	No	Upper secondary education	Regional and national	Product and process	Manufacturing	High	Clients and suppliers (national and international)/ Research organizations (regional and national)	High
5	Stavanger/Sandnes	Central	Yes	Higher education (short and long)	–	Product	Mining and quarrying	High	Clients and suppliers (regional)	Relatively high
6	Askim/Mysen, Tynset, Midt-Gudbrandsdalen, Nord-Gudbrandsdalen, Hadeland, Valdres,	Peripheral	No	Upper secondary education	–	Process	Agriculture, forestry and fishing/Construction	Low	–	Moderate

	Hønefoss, Hallingdal, Sande/Svelvik, Notodden/ Bø, Kragerø, Risør, Setesdal, Flekkefjord, Haugesund, Jæren, Høyanger, Molde, Narvik, Mo i Rana, Lofoten, Alta, Brekstad, Oppdal, Orkanger, Levanger/ Verdalsøra									
7	Kongsvinger, Elverum, Rjukan, Voss, Førde, Sandnessjøen, Vesterålen, Harstad, Andselv, Nord-Troms, Vadsø, Hammerfest, Kirkenes, Grong	Peripheral	No	–	–	–	Agriculture, forestry and fishing	Very low	–	Low
8	Ullensaker/Eidsvoll, Stjørdalshalsen	Central	No	Upper secondary education	–	–	Transportation and storage/Administrative and support service activities	Very low	–	Low
9	Bærum/Asker, Oslo	Very central	Yes	Higher education (short and long)	–	Product and process	Information and communication/ Financial and insurance activities/Real estate, professional, scientific and technical activities/ Administrative and support service activities	High	Clients and suppliers (regional and international)/ Research organizations (regional and international)	Very high

contribute rather equally to the various clusters, if we exclude two extraordinary counties such as the strongly specialized Rogaland (i.e. where Norway's oil capital Stavanger/Sandnes is located) and Oslo. In addition to this, Figure 2 reveals how, although some weak spatial patterns can be observed in the various clusters, there is no clear tendency that would allow us to argue that purely geographical factors contribute to determining the classification of the Norwegian economic regions based on the innovation, economic and demographic indicators we adopted (each segment in the bars represents the proportion of economic regions from each county that belongs to the various identified clusters). In this regard, the map displayed in Appendix D (Figure D1) strengthens this concept by showing the actual overall distribution of the Norwegian economic regions in the nine identified clusters (see Table 5).

5. Discussion

Our analysis confirms that firms in central locations have privileged access to human capital and contact points with different networks, which in turn influence their innovative activity. Moreover, regions that share geographical proximity to thick and diversified RISs (Isaksen and Trippl 2016), with varied sets and levels of skills (knowledge bases) (Asheim, Isaksen, and Trippl 2019), are important elements and drivers for knowledge creation and diffusion. We found that several of the economic regions that are clustered together based on their shared characteristics for innovation performance are geographically located within central or relatively central areas of Norway (Clusters 1, 3, 5, 9). The regions that perform well on product and process innovation share the factors of a productive industrial mix, with a joint balance between diversity and specialization within industry sectors, together with the presence of higher education institutions with a relatively broad offering. Moreover, Clusters 3, 5, and 9 also share the same territorial characteristics, and represent central and densely populated areas.

The regions that are dominated by highly innovative firms and sectors seem also to be characterized by dense networks, and this is an aspect that is consistent with the SIS approach (Malerba 2002, 2005; Nilsen and Njøs 2022). The industrial structure in the regions, their technology paths, and how the knowledge flows are structured within sectors have been of less interest to the conventional explanations from the EEG and RIS approaches, according to which territorial characteristics (e.g. localized and more open systems, and structural preconditions such as density or centrality) strongly influence the innovation capability of firms. Our analysis suggests that centrality and density seem to be less important for firms when it comes to product and process innovation than had previously been thought. Clusters 2, 4 and (partially) 6 are economic regions featuring small towns and rural areas, although they show a high, or at least moderate, level of innovativeness.

Our analysis demonstrates that peripheral regions, the main knowledge sources of which are represented by clients and suppliers in their respective sectors, show high innovation performances in process innovation (Cluster 2). In particular, Cluster 2 comprises economic regions that are characterized by extractive industries (oil and gas supply bases in Kristiansund, Florø and Brønnøysund), where a high concentration of multinational corporations serving the oil, gas and maritime sectors plays an important role in the economic activity. Accordingly, the role of spatio-sectoral embeddedness within the region is central to the ability to understand how these regions perform. This implies that we are not exclusively concerned with regional industrial dynamics or sectoral characteristics (SIS), but also with the intersection between territoriality and sectoral belonging. Firm agency is understood as being 'embedded', in the sense that actors perform actions and make decisions that are influenced by their territorial and sectoral belonging (Nilsen and Njøs 2022). This means that the way in which a path evolves, and how this evolution is influenced by agency, results not only from individual actions, but also from how adjacent actors, both within a region and beyond, respond (Isaksen et al. 2019).

Moreover, highly specialized regions within manufacturing sectors perform well on product and process innovation, despite their low geographical proximity to core centres, low density and low

centrality (Cluster 4). This study therefore suggests the need to question the alleged principal role played by territorial characteristics in innovation performances. The role of firms' sectoral belonging is a key factor that seems to have an impact on their innovativeness, compared to their territorial belonging. We observed that the successful and profitable petroleum and maritime sectors, in addition to manufacturing, seem to coincide in peripheral regions that share the same probability of high innovation performance. Firms in these sectors are engaged in national or global networks that are connected to suppliers in other regions. We therefore argue that networks within these sectors diffuse knowledge and ideas very efficiently, because they are embedded within a specific SIS, i.e. within the maritime or the petroleum sector. The question is whether the role of territorial or sectoral factors has the greatest influence on the firms' innovation performance in these regions. Based on our results, there is a need to pay more attention to the role of sectoral characteristics such as international sectoral frameworks, national policies, regulations, sectoral laws and institutions (Trippl et al. 2020). Inspired by Shearmur and Malerba (2002), we therefore argue that, instead of a perspective focusing solely on geographical location in judging innovation performance, we can supplement this by focusing on the *variety* of geographical environments, as sectors that are important for innovative activity in general.

We observed that a lot of innovation activity emerges in rural regions, or within 'thin' RISs (Isaksen, Tödtling and, and Trippl 2018). In the literature, increasing attention is being to innovation in peripheral regions (Fritsch and Wyrwich 2021; Grillitsch and Nilsson 2015; Shearmur and Doloreux 2016). The RIS approach focuses on how collaboration between organizations within and between regions can facilitate knowledge diffusion and innovation. In our analysis, the rural regions demonstrate that, although they are peripheral at first glance, as a result of their geographical location, in some cases they perform at the highest level when it comes to process innovation, especially within regions with a high level of agriculture, transportation and storage. Accordingly, geographical peripheries differ when it comes to performance on innovation, as suggested by the literature on 'thin' versus 'thick' RISs (Asheim, Isaksen, and Trippl 2019).

No cities or small towns are exclusively 'bounded' by spatiality as a factor (Shearmur 2012). This means that cities or regions comprise people (and firms) who are travelling in and out, and who are connected through and by networks that cut across city boundaries. Recent economic geography research tends to treat cities as arenas that consist of attributes that 'belong to them' ('firms are located in a city'), and not as mobile flows of firms and people that mainly constitute the city or a region, e.g. a designer can draw structures for a specific ship design from a non-core region, and sell them through his firm located in the city. Furthermore, a researcher of agricultural systems can produce brilliant ideas in the city where he lives, and introduce them in the countryside where he works. We therefore believe that this analysis points to how a dynamic relationship exists between different geographical and sectoral characteristics, on the one hand, and between knowledge and ideas in cities and their hinterlands, on the other hand. We also agree with insights that have been identified by scholars within the EEG field that this should be taken into greater account when nuancing the dichotomy between urban and non-core regions (Shearmur 2012).

6. Concluding remarks

This paper aims to disentangle the differences in innovation performance in 88 different economic regions in Norway. Using CIS data from all Norwegian firms from 2016 to 2018, we created an updated overview of the innovation fabric in Norway. Moreover, by combining the CIS data with several socioeconomic indicators, we conducted a cluster analysis in order to categorize the regions with similar sociodemographic conditions, degrees of openness, levels of collaboration, densities and centrality. This taxonomy offers a nuanced understanding of how peripheral regions in the Norwegian economic production fabric perform on innovation activity. By investigating how different variables come into play based on firm innovation performance, this paper demonstrates four main innovation routes or paths for the different economic regions.

First, our analysis confirms the theory that firms that belong to dense and central regions perform well regarding product and process innovation. Even though territorial characteristics (density and centrality) strongly influence the firms' innovation capability, this factor does not offer sufficient explanatory power in relation to important and critical elements of the findings.

The second finding is therefore that a lot of innovation takes place in peripheral regions that are populated by sectors where Norwegian firms have a strong competitive position, and have international networks and strong connections outside the region. We find these patterns mainly within process innovation, but also within product innovation. Drawing on the SIS approach, we argue that a combination of sectoral and territorial belonging needs to be taken into greater account in studies of regional development and firms' innovation. Accordingly, our contribution to the literature concerns the role of spatio-sectoral embeddedness, where future studies need to take both strands of the literature into account.

Thirdly, our empirical analysis demonstrates that there are significant differences in innovation performance between regions that, according to the theory, share the same ability to innovate. An additional contribution to the economic geography literature is therefore that, instead of a perspective that solely focuses on location in judging innovation performance, it can be supplemented by the *variety* of geographical environments that are important for innovative activity in general.

Fourthly, we question whether a robust boundary exists between the geographical concepts that underpin this type of research ('core' and 'periphery'). Going beyond this dichotomy, we might suggest that no cities or small towns are exclusively bounded by spatiality as a factor, and that the mobility of people and firms extends the alleged spatial boundaries between these geographical locations.

Based on the findings from our analysis, we draw some policy and research implications. Peripheral areas may be innovative places, and they should be treated as such. The terminology that policymakers and other stakeholders use should reflect this, and the proposed shift from the concept of 'peripherality' to that of 'diversity' may possibly better describe the complexity of non-metropolitan settings (Pugh and Dubois 2021). We need more evidence-based research that adopts original approaches, innovative tools and new methods in order to capture what actually happens in broadly defined peripheries, and to provide a fine-grained portrayal of the existing innovation activities and (actual and possible) regional development.

In this regard, our study seems to cast some doubt on the appropriateness of the geographical units of analysis (i.e. NUTS 1, NUTS 2 and, less frequently, NUTS 3) that are generally used in academic articles and policy. A sub-regional and functional approach (see e.g. Castells-Quintana, Royuela, and Veneri 2020; ESPON 2020; Faggian et al. 2018; NORDREGIO 2016), such as that adopted in this paper, may help policymakers to provide a more accurate representation when it comes to innovativeness in regions and countries. In other words, using too broad geographical units or rigid administrative boundaries may not fully capture the existence of new, interesting and less-studied phenomena. Building specific databases based on functional urban and (dis)aggregated regional areas would be helpful in this regard for policy and decision-makers.

The results of our empirical analysis suggest that more refined policy actions might be implemented, with the aim of triggering possible new development paths. Path importation (i.e. arrival of non-local firms) and upgrading (i.e. infusion of new technologies in the existing traditional manufacturing sectors) can be achieved in the targeted Norwegian economic regions by virtue of their adequate levels of skills, competences and openness towards external knowledge sources.

Regarding the research implications, we argue that future research should focus on the role of SISs in peripheral regions that lack endogenous capacity. From an empirical viewpoint, more in-depth qualitative studies are needed, with the aim of clarifying some specific contextual aspects that have been brought to light in the present study. When quantitative analyses are performed, there is a need to determine a causal inference between the degree and distribution of regional innovativeness and the extensive set of variables that was adopted.

Notes

1. There are 89 economic regions in Norway. We excluded Holmestrand from our final dataset, as this is a very small economic region, which would represent a clear outlier forming an uninformative cluster.
2. In the economic geography literature, a 'cluster' is generally defined as an agglomeration of geographically concentrated organisations (e.g. firms and research institutions) specialised in one or a few interrelated sectors (e.g. Porter 1990). To avoid misunderstandings, it may be helpful to clarify that, in this paper, the term 'cluster' exclusively refers to a given group of Norwegian economic regions that are more similar to each other than to those making up the other identified groups through K-means clustering. Such differentiation between clusters was based on the set of socioeconomic variables illustrated in Table 1 (see Section 2).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix A

Table A1. ANOVA table including univariate F tests for each clustering variable.

	ANOVA					
	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
Product innovation	4.761	8	0.619	79	7.691	0.000
Process innovation	5.144	8	0.580	79	8.864	0.000
Agriculture, forestry and fishing	5.216	8	0.573	79	9.102	0.000
Mining and quarrying	7.507	8	0.341	79	22.009	0.000
Manufacturing	5.046	8	0.590	79	8.550	0.000
Construction	4.270	8	0.669	79	6.383	0.000
Transportation and storage	6.397	8	0.453	79	14.108	0.000
Information and communication	9.031	8	0.187	79	48.373	0.000
Financial and insurance activities	5.345	8	0.560	79	9.544	0.000
Real estate, professional, scientific and technical activities	6.444	8	0.449	79	14.359	0.000
Administrative and support service activities	5.891	8	0.505	79	11.670	0.000
Regional clients and suppliers	2.369	8	0.861	79	2.750	0.010
National clients and suppliers	4.423	8	0.653	79	6.770	0.000
International clients and suppliers	3.832	8	0.713	79	5.374	0.000
Regional research organizations	2.844	8	0.813	79	3.498	0.002
National research organizations	3.975	8	0.699	79	5.690	0.000
International research organizations	5.562	8	0.538	79	10.340	0.000
Financial support (regional authorities)	3.721	8	0.725	79	5.135	0.000
Financial support (national authorities)	3.815	8	0.715	79	5.337	0.000
Upper secondary education	6.061	8	0.488	79	12.432	0.000
Higher education (short)	6.348	8	0.458	79	13.846	0.000
Higher education (long)	8.300	8	0.261	79	31.834	0.000
Centrality index	6.052	8	0.488	79	12.390	0.000
Population density	8.714	8	0.219	79	39.829	0.000

Appendix B

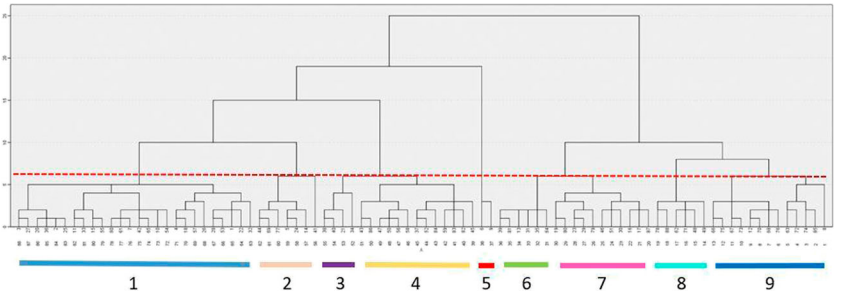

Figure B1. Dendrogram used for preliminary identification of the optimal number of clusters. Method: Hierarchical clustering with Ward's minimum variance (Euclidean distance). The red horizontal line is the threshold for the identification of the clusters.

Appendix C

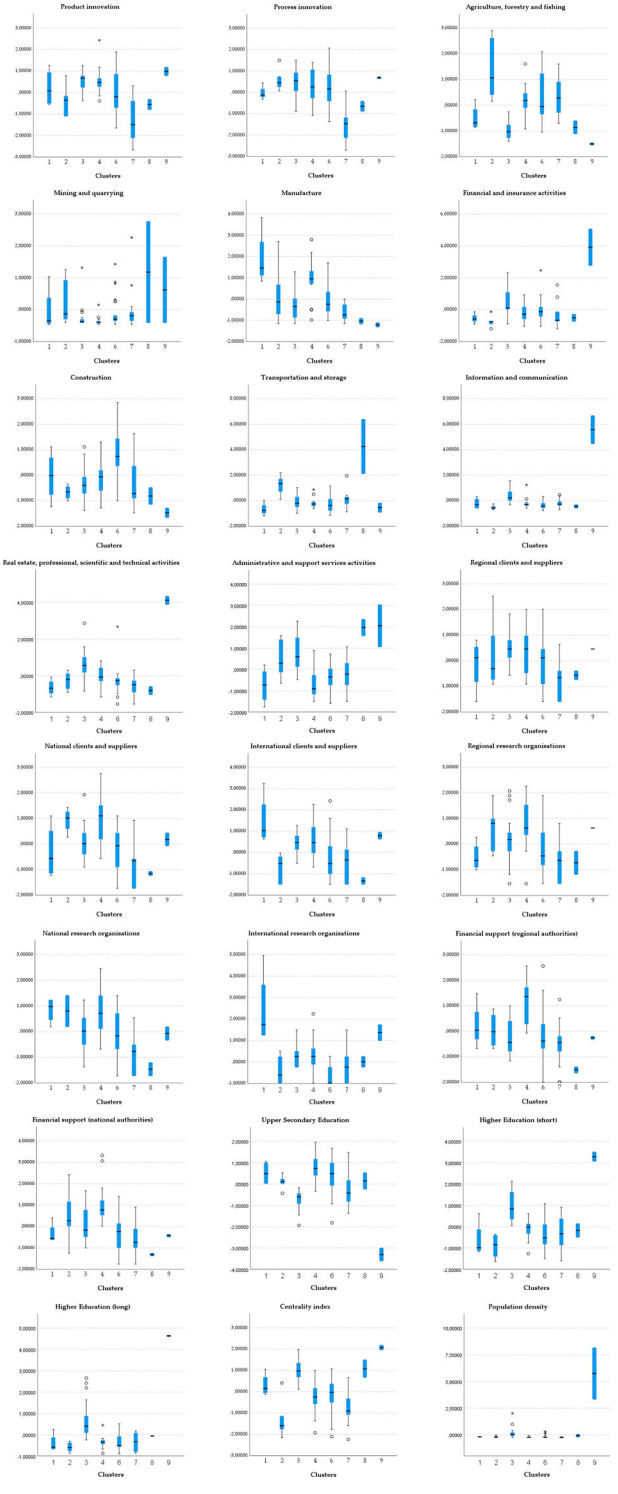

Figure C1. Kruskal-Wallis post hoc test – Variance within and between the identified clusters.

Appendix D

Figure D1. Distribution of the Norwegian economic regions in the nine identified clusters. Legend: Each colour identifies a given cluster. Map created with Flourish (https://flourish.studio/).