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Examining the efficacy of the Relatedness vs Complexity Matrix in Norway's peripheral regions and its implication for Smart Specialisation

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Abstract

While a relatively large body of literature deals with Smart Specialisation, understanding its potential in peripheral regions is still largely missing. The study builds upon economic research that advises policymakers to focus on related and complex activities. The aim is to assess whether the relatedness vs complexity framework developed by Balland et al. (2019) can accurately represent the situation in the periphery and if it can be utilized in the development of Smart Specialisation strategies. To achieve this, Norwegian registry data and case studies are analysed with a focus on 3 peripheral regions: Møre og Romsdal, Nordland, and Finnmark. The findings of the study indicate that the framework underestimates the complexity of activities in these regions, especially those that heavily rely on tacit knowledge. Consequently, the methodology used in the framework needs to be adapted to suit the local context. Additionally, the interpretation of results can be enhanced by utilizing the absolute average deviation of relatedness values. However, despite these limitations, the framework proves valuable as a monitoring and benchmarking tool, enabling policymakers to guide and oversee regional growth trajectories effectively.

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1. Introduction

Smart Specialisation is an innovative approach to help regions identify and develop their strengths for long-term economic growth. It is a policy concept that encourages each region to focus on its most promising areas of activity, often referred to as 'domains.' It has been adopted by several regions in Norway, including Møre og Romsdal, Nordland, and Finnmark, to enhance their regional economies. However, the effectiveness of Smart Specialisation is often challenged, particularly in the periphery. Their business environment is unique, dominated by natural resource-based industries and influenced by their geography, along with distinct demographic, social and economic characteristics. Lack of skilled resources, strong institutions, governance structure and ability to attract investments can influence the effectiveness of Smart Specialisation, raising questions about their appropriateness in these contexts. Foray (2019) referred to Smart Specialisation as a "policy running ahead of theory" in his review based on studies done since the introduction of the concept by the European Commission.

Balland et al. (2019) proposed a framework that aims to systematically identify economic trajectories that are available to regions and provides a new perspective on building economic diversity and resilience using the concepts relatedness and complexity. Relatedness refers to how closely different industries are connected, while complexity refers to how intricate and advanced these industries are. As an analytical tool, the framework promises to provide a quantitative overview of the region's strengths and weaknesses as a foundation for policymaking aimed at economic diversification. While a relatively large body of literature deals with the relatedness vs complexity framework, there is a notable gap in understanding the feasibility in different regional contexts and deciphering practical implications.

The aim of the study is to extend the literature by examining the framework's applicability and offer insights and recommendations for effective implementation. With empirical analysis and case studies from peripheral regions in Norway, this study also seeks to contribute to the understanding of how the framework can be tailored and utilised to enhance the development of Smart Specialisation strategies. The study's findings can add to the body of knowledge on regional and economic development, particularly for peripheral regions, by providing insights into the difficulties and opportunities they confront.

2. Theory & Concepts

2.1 Paradigm shift in innovation policy

Research on innovation and its connection to economic development dates back to Schumpeter in the 1930s who saw innovation and entrepreneurship as important drivers for resetting the economy to ensure new cycles of economic growth and coined the term "innovation management" (Florida et al., 2017). His theories are highly influential in regional studies and economics but have been criticised for placing too much emphasis on research as the main source for new technologies. In more recent times, the Schumpeterian approach to innovation has been replaced by a combination of several theories which emphasises the role of regions in constructing economic growth. These theoretical concepts include *clusters* (Porter, 1990), where emphasis is placed on geographic proximity in value chains, *innovative milieus* (Camagni, 1995), where the importance of knowledge exchange and policy intervention is heightened and *learning regions* (Asheim, 1996), where the role of interactive learning to develop regional networks is addressed.

These concepts have been adopted by academics and policy makers around the world but have also been subject to criticism for putting focus solely on research and development competences, for concentrating on local industrial specialisation and for its tendency to favor urban areas, often at the expense of least developed regions (Wøien et al., 2019). By favoring urban regions with established industrial clusters, these models may neglect the potential for innovation and development in less developed or rural areas. This can perpetuate regional disparities and hinder inclusive growth and economic opportunities. It is crucial to recognise that these strategies may not align with all industries and the distinctive circumstances of different regions. By adopting a more generic approach, policymakers and stakeholders can encourage a broader range of industries to embrace innovation and tailor their strategies to their specific needs and circumstances. It has become imperative to move away from previous innovation models and embrace a more inclusive and adaptable approach that caters to a wider range of industries and regional contexts.

2.2 Regional Innovation System

The regional innovation system (RIS) has made considerable contributions in this respect. The concept of innovation systems was initially applied to the national scale but has since its introduction been extended to the regional level to account for the unique institutional context and economic structure specific to each region (Tödtling and Trippl, 2005). RIS draws on clusters, innovative milieus, and learning regions, but also builds on a range of other factors that promote and diffuse innovation within a region. These factors arise from the interaction between different regional stakeholders within the Triple Helix Model popularised by Etzkowitz and Leydesdorff (1995) and drove innovation and regional development. A central argument of RIS is that none of these factors can be understood in isolation because every region is unique (Tödtling and Trippl, 2005). It represents a more dynamic perspective on economic growth since it understands innovation as a complex process involving a wide range of various actors and economic activities. Regional innovation systems have become a defacto framework for implementing regional innovation strategies and designing relevant policy mixes, especially within the framework of Smart Specialisation.

2.3 Smart Specialisation

Smart Specialisation was initiated in 2014 by the European Union (EU) and is a place-based innovation policy, based on the concept of RIS, to address the issue of overlapping research and innovation efforts (Foray et al., 2009). It is believed that every region should use its own strengths and competitive advantages and concentrate on research and innovation that align with its strengths. The purpose of this policy is to maximise the productivity and effectiveness of research and innovation spending across the EU. Since its introduction, Smart Specialisation has become the basis for the European Structure Fund's involvement in research and innovation (R&I) and a cornerstone of the EU Cohesion policy ambition to tackle environmental and climate change, secure our digital future, create jobs, and strengthen economies while protecting citizens, values, democracy, and rights (European Commission, 2010). It has been advocated that addressing these goals will not only place Europe in a better position to compete

in the global economy but also bring long-term economic prosperity by transitioning into knowledge-based economies.

All EU-member states are required to design and implement Regional Innovation Strategies for Smart Specialisation (RIS3) and will receive financial support from the European Regional Development Fund (ERDF) to support their activities for innovation and regional development (European Commission, 2010). This plan must also include a comprehensive outline for monitoring implementation initiatives and ensuring priorities are periodically reassessed. A total of 67 billion euros have been made available for the implementation of these strategies and more than 120 smart specialisation strategies have been submitted (European Commission, 2017). S3 has also been recommended as an approach to regional development for non-EU member states, for example, Norway, Iceland, Australia, and the United States of America. It is interesting to note that, even though these states do not share the same ERDF-related interests in implementing the concept, numerous components of the innovation policy reform seem to have been informally adopted (Kristensen et al., 2018).

The European Commission (2010) claims Smart Specialisation as the biggest effort to change the entire structure of regional economies and spur economic growth in European history. By pursuing new transformative activities connected to the existing ones, the goal is to strengthen the capacity of regions to gradually diversify (Asheim, 2019). Regions need to concentrate on re-combining elements and create capabilities that can be applied to new activities in which they can specialise in and subsequently, transform from within. This must be done by prioritising activities with the highest value through a process of self-assessment and entrepreneurial discovery. This stands in contrast to previous regional development policies building on e.g., cluster strategy, which was more research-based and sector-oriented.

It was important to refrain from traditional innovation thinking because competences (e.g., skills, capacity), knowledge bases (e.g., symbolic, cultural, synthetic, and analytical) and strengths within regions can range from basic services to high-tech industries and cannot be supported by only conducting fundamental research (Asheim, 2019). Smart Specialisation is considered as more inclusive in the way it can promote economic diversification in all regions in numerous ways, depending on current domains, innovative capabilities, and knowledge bases

(ibid). Furthermore, it encourages local stakeholder participation in the development process through the entrepreneurial discovery process (EDP). EDP aims to mobilise economic actors within the RIS framework to create a positive environment for innovation and entrepreneurship (Kristensen & Pugh, 2023). A dense network of highly engaged stakeholders with a high degree of trust will help create a positive environment for innovation and entrepreneurship because it accounts for the needs and opportunities available (Cvijanović et al., 2020). This will help the region attract the best talents and investment opportunities and address regional disparities and promote inclusive growth that benefits all levels of society by offering upskilling, employment, and potentially higher standards of living. These strategies can be more agile in design and implementation because there is an established dialogue between stakeholders and the feedback loop is much shorter, compared to the national level.

2.4 Smart Specialisation in peripheral regions

The Smart Specialisation approach to regional development holds perhaps the most potential for Sparsely Populated Areas (SPA), commonly known as peripheral regions. They are usually rich in natural resources, but also characterised by demographic obstacles, such as low population settlements scattered over long distances, large land masses of open landscapes, small settlement structures, harsh climate, and fragile ecosystems (Teräs et al., 2015). Since Smart Specialisation encourages regions to build on their unique characteristics and promotes collaboration and connectivity across regions, it carries the promise to minimise the effects of regional disparities. It can also support entrepreneurship, increase employment opportunities, create balanced, diversified, and resilient economies in addition to contributing to a more balanced growth.

While Smart Specialisation has been well received, critics have stressed that there may be too much inward orientation on industries in regions. This can limit the scope for new strategies that go beyond what has worked in the past and prevent the development of new and emerging economic activities that promote more fundamental structural changes in regional economies (Asheim, 2019). This makes it essential to incorporate a forward-looking approach during the design and implementation of Smart Specialisation strategies. The European Commission

divided the RIS3 design into six steps: 1. Analysis of regional and national context 2. Governance 3. Shared vision 4. Priority setting 5. Definition of coherent policy mix, roadmaps and action plans 6. Monitoring and evaluation. This comprehensive process enables regions to anticipate and respond to emerging opportunities and challenges, fostering innovation and structural changes in their economies.

2.5 A complementary framework for Smart Specialisation

The first step of designing Smart Specialisation strategies should be to self-assess strengths and weaknesses by analysing information on existing industries, human capital, infrastructure, institutions, and resources and aligning it with trends in markets, technology, and society to get the best results possible (Foray & Kommission, 2012). However, the necessary tools and methods are yet to be realised and the development of appropriate tools can be considered as a critical area for ongoing research (OECD, 2013).

To help policymakers plan for Smart Specialisation strategies, Balland et al. (2019) propose a framework based on the concept of relatedness and complexity. The framework systematically identifies trajectories that are available to regions and urges policy makers to plan for economic diversity that increases the complexity in regional economies and to promote activities that are closely related to regions strengths (Rigby et al., 2022). The framework can help establish targeted policies that maximise resources and innovation capacity as well as track changes in regional capabilities by feeding new data into the framework. The clarity provided by the framework makes it easier to engage stakeholders and reduce the risk of moving from one activity and industry to another.

The principle of relatedness refers to the similarities and differences between the various types of knowledge and in way they can be used (Balland et al., 2019). Activities are considered related when they require similar inputs or when they can act as substitutes for one and other (Hidalgo et al., 2018). Seeing that related activities demand less overlap and can reduce the risk of moving from one technology to one other (Rigby et al., 2022), the presence of relatedness is considered one of the primary determinants of regions abilities to diversify into new activities

(Neffke et al., 2011). At the same time, policy makers must also consider the complexity of the new economic activity since it is a determinant of how difficult it is to branch into the activity. Activities are considered complex when they consist of various components, require broad sets of skills, are produced in few regions and are difficult to imitate (Hidalgo & Hausmann, 2009; Balland et al., 2022). Complexity also implies a greater potential in value and has been found to provide unique benefits, such as sustained competitive advantage and a speedier growth rate (Pinheiro et al., 2022).

These activities are mapped in **Figure 1** and are specified by their level of relatedness and complexity relative to existing regional knowledge bases.

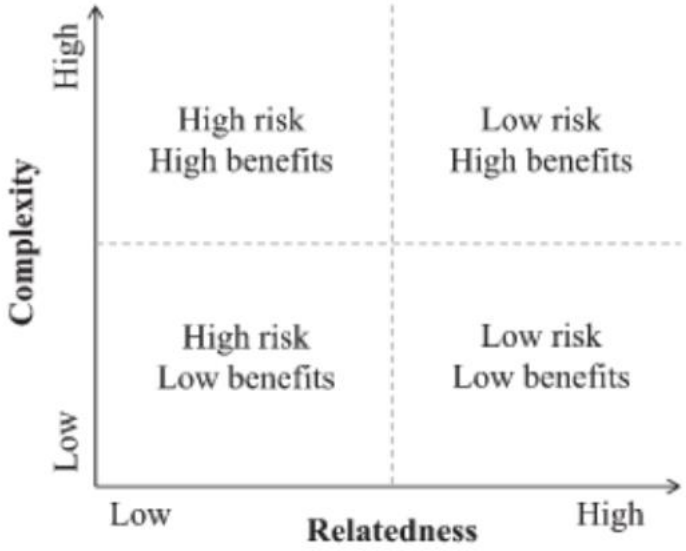

Figure 1: *Framework for Smart Specialisation.*
Source (Balland, Boschma, Crespo and Rigby, p. 8, 2019)

The ideal scenario for any region is to invest in all or most activities found in the low-risk and high-benefits quadrant (top right). They hold the most potential for economic diversification and eventually growth. However, most regions, especially in the periphery, do not have the technological capacity or human resources necessary to deal with such sophisticated activities (Kroll, 2015). Activities in this quadrant tend to belong in complex areas such as airspace,

medical device manufacturing, nanotechnology and pharmaceuticals favouring regions with high patent activity and a diversified portfolio of activities. These activities demand a greater allocation of resources, advanced infrastructure, and specialized skills that are lacking in the region, thereby creating a significant barrier to entry. However, engaging in activities from this quadrant will increase the breadth and depth of the region's knowledge base (Rigby et al., 2022). Radical innovation is more likely to occur, resulting in the creation of high-value products and services. Regions can diversify their economy by leveraging their existing skills and developing new skills. It will also give access to new investments from both private organisations and public funds that were previously unattainable. These activities can also be a way to attract new talent to the peripheral regions with higher salaries and lower cost of living than bigger regions. This starts a cycle of growth and development that culminates in the development of a competitive advantage, resilience to economic shocks and long-term success of the region.

The same advantages are also applicable for the other low-risk quadrant but with low expected returns (bottom right) since they are related to current activities and build on current domains. Activities in this quadrant leverage existing competences and knowledge (both explicit and tacit), with the formation of clusters (Ketels & Protsiv, 2016), enabling the region to transition faster. There is also a possibility of constructive interaction between existing and new activities in terms of customers and suppliers. This would reduce the risk of transition and make it easier for the region to attract investments and gain public trust. The existing labour market can be utilised and training costs can be kept to a minimum. However, jobs related to these new activities would not offer higher salaries or standard of living since they are of low complexity in low-tech industries and do not necessitate higher levels of analytical skills (Asheim, 2019). Skillsets and competencies available in the region might become homogeneous and cause a stagnation in innovation and lead to a lock-in situation (Boschma, 2017) due to overdependence on certain industries where the related activities are rooted.

In certain situations, investing in activities that are more complex but not related to existing activities can be a more suitable option. These activities can be found in the upper left quadrant and denote high-risk activities with high expected returns (Rigby et al., 2022). This means that the new activities are far removed from the current regional economic profile and indicates a

more radical diversification strategy that can transform entire industries and bring forth innovative technologies that are entirely new (Balland et al., 2019). Numerous studies have shown that complex activities have greater innovation potential, meaning it can be used to attract more investments and new talent as well as offer higher wages to individuals with relevant experience and education. It can also transform industries to be more sustainable (e.g., reduce their dependence on finite resources) and remain competitive in the global market even during economic disruptions and changes in consumer behaviour. However, their complex nature makes them difficult to enter. While every region, including peripheral regions, are expected to have opportunities in this quadrant, attempting such long jumps will be next to impossible without accessing external knowledge sources and mobilising human resources that compensate for the skill gap in the local labour market (Balland et al., 2019; Sörvik et al., 2019). However, the influx of new labour and necessary competencies can result in higher unemployment rate and inequality since the benefits of the new activities are not equally distributed. It can also be seen as a loss of "culture and identity" since industries can have a significant social and psychological imprint if it has a long history in the region. The city of Stavanger in Rogaland was called "Norway's oil capital" and the recent transition from fossil fuels to renewable energy has drawn criticism from the local population over the fear that it may threaten their way of living. A significant challenge that peripheral regions now face is the choice between adopting radical policy measures to promote these complex activities or tempering their aspirations to match regional competencies and thereby aim for more attainable initial objectives.

Viable options can also be found in the bottom left quadrant of the matrix. Activities in this quadrant are high-risk and are not related to current capabilities. Regions might see these activities as an opportunity to diversify their economy and reduce their reliance on specific industries. It could be used to utilise resources that are suited for low-relatedness and low-complexity activities or increase employment opportunities as these activities offer a lot of entry-level jobs or require less specialised skills, making them more accessible to the local workforce. These activities have a low barrier to entry and can be important blocks for more complex activities in the future. Most importantly, regions may identify emerging sectors or niche markets that have the potential for future development and are not related to their existing

economic base (Asheim et al., 2011). However, these activities may have limited value chains, market competitiveness, and potential for sustainable growth. If the demand for such activities declines or faces competition from other regions, the region's economy may suffer and struggle to recover.

3. Purpose of the study

Seven regions in Norway have registered on the S3 platform, including several regions which can be termed as "geographically peripheral" when observing concentrations of population, businesses, and institutions. In a study published by Teräs et al. (2015), the authors observed a persistent tendency in peripheral regions to preselect a few industries and abstain from 'picking the winners' in the priority selection process. Since the relatedness vs complexity framework seeks to provide a comprehensive overview of the regions' economic outlook, it should be able to help outline the most fitting strategies for Smart Specialisation. The question then becomes:

To what extent does the relatedness vs complexity framework represent the activities in peripheral regions, and how can this information be utilized to improve Smart Specialisation strategies?

The study can provide valuable insights for policymakers and development agencies in peripheral regions. Understanding the applicability of the framework can help inform the design and implementation of policies and strategies aimed at promoting economic development. The findings can guide decision-makers in identifying effective tools and approaches that support the process of developing targeted strategies for Smart Specialisation.

4. Smart Specialisation in Norway

The Norwegian economy has remained consistently competitive and remarkably resilient, despite the disadvantages of being situated in the northern periphery of Europe and having a small and scattered population. The country has a relatively open economy but low R&D

activity in the Scandinavian context (Fitjar & Rodriguez-Pose, 2011). The success of the Norwegian economy is partly linked to its abundant in natural resources, especially the oil and gas reserves from the Norwegian Continental Shelf, and partly to the establishment of strong political and social organisations (e.g., universities, research centres, businesses) that have enabled Norway in becoming a knowledge-based economy with a highly educated population (ibid). In fact, the Norwegian Gross Domestic Product (GDP) *per capita* frequently ranks in the top ten in global measures, indicating high levels of government quality, institution capacity, income, and general well-being (Jordahl et al., 2023).

The picture is more mixed, however, when taking a closer look into the country's innovation patterns. According to the Innovation Union Scoreboard (IUS) in 2014, Norway scored lower than the EU average and was considered as a 'moderate innovator'. Businesses devoted only a small portion of their resources and total turnover on innovation expenditure (The Research Council of Norway, 2015). In 2012, businesses used about 1.1% of their overall turnover on innovation activities, while Sweden, Denmark and Finland devoted 3.6, 3.2 and 2.3 %, respectively. The Norwegian economy is reliant on the exploration of natural resources and therefore includes a lot of low-complexity activities. On top of this, it is dominated by a small number of large companies and only a few of them can be termed as innovative.

Furthermore, the majority of the research and innovation activities are concentrated in the capital region or in industrialised and economically dynamic regions. Strong differences in industrial structure, quality of universities and the proximity of research centres and other knowledge-intensive institutions contribute to the difference in research output from different regions in Norway. The allocation patterns of funding from Research Council of Norway (RCN, Forskningsrådet) further exacerbated the issue.

Norway took its first steps towards Smart Specialisation with the Planning and Building Act in 2008. The Act coordinates various tasks of economic agents spanning from the municipal to the national level and provides a framework for the conservation and exploitation of regional natural resources (Ministry of the Environment, 2008). The RCN launched the Program for Regional R&D and Innovation (VRI), running between 2007 and 2017, and is considered as the predecessor to the implementation of Smart Specialisation in Norway. VRI was designed to

empower regions and to *"promote knowledge development, innovation and value creation through regional collaboration – particularly between companies and R&D institutions – and to encourage increased investment in R&D in and for the regions"* (The Research Council of Norway, 2007: 4).

The programme resulted in the identification of a limited number of priority areas and was important for changes in innovation thinking (Kyriakou et al., 2016). However, its impact on regional growth remains elusive as researchers found that the economic activities performed under the programme were tied to already strong clusters (ibid). The final review of the VRI initiative also revealed that there were, in many cases, significant differences across regions' collaboration patterns and in how well the strategy was institutionalised. It also concluded that some regions may possess better prerequisites to diversify through Smart Specialisation principles than others.

5. Data and methodology

5.1 Data sources and rationale

This paper uses registry data from establishments from Statistics Norway on Norwegian residents over the age of 18 employed in the private sector and collected for the years 2009-2014. The data was further processed by Broekel et. al. (Mimeo) to find the number of workers per industry in each economic region in Norway. Worker information for 417 activities (or industries) can be found in the dataset spread over 67 labour-market regions for the year of 2014, when the first phase of Smart Specialisation was initiated by the European Union. Activities were identified at the 4-digit NACE level using the SNI2007 industry classification system. Labour-market regions are categorised as "economic regions" in Norway. Economic regions were aggregated at the county (fylkeskommune) level for the purpose of meaningful interpretation since priorities for Smart Specialisation are to be set at the county-level in Norway.

Previous papers on the role of relatedness and complexity on regional economic development or diversification potential have used trade data for analysis. However, using employment data provides valuable insights into knowledge and competencies represented by the labour force. Skills transcend industries and individuals can be employed in similar roles in different industries (Neffke & Henning, 2013). Labour data provides more detail about the potential of knowledge spillover and how complex, tacit knowledge travels between industries. This provides a more comprehensive perspective compared to any other single indicator, such as patent data, which is usually industry specific. Patent data might not cover entire industries where developing patents is not the norm, such as the service sector. Broekel et. al. (Mimeo) also advocates for the labour data approach after discovering employment growth in Norway was more strongly influenced by industrial relatedness than by occupational relatedness or other factors influencing the region's composition, further emphasising the transferability of skills between industries. Peripheral regions are usually engaged in activities that are not technologically complex, but dependent on non-formalised knowledge developed over time by individuals involved in the industry (Storper & Venables, 2004).

Labour data can be crucial for understanding the Norwegian perspective, primarily because the lack of skilled human resource is often the limiting factor for economic development in Norway. The industrial structure is shaped by the natural resources and landscape of the region and best results can be yielded from the small population by developing related skills applicable to many industries.

5.2 Calculating relatedness density and complexity

The EconGeo package for Rstudio, developed by Balland (2017), was used extensively in the preparation of the data for this paper. The economic region dataset was converted into an industry and economic region matrix to calculate the revealed comparative advantage (RCA), meaning the location quotient is above 1. Regions with a comparative advantage are more likely to succeed in an activity because of the presence of unique skills and resources as well as other factors of production (Fujita et al., 1999). The RCA so computed using the following formula:

RCAizt = PATizt n z=1 PATizt / m i=1 PATizt m i=1 n z=1 PATizt

The relatedness of each activity to other activities in the region was calculated based on a co-occurrence matrix of all the activities in the region, which provides an empirical illustration of how activities in the region interact with each other. It also shows how activities benefit from proximity and agglomeration effects since industries that interact frequently are likely to be located near each other and have several types of linkages in terms of resources, labour, customers, and other interdependencies (Glaeser et al., 1992).

This was further combined in the activity vs region matrix to find the relatedness density of each economic location. The relatedness density of each activity in the region was calculated from the average of the relatedness density of the activity in each location within the region, rather than the maximum, to account for the uncertainty of availability of other factors necessary for the successful growth of the activity.

The average complexity of each activity in a region was found using the MORt (Multiplying Output Reflected Transformation) method. It acknowledges that complexity is not only dependent on the quantity of labour available but also the diversity and variety of skills it represents and therefore, is able to capture the breadth and depth of capabilities present within a region.

5.3 Reviewing the regional strategy papers

This paper focuses on three regions in Norway: Møre og Romsdal, Nordland and Finnmark. All three regions fall under the categorisation of peripheral regions and sparsely populated areas, as defined by the EU. Their geographical location and characteristics make a significant contribution to their industrial structure. All three regions have invested heavily in industries that exploit natural resources - aquaculture, forestry, and mining - but differences arise from variations in availability, specialisation and historical development. However, these regions are dominated by a few major industries which employ most of the population and have the power to influence public policy making. The geographical, industrial, and social situation of the three regions make them ideal cases for the implementation of Smart Specialisation strategies. **Table**

1 includes the strategy papers published by the three regions and includes the priorities as well as the implementation period.

Region	Strategy Paper	Priorities	Implementation period
Møre og Romsdal	Research and Innovation strategies	• Maritime • Marine • Furniture • Petroleum • Knowledge-based industries	2016-2020
Nordland	Innovation Strategy for Nordland	• Seafood • Processing industry • Experience-based tourism • Mechanical and maritime industries	2014-2020
Finnmark	Regional Innovation Strategy for Finnmark (RIS3) - Based on SMART specialization principles	• Energy and Petroleum • Building and construction industry • Arctic bioeconomy • Mineral Industry • Experience-based tourism	2014-2023 (Updated in 2019)

Table 1: Summary of the Smart Specialisation strategy paper for Møre og Romsdal, Nordland and Finnmark

6. Empirical Analysis

Table 2 provides an overview of distinctive characteristics and measures of three regions to get a better understanding of their capabilities and limitations. Møre og Romsdal has a significantly higher population density (19.28) due to the presence of urbanised cities such as Ålesund and Molde compared to Nordland (8.98) and Finnmark (1.76) where smaller towns and scattered settlements are commonplace even though the labour regions cover more land area. Population growth figures are also worrying since Nordland and Finnmark are expected to experience negative growth until 2050 while Møre og Romsdal has a meagre 5% growth projection, constituting the lowest among all regions in Norway (Statistics Norway, 2022). Inbound labour

mobility is also unlikely for these regions. A major source of "new" labour in Finnmark are asylum seekers and immigrants from Eastern Europe. They are more reliant on their closeness to Finland and Russia for business development, compared to other regions in Norway, pointing to a lack of regional collaboration (Finnmark County Authority, 2019). Opportunities for higher education are also quite limited in these regions with UiT - The Arctic University of Norway being the most established institution along with a campus for NTNU in Ålesund and Nord University in Bodø as the next best alternatives. Research output is also quite low in these regions and expenditure on research per capita is well below the national average. Møre og Romsdal (271) is involved in the greatest number of activities and is the most specialised, based on the Krugman index, because of its involvement in the shipbuilding and aquaculture industries. An analysis of the data from Nordland provides homogeneous results because it has an industrial structure that is almost identical to Møre og Romsdal but with different specialisations. However, Dosi et al. (2022) found that a high degree of specialisation is detrimental for long-term growth resilience. Specialisation can limit the diversity and variety of industries within a region, resulting in a lower potential for finding related products. Finnmark has lower levels of specialisation (0.49) but it might have been caused by the lack of critical mass since it is involved in the least number of activities among all Norwegian regions.

	Møre og Romsdal	Nordland	Finnmark
Regions	7	7	4
Population in 2014	261530	212686	75207
Population density	19.28	8.98	1.76
Registered workers	76588	51311	106393
Activities	271	226	166
Krugman index (level of specialisation)	0.76	0.65	0.58

Table 2: Description of the region and their activities based on national registry data

Figure 2 show the position of each activity present in the region in terms of their relatedness and complexity and the size of each circle represents the number of workers involved in the activity, indicating the importance of the activity if it is assumed that labour is the limiting resource for the activity. The figure only focuses on the quadrants with low relatedness. None of the three regions have any activities in the upper left quadrant but this is unsurprising since

they are not known for hosting high-tech industries. Only Nordland has an activity (manufacturing of ready-mixed concrete) in the lower right quadrant. However, all three regions possess complex activities with Møre og Romsdal (90) as the highest followed by Nordland (48) and Finnmark (20). The data can be seen as an accurate representation of the differences between the regions' economic conditions and their degree of success is proportionate to the number of complex activities they are engaged in.

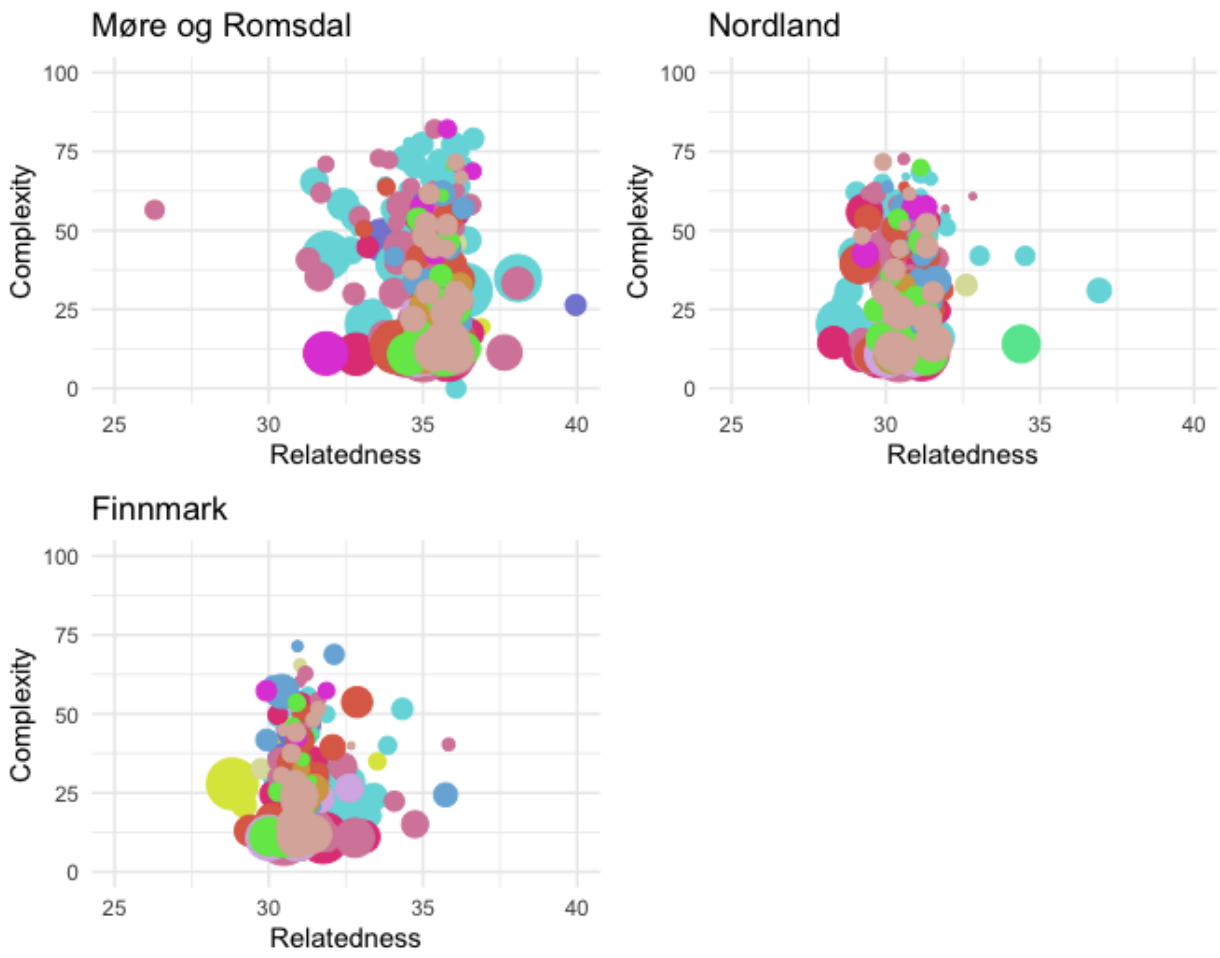

Figure 2: Relatedness vs complexity plots for Møre og Romsdal, Nordland and Finnmark

Balland et al. (2019) proposes following a "casino" policy strategy for these regions by focusing on developing the complex activities found from the matrix. However, the feasibility is

questionable according to the literature because of the excessive amounts of investments required in pursuing unrelated diversification opportunities.

The next section discusses the different priorities chosen by the regions and the rationale provided and comparing with the results obtained from the framework to observe similarities and differences between theoretical considerations and practical implementation.

6.1 Møre og Romsdal

Møre og Romsdal focused on increasing the absorptive capacity and commercialisation potential of their existing industries and activities by investing in new generic technologies such as biotechnology, logistics, material technology, robotization and automatization, design, bioeconomy, visualisation/media/communication (Asheim et al., 2017). **Table 3** shows us that only activities related to material technology could be found in the high-complexity quadrant.

Activity	Complexity	Group
Manuf. metal forming machinery	82,1	Manufacturing
W.sale mach. textile industry etc.	82,1	Wholesale and retail trade; repair of motor vehicles
Financial leasing	82,1	Financial and insurance activities
Manuf. of doors/windows of metal	79,0	Manufacturing
Rep. of electrical equip.	77,7	Manufacturing
Manuf. of plastics in primary forms	77,3	Manufacturing
Manuf. of mattresses	77,1	Manufacturing
Manuf. of other textiles n.e.c.	75,2	Manufacturing
Manuf. of fasteners etc.	73,5	Manufacturing
Manuf. of perfumes, toilet prep.	72,9	Manufacturing

Table 3: Top 10 activities in Møre og Romsdal in terms of complexity

However, the framework does not reflect the competencies held by the region in activities related to the maritime, marine and furniture industry. They have high scores for relatedness compared to other activities in the region but is still to be placed in the lower left quadrant, as shown in **Table 4**.

Activity	Relatedness	Group
Operation of gravel and sand pits	39,95	Mining and quarrying
Manuf. of other furniture	38,08	Manufacturing
W.sale fish, crustaceans etc.	38,07	Wholesale and retail trade; repair of motor vehicles
Ret. sale sporting equip.	37,64	Wholesale and retail trade; repair of motor vehicles
Support services to forestry	36,9	Agriculture, forestry and fishing
Manuf. of ready-mixed concrete	36,68	Manufacturing
Manuf. of doors/windows of metal	36,63	Manufacturing
Security, comm.contr. brokerage	36,62	Financial and insurance activities
W.sale office furniture	36,54	Wholesale and retail trade; repair of motor vehicles
Development of building projects	36,51	Construction

Table 4: Top 10 activities in Møre og Romsdal in terms of relatedness

The presence of multinational companies and globally accredited clusters in the multiple industries along with the identification of "megatrends" empowered the decision-making process following the entrepreneurial discovery process. The stakeholders thought it was important to improve the regional innovation system and the quality of output each of them produces, rather than investing in new activities that are potentially unrelated to the region's existing capabilities.

6.2 Nordland

The innovation strategy of Nordland County Council (2014-2020) for Smart Specialisation aimed to build a more diversified industrial structure by concentrating on place-based strengths. The strategy targeted five *focus fields*, namely the marine industry, supplier sector, processing industry, tourism industry and knowledge-intensive business services (Nordland County Council). The selection of these fields is linked to the access of place-based resources, especially competencies, integrated action patterns along with natural and cultural resources that strengthens the competitiveness of these industries (Finne et al., 2021). Nordland is the national hub in the Norwegian marine industry and constitutes approximately 65% of the

Norwegian fish export (Nordland County Council). Studies have shown that the competencies within the marine industry can be further redeployed into more complex technologies, but also to create appreciable synergies within other sectors, like supplier and transportation sectors (Johansen et al., 2019). However, analysis of the framework does support the claims about the marine industry made by the regional authorities. They have slightly above average relatedness and are of low complexity but Nordland holds a lot of potential in the supplier industries **(Table 5)** where activities are complex and related to other activities in the region **(Table 6).** Actitivities related to knowledge-intensive industries such as lease of intellectual property, media representation and news agency can be found in the upper left quadrant but tourism activities are in the lower left quadrant.

Activity	Complexity	Group
Agents sale of furniture etc.	72,61	Wholesale and retail trade; repair of motor vehicles
Leas of intellect. property etc.	71,67	Administrative and support service activities
Media representation	69,90	Professional, scientific and technical activities
Manuf. of dyes and pigments	68,20	Manufacturing
Manuf. of other chemical prod. n.e.c.	67,00	Manufacturing
Manuf. of flat glass	66,29	Manufacturing
Manuf. wire prod., chain and springs	64,90	Manufacturing
News agency act.	63,80	Information and communication
Removal services	63,76	Transportation and storage
Manuf. of industrial gases	62,07	Manufacturing

Table 5: Top 10 activities in Nordland in terms of complexity

Nordland also has substantial energy production capacity and considerable unexplored potential in renewable energy, particularly in wind energy and hydroelectric power (Steen et al., 2019). The region constitutes approximately 10% of the total electricity production in Norway. This could be used to supply the energy-intensive sectors (e.g. metal processing) consuming more than 60% of the energy currently being produced in the region, meaning it is highly related to other activities in the region.

Activity	Relatedness	Group
Manuf. of ready-mixed concrete	53,06	Manufacturing
Coll. of non-hazardous waste	44,18	Water supply; sewerage, waste management
Build. ships/floating struct.	36,92	Manufacturing
Manuf. of other plastic products	34,52	Manufacturing
Distrib. of electricity	34,39	Electricity, gas, steam and air conditioning supply
Other gen-purp. machinery n.e.c.	33,04	Manufacturing
W.sale china, glass, clean. mater.	32,82	Wholesale and retail trade; repair of motor vehicles
Water supply	32,61	Water supply; sewerage, waste management
Manuf. other spec. purp. mach.	31,98	Manufacturing
W.sale textiles	31,93	Wholesale and retail trade; repair of motor vehicles

Table 6: Top 10 activities in Nordland in terms of relatedness

Particular attention must be given to Nordland since SINTEF concluded that their innovation strategy was highly successful and has been internationally recognised for their exceptional perforance (Finne et al., 2020).

6.3 Finnmark

While the implementation of Smart Specialisation principles was still underway in the time period that this study draws on, the region had taken decisive actions in 2019 and specified five industries as primary targets. These sectors included energy and petroleum, building and construction industry, arctic bioeconomy, mineral industry and experience-based tourism (Finnmark County Authorty, 2019), but activities in these industries are not featured in **Table 7** as the framework does not consider them as highly complex.

Activity	Complexity	Group
Sound record./music publishing act.	71,44	Information and communication
Book publishing	68,85	Information and communication

Coll. of hazardous waste	65,45	Water supply; sewerage, waste management
Ret. sale medic./orthopaedic goods	62,74	Wholesale and retail trade; repair of motor vehicles
W.sale chemical prod.	60,23	Wholesale and retail trade; repair of motor vehicles
Other telecommunications act.	59,65	Information and communication
Ret. sale carpets, rugs, wall/floor cover.	57,41	Wholesale and retail trade; repair of motor vehicles
Act. on insurance agents/brokers	57,35	Financial and insurance activities
Other credit granting	57,30	Financial and insurance activities
Television progr./broadcast. act.	57,09	Information and communication

Table 7: Top 10 activities in Finnmark in terms of complexity

Like many other peripheral regions situated in northern Europe, the region relies heavily on natural resources for economic growth, especially since the building of multiple oil and gas drilling facilities on the coastal waters of Finnmark in the early 2000s (Teräs et al., 2018). Despite the mineral industry becoming heavily affected by the bankruptcy of Sydvaranger in 2015 (the largest mining company in Norway), the inclusion of this industry has been key to discover new innovation potential that meets the environmental requirements in Norway (Finnmark County Authority, 2019). However, the picture is more mixed when taking a closer look on **Table 8**, as only the extraction of crude petroleum is seen as a complex activity and none of the other activities are above average in terms of relatedness.

Activity	Relatedness	Complexity	Group
Extraction of crude petroleum	30,75	51,08	Mining and quarrying
Extraction of natural gas	30,94	45,53	Mining and quarrying
Mining of iron ores	30,53	17,51	Mining and quarrying
Quarry. build. stone, limestone etc.	31,19	28,88	Mining and quarrying
Operation of gravel and sand pits	31,49	26,39	Mining and quarrying
Other mining and quarrying n.e.c.	30,52	35,48	Mining and quarrying
Supp. for petro/natural gas extrac	31,13	46,92	Mining and quarrying
W.sale mining., construc mach. etc.	31,09	25,82	Wholesale and retail trade; repair of motor vehicles

Table 8: Mining activities in Finnmark

The innovation opportunities are predominantly related to the improvement of energy solutions and monitoring of discharges to the Norwegian fjords (ibid). Analysis also shows appreciable effects to meet environmental requirements within the energy industry, as many companies have engaged in wind power projects and adopted 'smart' thinking by exploring new innovation solutions, such as converting wind power to hydrogen. Fish refineries and fisheries have also remained consistently important to the economy in Finnmark (Teräs et al., 2018), especially considering that many companies have begun venturing into arctic biomarine. While the value creation in this 'new' part of the industry has been considerable, the region still appears to be largely product oriented, and most companies have been looking to research institutions or external competencies located outside Finnmark (Finnmark County Authority, 2019). However, there are no activities in the dataset that match the description provided in the strategy paper possibly because these activities are yet to be realised.

7. Discussion

This chapter provides a comprehensive analysis of the relatedness and complexity framework, drawing upon literature, empirical data, and practical examples to discuss its limitations within the context of the methodology employed for calculation and illustration. The research also proposes potential solutions to address these limitations. Moreover, the chapter extends beyond the suggested applications of the framework found in the literature by introducing additional practical applications and exploring alternative approaches for its current use. Through an objective examination of the framework's limitations and the proposal of novel applications, this chapter contributes to a more nuanced understanding of the relatedness vs complexity framework and its potential for enhancing decision-making processes.

It is important to note that the framework does not prescribe specific actions for policymakers; instead, it positions activities within quadrants based on their relatedness and complexity in relation to other regional activities and was intended to provide a quantitative understanding of the region's strengths and weaknesses. Smart Specialisation dictates that the prioritisation of activities should be rooted in the region's existing capabilities and its capacity to create a

balanced policy mix based on feasibility, risk and potential impact. Therefore, the regions' selection of priorities is not the focus of this paper, but it is important to understand the underlying rationale behind each choice considering it is rooted in the potential found through the entrepreneurial discovery process. Some choices, like tourism and mining, are simple to understand even though they are in the lower left quadrant since the regions possess a comparative advantage because of their geographic location and the activities have high employment opportunities. The discrepancies start appearing when comparing "high-value" activities in industries such as marine and maritime industries, which has developed in the region over a long period of time and is a major contributor to the regional economy.

Regional policymakers may identify these industries as complex overall, but there could be several sources for the inconsistencies. Firstly, it is possible that the activities that make it complex are not present in the data used in the preparation of this paper because it is specific to the region or industry. Secondly, a lot of the "success" in these industries is attributed to tacit knowledge that cannot be captured by conventional methods. Davies and Maré (2021) found that adapting to the local context provided more robust values for relatedness and complexity compared to using RCA co-occurences provided as a default in the Econgeo package. Lastly, the entrepreneurial discovery process considers regional conditions such as the governance, interregional linkages and the impact of clusters but Balland et al. (2019) acknowledges that the framework does not. These factors were also identified as key factors for regional growth in the VRI project and should be accounted for.

All three regions identified broad industries in their strategy paper instead of domains and therefore, did not follow the guidelines for Smart Specialisation. This is understandable because the concept of domain is unclear, especially in EDP conducted in peripheral regions where stakeholders are not informed about the mechanics and benefits of Smart Specialisation. Instead, priorities are sectoral rather than being based on groups of activities or technologies (Mäenpää & Teräs, 2018). However, this resulted in a disconnect between the terminology used in the strategy documentation and the configuration of data collected in Norway. It was quite challenging to map activities in the dataset with priorities set in the strategy documentation during the analysis.

The matrix illustration based on the framework also provided a “gloomy” outlook for the regions as only 30% of the available space was occupied, which contrasts with their “medium” status as innovators. This paper proposes an alternate version using the average absolute deviation (AAD) values for relatedness. Policymakers can learn more about the diversity and dispersion of activities within a region by using AAD. It makes it possible to distinguish clearly between various activities, assisting in the discovery of hidden opportunities in the region. **Figure 3** shows that each region offers alternatives in each of the four quadrants, indicating a wide variety of activities. Stakeholders equipped with this knowledge can evaluate each activity's potential in relation to other ones taking place in the area. This information encourages thoughtful decision-making and aids in the establishment of sensible priorities for Smart Specialisation strategies, resulting in more focused and successful economic development projects.

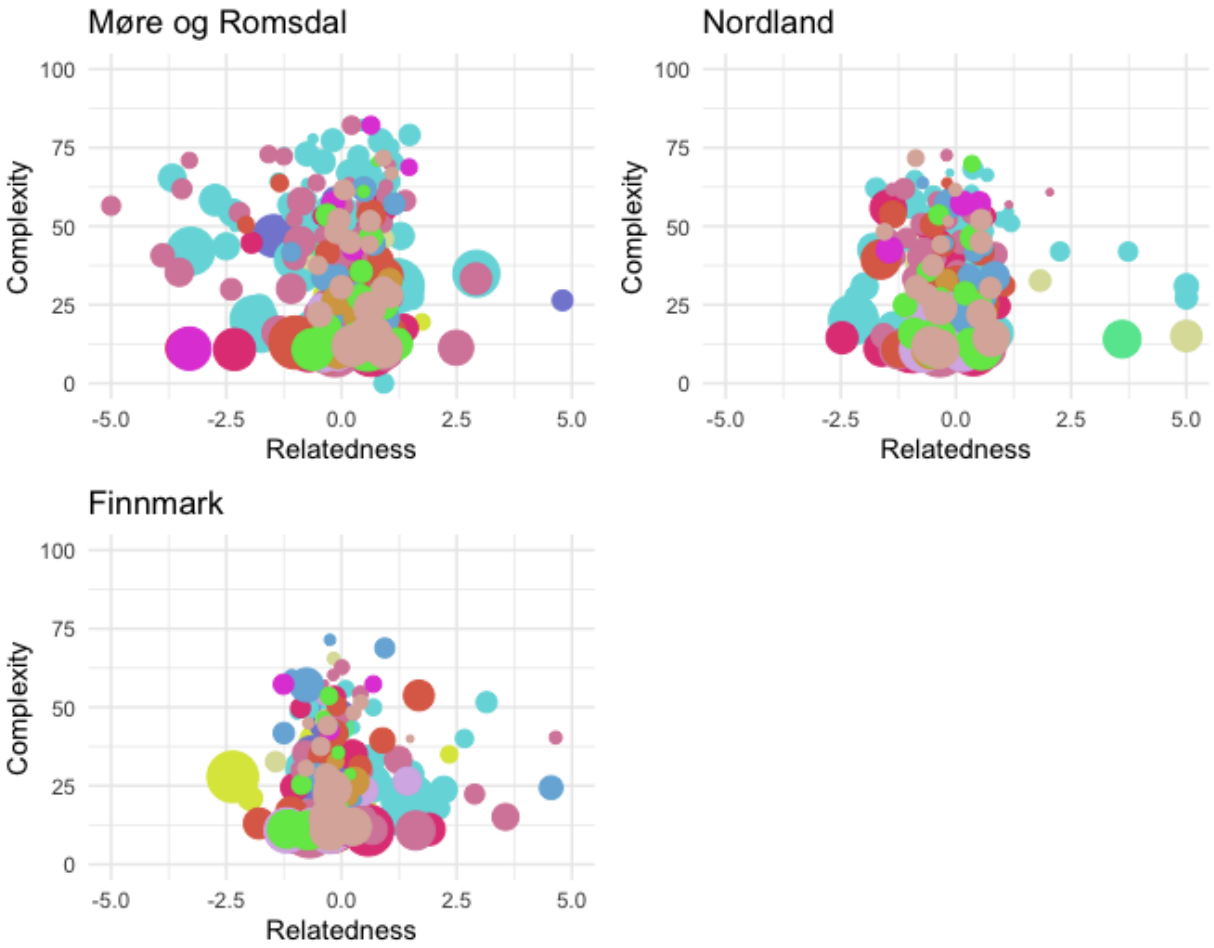

Figure 3: Relatedness vs complexity plots for Møre og Romsdal, Nordland and Finnmark using AAD values for relatedness

In their paper, Balland et al. (2019) suggested two alternative applications of the framework. The first suggestion was to analyse all activities within the region with the framework and select priorities based on the result. However, the inconsistencies in the results for peripheral regions along with the inability to match activities in the data with real-life practices make it impractical to use as a filter before EDP. The second alternative is more plausible for peripheral regions where EDP dictates the selection of activities to be included in the Smart Specialisation strategy using the prescribed bottom-up approach and the results are prioritised based on the scores of the framework, if found in the data. The strategies of three regions in this study also emphasised on the necessity of basic or fundamental research in different areas and the framework could be used to prioritise those efforts based on the potential impact it could have on diversity of the region's activities.

In addition to the discussion about its current applications in literature, it can also fill the void of a monitoring tool pointed out by OECD (2013) and inform decision-makers about the strategy accomplishments and whether implementation is proceeding as planned (Gianelle & Kleibrink, 2015). The information from the framework provides insights into the dynamics of economic development and opens new avenues for evidence-based policymaking and the continuous improvement of Smart Specialisation strategies. It can be used to assess the changes in activities or technologies over a period and to identify which activity has entered or exited the region. Many researchers, including Balland and Rigby (2016), have also used the measures of relatedness and economic and technological complexity as a benchmarking tool for comparing regions and countries in an attempt to understand best practices and to identify trends. Boschma et al. (2013) found from a study of U.S. cities that a new activity or technology is 30% more likely to enter the region if the level of relatedness with existing activity increases by 10%. On the other hand, existing activities are 8% less likely to leave the region for the same increase in relatedness.

Understanding the region's own strengths and weaknesses would be better served by measuring firm innovation capacity and calculate scientific, technological, or industrial indexes (OECD,

2013) since it is more likely that these measures will include regional conditions, at least as a latent variable, and show a more realistic picture of the region's capabilities. It is possible to measure innovation inputs such as employees working on innovation-based projects, training programs, R&D partnerships, and funding from regional and national schemes vs innovation outputs like the launch of new products or services and its revenue and market shares. High-tech companies can also use the number and quality of patents they produce. Bessant (2013) proposed the "innovation fitness test" that uses survey questionnaires and structured interviews to categorise and quantify firm competencies. All relevant stakeholders in the regional innovation system should also be ranked based on their productivity, efficiency and quality of output. Regions that suffer from weak institutional settings are frequently associated with low quality of governance and lack experimentation and collaboration culture (Rodriguez-Pose et al., 2014), and thus, can hamper the economic and social impact of place-based policy (Iammarino et al., 2019). The quantification will provide an objective definition of core and peripheral regions. It can also help regional policymakers in their search for strategies that promote regional growth by identifying gaps in the institutional setup, efficiently allocating resources and measuring the possibility of constructive collaboration.

8. Conclusion

This study sought to understand to which extent the relatedness and complexity framework represent the activities in peripheral regions, and how this can information be utilized to improve Smart Specialisation strategies. Empirical data was used to analyze the economic activities in the aforementioned regions, considering their relatedness and complexity, and compared with observations from their strategy documentation. This allows for a closer examination of the realities of regional economies and their potential for development and aid in the design of Smart Specialisation strategies.

Upon examination, the study reveals discrepancies between the rationale provided by existing Smart Specialisation strategies and the analysis derived from regional data. This shows both the strengths and limitations of the relatedness vs complexity framework and the strategies

currently in place. For instance, the framework did not wholly account for the impact of local factors on industry development. On the other hand, some strategies may have overlooked potentially beneficial activities.

By bringing these issues to light, the study enhances our understanding of the framework and Smart Specialisation strategies and underscores the role of regional stakeholders in economic growth. Furthermore, it proposes potential improvements and alternative uses for the relatedness vs complexity framework. This could lead to more nuanced and effective policymaking, tailoring strategies better suited to unique regional contexts and contributing positively to regional economic development.

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