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How Might The Interconnectedness Of Knowledge Spaces And Technological Relatedness Promote Regional Diversity?

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Abstract: *Knowledge plays a vital role in promoting economic development. Studying the relationship between technology and the knowledge space is extremely important for countries to develop sustainable development strategies. This study comprehensively assesses the link between knowledge spaces and technology, then analyzes its influence on regional economic diversification. In addition, the study also assesses regional resilience and the importance of national innovation systems. The paper also shows that, for sustainable economic development, countries need to focus on building networks and improving the management efficiency of the economy, smart specialization, and promoting creative innovation.*

Keywords - *Knowledge Spaces, Innovation, Regional Diversity, Sustainable Development, Innovation Networks*

I. INTRODUCTION

Improving people's standard of life is often attributed to innovations that boost the economy. This action often occurs in sectors that rely heavily on tacit and ambiguous information. These features highlight the importance of receptive skills for information dissemination, comprehension, acquisition, and application. It can only be achieved by close mental closeness. The emergence of new knowledge spaces is made possible by the constant flow of information.

As it has been shown (Audretsch & Feldman, 1996) that information spills more easily into related domains, the construction of such knowledge spaces is made possible by the relatedness of technology. The region was chosen as the geographical representation of the knowledge space for the purposes of this investigation. After the significance of technology relatedness as a factor driving regional diversification has been established, the study's primary emphasis shifts to encouraging the diversity of regions resulting from technological relatedness. That is the actual formulation of the study's research topic. Studies of variety, specifically those that distinguish between related and unconnected types of diversity, have been investigated to provide an answer to this topic. The first one is better for economic growth, despite the fact that the second one has certain advantages.

In any event, regional diversification remains a path-dependency process, even in the face of significant advances. As a result, it became clear that an area may be robust if it diversifies in ways that emphasize its strengths. This stance is congruent with the European Union's Smart Specialization strategy.

This research is structured as follows. Right after the introduction, the second part emphasizes the reality of knowledge spaces and provides many definitions of technical relatedness, ultimately concluding that they are intertwined. Third, the distinction between related and unrelated diversity at the regional level is highlighted. The following section, the fourth, discusses regional resilience and the function of innovation systems. The fifth section, which comes before the conclusion proper, establishes a connection between the significance of related diversity and policy consequences within a European context.

II. GEOGRAPHICALLY REPRESENTED KNOWLEDGE DOMAINS BASED ON THEIR TECHNICAL RELEVANCE

Understanding provides the foundation for new ideas and fuels economic expansion and social progress. Knowledge has a spatial dimension because of the need for closeness in dealing with complexities, ambiguities, and tacit agreements. That is why it is crucial that tacit knowledge is embodied and context-specific information, which is mainly "sticky" in one place (Morgan, 2002). This feature is vital in explaining the spatial concentration of knowledge-intensive activities.

Knowledge spaces are more likely to form when businesses, academic institutions, and government agencies are geographically concentrated. Their proximity will reveal a network of people who can help each other get through language and cultural barriers. In addition, when two or more bodies of information are complementary, new knowledge is generated, leading to innovation. These knowledge centers may be a cluster or a larger geographical area. Within the scope of this investigation, the latter will be prioritized even if policy implications are involved.

Knowledge spillovers are crucial to the spread of information. Knowledge spillovers are more prevalent in overlapping industries, as observed by Franken. Technological relatedness defines and intertwines knowledge areas. The proximity of external information to a company's knowledge base facilitates the firm's ability to grasp, absorb, and use it (Boschma). So, absorptive abilities, which are more likely to be the case when there is cognitive closeness, are necessary for knowledge spillovers to occur.

The key to fostering economic growth via innovation is communication. The presence of a standard set of skills is crucial to its success. Different sectors' technical interdependencies were considered in the 1980s by using the concept of technological relatedness at a sectoral level. In reality, it was crucial to identify the technologically leading industries, which were marked by a high degree of inter-industry information exchange, to conclude that they are helpful to economic growth.

Since efficient communication is inversely proportional to cognitive distance, we should not anticipate regional knowledge spillovers to occur at random across any sector. So, sectors that share similar technologies may teach one another more. It would be worthwhile to investigate how businesses might be technologically tied before rushing to evaluate this connection. The link between producers and consumers is the initial mechanism that causes technological feedback across industries (Boschma, 2009). Consequently, cutting-edge essential inputs may have a technical impact on end-user sectors. Moreover, new developments may emerge as a result of the interdependence of the industrial system. Without this complementary relationship, technological closeness cannot exist. The final one discusses how inventions based on the same technology tend to be tied together.

Nonetheless, we need a numerical indicator. In this respect, some writers have attempted to evaluate the degree of similarity between various technologies. In Caves (1981), we saw how far wherein companies within distinct sectors might be deemed distinct from one another. He made use of the SIC to make his point, which was that enterprises that are dissimilar by the first four digits of their SIC code but similar by the second three digits are just "units" away from one another. When their membership numbers in the same industry are two digits, they are considered one "unit" apart, and so on. Lemelin's (1982) technology-relatedness metric resulted from an investigation of the connection between input structures. As NUTS3s are linked to the local job market, Frenken et al. (2007) used this technique to examine regional development at that level. Input-output tables revealed the similarities between the input mixes of the two sectors, thereby capturing the technical interconnectedness of industries. It is believed that the manufacturing technologies are reflected in the input mix. Hence, the less the technical gap between the two sectors, the more similar their input mixtures. The resulting ripple effect will be substantial. Knowledge-intensive industries were singled out for this approach because they benefit the most from information spillovers. By applying the survival principle1 to the research on relatedness, Teece et al. (1994) found that closely related operations would be integrated inside the company more often.

Moreover, Teece (1994) emphasized the beneficial connection between technical similarity and prior knowledge. Farjoun (1994) defined technical relatedness in terms of shared patterns in the kinds and levels of human skill needed for their implementation. As an alternative to the SIC-based measures of technological relatedness, Fan and Lang (2000) used the commodity flow data from U.S. input-output tables to develop the concept that relatedness depends on the interchangeability of products and services for their own production. This concept is known as vertical relatedness. In addition, they clarified the concept of complementarity by describing how they share inputs, markets, and distribution. The absence of relatedness type, the lack of the degree of relatedness, and the possibility of classification mistakes meant that the SIC-based measurements were insufficient. Using international export statistics, Hausmann and Klinger (2007) calculated the degree of similarity between pairs of items. As exports signify goods in which a nation has a comparative advantage, the greater the similarity between the goods, the more likely both countries would export them. Although Neffke and Svensson Henning (2008) used a co-occurrence measure to quantify technical relatedness, revealed relatedness was defined by Neffke and Svensson Henning (2008). This approach intends to take advantage of cross-industry economies of scope by spotting the co-occurrence of goods from multiple sectors at the plant level.

Many researchers (Lamoreaux and Sokoloff, 1996; O'Huallachain, 1999; Jaffe, and Trajten- Berg, 2002; O'Huallachain and Lee, 2010) have utilized patent data to analyze innovation. Technical connections allow for the charting of mental terrains. Its widespread use may be attributed to easy access to relevant information. The study of emerging technological fields not yet recognized by industrial categorization systems also benefits from this approach. Not only may new technologies be identified, but the cognitive closeness between old and new ones can also be determined. While it is generally agreed that this method of measuring relatedness is more complex than SIC-based methods, it is not without its limitations. To begin, not all of the newly created information gets patented. Second, it is questionable if patents really capture all knowledge because of the significance of tacit knowledge and the difficulty of codifying it.

The use of technical relatedness, as assessed by patents, to identify knowledge spaces in the US and EU15 is now being considered. The technical distribution of patents within a region reflects the underlying knowledge in that region, as indicated by Kogler et al. (2013). Information about patents issued between 1975 and 2010 was culled from databases maintained by the United States Patent and Trademark Office. Based on the specialized expertise required to use the technology, they are classified into one or more categories. Patents, like technological categories, undergo frequent reclassification. In this instance, we evaluate connections across patent families over a single calendar year. Create a co-occurrence matrix where each cell represents a patent class and its technical relationship to another. Interestingly, it was observed that specific patent categories tend to cluster together, as seen by the increasing technical closeness between patents. Moreover, regional average relatedness was determined, showing that the degree of similarity between patents in the United States' knowledge network is rising. The development of technical specialization is consistent with this beginning. Each area has its own distinct culture because of the unique combination of history, geography, technology, and organizational prowess that defines it.

A similar approach was used by Kogler et al. (2016) to create a map of the knowledge space in the EU15. In discussing the dynamics of knowledge growth within and across areas, he emphasized the role of technological closeness in defining knowledge spaces. According to the data, technical specialization has been on the rise. The processes of technological diversification and technological abandonment also play a significant influence in certain domains. These procedures are founded on the local body of knowledge. From this, we learn that the technical closeness of the technology classes in which a NUTS2 area is already diversified is positively related to the chance that the region would diversify into another technology class.

III. DIVERSIFICATION, RELATED AND UNRELATED VARIETY

It would be fascinating to look into the impact of technical similarity on the degree to which information spills over from one area to another. Concentration will be seen in sectors where spillovers play a significant role, such as those in which R&D spending benefits third parties, if distance counts. Nevertheless, Marshall (1920) emphasized that this process has spatial bounds, which might lead to the emergence of agglomeration externalities. Instead, Jacobs (1969) emphasized the value of diversity, which he found to improve the likelihood of creativity. To determine whether knowledge spillovers are more common within or within sectors, Glaeser et al. (1992) conducted an analysis. To do this, we analyzed industry concentration and competitiveness data from 170 major U.S. cities. Large urban centers were selected because the greater density of communication pathways facilitates information dissemination. Nonetheless, data indicated that a city's variety boosted development since information spreads across sectors. The transfer of knowledge across fields spurs development (Glaeser 1992).

However, it has not been determined what form of diversity best promotes creativity and, by extension, economic growth. Frenken et al. (2007) highlight three ways economic growth and diversity are connected. The New Growth Theory, to be more specific, investigates the correlation between diversity, spillovers, and economic development. Jacobs (1992) and Glaeser et al. provide us with this strategy (1992). According to this hypothesis, instead of focusing on industries that do not have this quality, a region would focus on industries with a certain composition of complementary sectors. There is also a relationship to joblessness if you think of diversity as a method for protecting against downward demand shocks from the outside world. This tactic is similar to the corporate practice of diversification. Highly specialized areas will feel the consequences of a demand shock more strongly regarding unemployment and, by extension, economic growth than highly diverse regions. Lastly, geographical concentration may lead to unemployment and stagnation (Pasinetti 1993). As the product lifecycle dynamics may argue, the main point is that diversification is necessary to absorb the superfluous labor in the current industries created by a jump in productivity or some form of demand saturation. After the positive effects of diversity on creativity and, by extension, economic growth, researchers may focus on a specific kind of diversity: related diversity. So far, it seems that knowledge spillovers are most responsible for animating knowledge spaces and that the latter do so primarily among areas that are "cognitively close".

Additionally, areas gain when more diverse sectors are developed. Since greater variety indicates more possibility for inter-industry knowledge spillovers, the so-called related variety notion suggests that areas may gain by manufacturing a wide range of goods and services. It suggests that an area is a home to a broad variety of interconnected industries that may teach one another and inspire novel combinations of products and processes (Frenken et al, 2007). To settle the MAR vs. Jacobs debate, this concept was born. The first group believed that specialization promotes economic growth since knowledge spillovers are primarily an issue between industries. In this view, innovation is a gradual process, and localization economies do hold. All companies operating in the same industry have access to the same external economies. By sharing information within industries, businesses may save money on transporting inputs and outputs and create a more competitive labor market for themselves (Beaudry et al. 2008). Constant and growing innovation is a fact of life. These often occur amongst groups of affiliated businesses. These kinds of breakthroughs thrive in environments where people learn by doing and learn via the application. They ultimately result in higher production, but it doesn't mean more employment will be created.

On the other hand, those who subscribe to Jacobs's externalities see the increased divisions of labor as a means to promote groundbreaking creativity. This idea uses the Shumpeterian notion of innovation as "Neue Kombinationen." They birth whole novel goods or processes that are discontinuous by definition, paving the way for new industries or enterprises with the potential to displace established ones. When established industries or resources are depleted, radical innovations are required to replenish them. They are characterized by a significant degree of ambiguity due to their ability for reshaping. New markets and job opportunities are two byproducts of radical innovation. Although both Jacob and MAR externalities benefit regional growth, this study focuses on the former.

It's important to remember that it's far simpler to recombine bits of information already tied to one another. Hence, diversity aids in regional economic growth when it is connected. This connection may be thought of in commercial and technical terms. The former kind of connection facilitates the merging of supply and demand markets, which in turn generates economies of scale. It makes it easier for startups to get the capital they need to build a client and supplier base. Regarding the second kind of relatedness, the same economies of scope apply.

When it comes to really revolutionary ideas, the connectedness and diversity of relevant technologies are equally important. Although diversification is a path-dependent process, Tanner (2015) confirmed fuel cells in the context of revolutionary development. Using a case study of Denmark's food processing sector, Essletzbichler (1999) has established how areas progress along clearly defined technological trajectories. If successful in reaching markets, fuel cell technology can be disruptive since it is based on a new, complicated body of knowledge that may leave the current technology obsolete.

According to the Windows of Locational Opportunities (WLO) theory, emerging sectors have considerable leeway in deciding where to shop since they are not dependent on established ones. However, Storper and Walker (1989) knew that localization boundaries existed because of the region's high degree of industry. Nevertheless, WTO theory has neglected the significance of links between regional expertise and disruptive technology development. These connections are essential to the fuel cell technology argument. First, regional data on fuel cell knowledge production needed to be collected, then the set of knowledge fields linked to fuel cells could be investigated, along with the frequency of each fuel cell-related knowledge field compared to total non-fuel cell knowledge production. Applications for patents have been utilized because they represent all areas of knowledge. Hence, fuel cell patent applications are considered to include IPC codes representing the knowledge categories that are co-classified with fuel cells. The findings indicated a positive, statistically significant correlation between fuel cell patenting in a given location and progress in five foundational technologies. Moreover, data show that fuel cell patenting is inversely proportional to the quantity of information that is unrelated to fuel cells. Despite being a groundbreaking idea, fuel cells flourish in areas with complementary technical expertise. According to related-variety theory, the possibility of an area branching into fuel-cell increases with the quantity of fuel-cell-related information in that region.

This research is reminiscent of others who looked at regional branching. Consistent with the regional branching hypothesis is the observation that recombining knowledge areas within a region may give rise to an entirely new sector (Frenken and Boschma, 2007). Knowledge spillovers make this feasible, and they may occur due to many different factors, including but not limited to company diversification, entrepreneurial spin-offs, labor mobility, and social networking. Space is crucial because it explains why so many spin-offs are set up in close proximity to their parent company, why new divisions are often housed inside existing operations, and why so many people choose to move between jobs within the same geographic labor market. In addition, the knowledge networks via which ideas spread are often regional. Branch theory is used to determine the scope according to which new routines are more probable to emerge within linked sectors in the same location where similar routines or industries previously predominated. After the value of related diversity has been determined, the relevance of unrelated diversity must be illuminated.

As the returns on different assets are uncorrelated, a portfolio with a lot of diversity like this could lower risk. It's one technique to protect a region's economy from the domino effect that rapid asymmetric shocks may have. It has been stated that specialization would raise the danger of unemployment and halt growth, while unrelated diversity is positively associated with unemployment growth. Whatever the case, unconnected variation does not promote the growth of the externalities that boost employment and GDP.

The impact of unrelated and related diversity on regional economic growth has been the subject of several empirical studies. Frenken et al. (2007) investigated whether the unemployment increase in the NUTS3 regions of the Netherlands is adversely connected with the presence of unrelated diversity. There was a negative correlation between unemployment and inactivity rate increases when both related and unrelated diversity was held constant as independent factors. So, it is hypothesized that areas with more different features would have slower rates of joblessness expansion. The negative correlation between urbanized economies and joblessness is particularly noteworthy. These results support the case for shock resistance caused by genetic diversity.

To investigate the influences on German economic growth from 2003 to 2008, Brachert et al. (2011) created a related and unrelated occupational-functional method. This framework differentiates between three functional occupational categories to reflect the cognitive and functional aspects of a region's economic sectoral composition: "White Collar" workers who perform mostly executive functions; "Blue Collar" workers who perform predominantly manufacturing tasks; and "R&D Occupations." As Franken et al. (2007) proposed, they then determined independent and correlated diversity. Notably, coefficients for related and unrelated diversity were insignificant, suggesting neither kind of diversity significantly influences job growth across German labor market areas. However, when coupled with a high degree of functional specialization in the areas, related diversity positively affects regional growth. Moreover, a high degree of functional closeness is required to produce pleasurable feelings from unrelated diversity. Connected sectors are more likely to stay in the area, as Neffke et al. (2011) documented.

IV. REGIONAL RESILIENCE

The challenge now is how to best set up these knowledge spaces in a way that promotes regional resilience. To rephrase, how can communities and regions weather temporary and permanent economic storms while still providing citizens with enough opportunity and comfort? The recent situation has shown the significance of responding.

First of all, it is necessary to establish precisely what " resilience " means in the context of a geographical area. To begin with, it has nothing in common with the equilibrium notion of resilience, whereby strength is defined as the ability to recover to pre-shock levels after a disturbance. Instead, regions' long-term potential to reorganize their socio-economic structure is prioritized in an evolutionary approach to resilience (Boschma, 2013). The ability to reorganize their socio-economic and institutional systems to establish new development routes is more important than the ability to react to shocks (Boschma, 2013). In any case, it is obvious that regions are marked by path dependence, and therefore the essence of resilience is in knowing how many fresh development routes be born from the current institutional and industrial frameworks.

Adaptation and adaptability are two distinct concepts, as introduced by Grabher (1993). The former, he said, is what allows people to specialize their resources in accordance with established plans. The latter represents the potential to create novel routes, and it is positively correlated with the presence of generalizable, uncommitted resources that may be put to any number of unexpected applications.

However, there is still room for improvement in the evolutionary approach to regional resilience due to the need to integrate both the long and short term. In addition, you'll need the knowledge of how regions create new development routes that don't have to be completely independent of the old ones. Adaptation should be achieved without compromising adapting capacity, and regions should master this skill. The last step is to design the industrial and institutional aspects to promote regional resilience.

It has been stated that related diversity is crucial to a region's economic growth. It aids in matching regional labor, which speeds up the recuperation process. It also makes it difficult for talented locals to leave the area. Moreover, remembering the branching theory highlights the continued significance of regional heritage in recombining knowledge that ultimately leads to new development pathways. The "Trap of specialization" might affect a place due to its extreme specialization (Grabher, 1993). So, it would be advantageous if they used their specialized expertise to branch out into other related activities or link with other sectors in other locations from which they might gain knowledge via spillovers. Several empirical investigations have shown that a lack of economic concentration in a location with too much diversity may be disastrous. Hence, linked diversity is the intersection of adaptation and malleability. These features define a resilient area where businesses thrive despite or because of the existence of other businesses.

Openness and efficient management in regional networks are required to meet the requirements of adaptation and adaptability. In addition, local clustering and linkages to external information are both enhanced by the optimum amount of knowledge closeness, which is neither too near nor too remote.

Institutions cannot be ignored because of their vital role in keeping the region's industry competitive. They will have to make subtle modifications throughout time to adapt to the shifting demands of their environment. When a country's institutions are tailored only to the requirements of its dominant sector, a situation known as "institutional lock-in" might develop (Boschma, 2009). How can different areas become resilient?

First of all, a robust innovation system is urgently required. It facilitates the development of both regional interest and international channels. Within a geographically specified cluster, they provide the opportunity for collaborative learning and the generation of new knowledge among businesses and other groups (Bethelt, 2010). If local excitement results from just being there, global pipelines need the backing of established institutions and physical structures.

It would also be welcomed if the 'learning region' existed. The existing economic qualities combine the potential and the possibility to learn to improve economic performance. Its foundation is the integration of many knowledge systems and instructional approaches. Ultimately, it is predicated on the idea that education improves lives and frees people (Lundvall, 2016).

The establishment of a system of innovation that strengthens a region's resilience requires a contemporary infrastructure that promotes output, a supportive financial system that offers patient capital since the effects will be evident in the long term, and a relatedly-diversified economic base. In the end, it will produce a workforce that is both creative and capable of striking off on its own.

V. POLICY IMPLICATIONS

To develop new avenues for expansion, strategies that are only focused on bolstering clusters via new networks and establishing cluster management organizations seldom prove effective (Tanner, 2015). The issue is that these plans fail to capitalize on the region's actual advantages.

Instead, the idea of Smart Specialization was implemented inside European frameworks to determine what each area excels at. When all the pieces were in place, the focus was placed on R&D in the selected competitive sectors, with the end goal being the development of a regional innovation vision. The intelligent specialization methodology is distinguished first by its relation to the underlying logic of the innovation system (McCann et al., 2014). Until now, it has been addressed how even when introducing radical innovation, it is essential to consider the current development trajectories. The reality is that preexisting dynamics and established frameworks are crucial to an intelligent specialization strategy. In addition, it highlights the recognition of the knowledge-intensive sectors. Initially designed for a specific industry, this initiative is currently being implemented on a regional scale, which means making adaptations and considering local institutions and governance that may slow the spread of innovations. The nature of these connections might shift depending on where you live. So, it is not a "one size fits all" strategy but one tailored to certain locations. Certain areas may be very forward-thinking, while others are falling behind and must hone in on what they do well. For example, the intelligent specialization initiative in Spain's Extremadura area emphasizes agriculture and cattle.

By emphasizing technical diversity within a field in which the area may have a competitive advantage, "smart specialization" encourages regional economic growth. This concept is consistent with efforts to expand the technical capabilities of the most significant domestically based economic sectors. As a result, this is consistent with Frenken and colleagues' (2001) technical relatedness thesis (2007). The explanation is that most business exits from an area occur in industries that have nothing to do with the regional profile (Neffke et al. 2011).

However, complications have emerged due to the challenge of adapting a sectoral strategy to a regional context. It is not easy to deal with, and it attempts to encourage innovation not just inside one area but across regions.

VI. CONCLUSION

Increasing one's level of education often results in a more prosperous economy. Knowledge spaces emerge due to the channels via which information travels, the reality of information spillovers, and the need for absorptive skills. A connection between knowledge spaces and technical relatedness was formed after many definitions of technological relatedness were considered, with the patent-based definition emerging as the most popular. So, the first inference is that the second aids in developing the first. This research has limited its geographic scope to the region's definition of these areas.

To address the study issue of how to encourage regional diversity for regional growth, the connection between technological relatedness and knowledge spaces has been a crucial economy. Furthermore, it has been discovered that a region's potential for diversification is best captured by the degree to which its technologies are intertwined. Even in the case of a radical breakthrough like the fuel cell, the development process is seldom independent of prior knowledge. Hence, regional growth may be encouraged by a combination of variety and conformity with the existing body of knowledge in the area. This study agrees with the related variety principle, which states that an area should diversity in knowledge-related sectors to capitalize on the benefits stemming from its unique character and push forward with innovative new ideas. It has been shown that innovation drives economic growth. Unrelated variety, on the other hand, is inversely related to rising unemployment. Nonetheless, linked diversity is believed to be better for regional economic growth.

The research then zeroed in on the idea of regional resilience after having evaluated the significance of technological relatedness in the development of a region's knowledge and the planning of its subsequent steps. The current crisis and the considerable uncertainty surrounding innovation highlight a region's need for resilience. It is not about getting back to normal after being shaken up. In reality, the success of this idea depends on a synergy between adaptation and adaptability (Grabher, 1993). The ability to take advantage of and shift course away from established norms is one, while the availability of adaptable regional sources in the face of shocks is another. As regional resilience bridges the gap between the two tiers of resilience described by Grabher, it is consistent with the idea of related diversity. Nonetheless, much work is required to achieve a resilient area. In order to boost regional development, institutions and businesses need to work together.

The findings to date have significant consequences for public policy. Particular emphasis should be placed on the current knowledge base in order to encourage innovation within predetermined knowledge spaces, in this instance, regions. If an area wants to diversify in a way that promotes economic growth, it should look to its core skills as a place to begin. The EU's Smart Specialization initiative emphasizes regional growth that follows established technology pathways. This strategy was developed to realize the benefits associated with the idea of the linked variety.

Finally, the interconnectedness of technology-enabled information spaces makes them more vibrant and valuable. It specifies robust routes and makes a possible contextual variation. Policies attempt to understand this interdependence.

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