3 Innovation measurement through a rural lens

How we define innovation in rural regions has an impact on how policies are designed. This chapter examines indicators that are relevant for unlocking innovation in rural regions. It first describes definitions on rural regions that are internationally comparable. Then is summarises measures of innovation most relevant for rural regions.

Understanding innovation in rural regions starts with first defining what is considered rural and what is meant by innovation. Building on the Rural Well-being framework (OECD, 2020[1]), the underlying premise of this work is that, on average, innovation occurs and affects societies differently in rural regions than in urban regions. This may be due to the underlying sectoral, occupational and territorial attributes that characterise low-density areas with longer distances from metropolitan functional urban areas (FUAs). Critically, to the furthest extent possible, the OECD considers a continuum of territories rather than the traditional dichotomy of urban and rural.

Defining rural using physical and driving distances within administrative boundaries

Rural is everywhere and exists as a continuum. What we commonly understand as rural is implicitly spatial and relative. In practice, governments delineate typologies of territories but there is no clear cut-off between regions or areas. Rural characteristics can exist within more urbanised regions and rural attributes are apparent across the spectrum of territorial characteristics. This continuum of rurality is delineated in the recent OECD publication on rural well-being (OECD, 2020[1]).

The term rural is often used to describe territories that have relatively low-density human settlement patterns, with relatively large distances to more densely populated areas. Often, rural regions are characterised as regions with activities closely related to natural resource industries such as mining and agriculture. However, this sectoral definition overlooks many of the different varieties of rural territories and what this means for political agenda-setting in rural regions. Indeed, a region that is identified as “rural” has implications on government finance and wider regional policy making.

In consultation with OECD national governments, the OECD harmonised a set of guidelines for classifying territorial characteristics across countries that avoid the traditional, and sometimes harmful, rural-urban dichotomy. This unified definition of rural[1] provides the basis for analysis across countries within rural economies (OECD, 2020[1]). The most recent definitions of rural regions have benefitted from a reflection on the combination of physical (“first-nature”) and human (“second-nature”) geographies. Rural regions are defined by economic remoteness, with three distinct features related to the *physical distance to major markets*, *economic connectedness* and *sector specialisation.* Considering these features, rural regions are physically distant from major markets, with specialisation in niche markets and those linked with natural resources such as agriculture and tourism. The degree of economic connectedness with surrounding areas may vary by relative density, infrastructure availability and complementarities between and within rural or urban regions.

The degree of economic and physical connectedness and access to natural resources has an impact on how and what firms and individuals innovate. As such, in accessible rural regions, firms and individuals are more likely to innovate to meet the needs of local and accessible markets, with easier access to both supply chains, regional commercial markets and relative advantages sometimes related to the costs of living and relatively easier access to basic services. This includes, for example, firms in the manufacturing or services sector. In more remote regions, firms and individuals may have a relative comparative advantage in innovating in the agricultural or services sectors. However, because these are areas that often suffer from more limited access to markets and basic government services, innovation and productivity activities take place to first overcome these barriers and then bring new products and processes to the market or firm.

At a geographical scale, we use a variety of definitions to discuss innovation as it concerns rural areas: Territorial Level 2 (TL2)[2] and the share of non-metropolitan populations within each TL2 region at the largest scale; the degree of urbanisation, which is based on grid-level classification at lower scales; and Territorial Level 3 (TL3) at an intermediate level (for further description, please see Box 3.1). The preferred level of territorial analysis in this report will be the most recent adopted definitions of territorial disaggregation elaborated recently by Fadic et al. (2019[2]) in Box 3.1, based on TL3. When there are limitations in the availability of analytical tools, alternative measures are also used. The order of priority for rural definitions in this report is the following:

- **Territorial typology based on access to cities** by Fadic et al. (2019[2]). This is feasible if the analysis is available at least at TL3 or lower, which roughly corresponds to the third highest level of territorial classifications in most OECD countries. In previous years, some of the analysis is only available in older classification systems that identify TL3 regions as predominantly urban, intermediate and predominantly rural regions.
- **The degree of urbanisation** identifies rural areas, towns and suburbs, and cities separately. Data are assessed at the grid level.
- **The degree of rurality** based on the share of populations within TL2 that are living outside FUA (non-metro) regions. This allows for data to be analysed on the TL2 regions with an indicator of relative shares of rural populations based on OECD internal estimates of TL3 regions.

To the furthest extent possible, national rural comparisons will not be used for rural analysis.

Box 3.1. Classifications of rural regions

In 2019, the OECD published a new classification that is based on functional urban areas (FUAs) that incorporates density and the driving estimations for the time it takes to access dense metropolitan areas. To the furthest extent possible, rural will be defined as one of three types of small regions (TL3) with less than 50% of the regional population living in metropolitan areas. This includes rural regions inside FUAs (where at least 50% of the population lives within a 1-hour driving distance away from a dense urban area with a population larger than 250 000 inhabitants), rural regions close to small or medium cities of populations smaller or equivalent to 250 000 inhabitants, and rural remote areas. When this is not possible, the second-best definition will include the degree of urbanisation classification that consists of cities, towns and suburbs, and rural areas. The degree of urbanisation is applied to a global estimated population grid for the years 1975, 1990, 2000 and 2015 and projections up to 2050 (see Annex 1.D). This allows the report to show the trends in urbanisation over 75 years with unprecedented international comparability. The degree of urbanisation was designed to create a simple and neutral method that could be applied in every country in the world. It relies primarily on population size and density thresholds applied to a population grid with cells of 1 by 1 km. Roughly speaking:

1. Cities consist of contiguous grid cells that have a density of at least 1 500 inhabitants per km^2 or are at least 50% built up. They must have a population of at least 50 000 inhabitants.
2. Towns and semi-dense areas consist of contiguous grid cells with a density of at least 300 inhabitants per km^2 and are at least 3% built up. They must have a total population of at least 5 000 inhabitants.
3. Rural areas are cells that do not belong to a city or a town and are semi-dense areas. Most of these have a density below 300 inhabitants per km^2.

Finally, when no other method of measurement is available, we will use the degree of rurality within large regions (TL2) or the country. This is based on a simple calculation of the population total within each of the five access to city typologies over the total TL2 or country population. We then take the three non-metropolitan categories within the Access to City typology in the entire population as a proxy for the degree of rurality of the TL2 region or country.

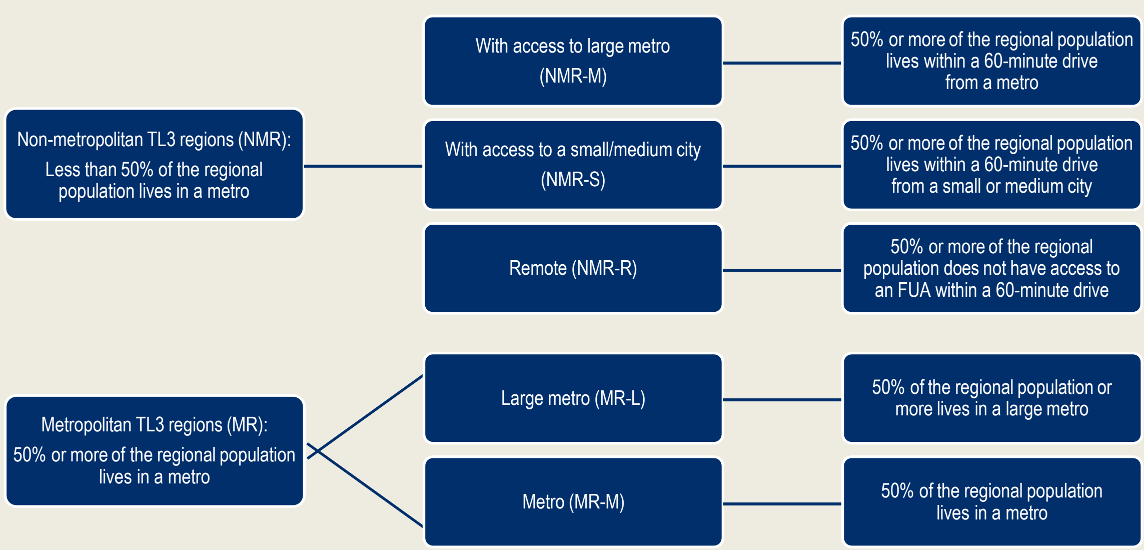
The diverse types of rural regions all have different characteristics and policy needs. There are three types of non-metropolitan regions that are considered, to various degrees, to share rural more rural characteristics than urban ones. Non-metropolitan regions (NMRs) are defined as having less than

50% of the population living in an FUA with a population larger than 250 000 inhabitants. The three types of NMRs include regions with access to a metropolitan region, non-metropolitan areas with access to a small- or medium-sized city, and non-metropolitan regions in remote areas.

- **Non-metropolitan regions with access to a metropolitan region:** These regions have 50% or more of the regional population that lives within a 60-minute drive to a metropolitan area. This is similar in part to towns and suburbs surrounding the distant periphery of major metropolitan centres. An example of such regions includes Tyrolean Oberland in Austria (AT334), Montmagny in Quebec, Canada (CA2418), Jura in France (FRC22) and Nagasaki in Japan (JPJ42). The challenges of such regions are often tied to economies of metropolitan areas, while focusing on industries such as tourism, without some of the infrastructure barriers of less densely populated areas.
- **Non-metropolitan regions with access to small- or medium-sized cities:** These are regions with 50% or more of the regional population living within a 60-minute drive from a small- or medium-sized city. Examples of these types of regions include the administrative district of Neufchâteau in Belgium (BE344), San Antonio in Chile (CL056), South Bohemia in the Czech Republic (CZ031), East Lancashire in the United Kingdom (UKD46) and Springfield in Illinois, United States (US158). These regions have a strong manufacturing base and linkages to neighbouring economies.
- **Non-metropolitan regions without access to cities (remote):** These are regions with 50% or more of the regional population without access to an FUA (metropolitan) within a 60-minute drive. Examples of such areas include West Estonia in Estonia (EE004), Lapland in Finland (FI1D7), Sonneberg in Germany (DEG0H) and Lesbos in Greece (EL411). Rural remote areas have economies with fewer interlinkages with major cities and often focus on tourism, while rural remote regions, such as those in Canada, Chile, Colombia, Finland, Mexico and the United States (US) often also have an important share of the population with an Indigenous heritage that face distinct challenges.

The schematic breakdown is available in the figure below.

Figure 3.1. OECD typology for access to cities



Note: Large metro: an FUA with a population larger than 1.5 million inhabitants; Metro: an FUA with a population larger than 250 000 inhabitants; Small or medium city: an FUA with a population smaller or equal to 250 000 inhabitants.
Source: Fadic, M. et al. (2019[2]) (2019), "Classifying small (TL3) regions based on metropolitan population, low density and remoteness", https://dx.doi.org/10.1787/b902cc00-en.

A fresh look at measuring innovation in rural regions

Innovation, according to the 4th revision of the Oslo Manual, is defined as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD/Eurostat, 2018[3]). The recent revision of the manual now includes definitions specifically for the business sector that targets product and process innovations, including management practices, that have previously not been introduced to the market or brought to use by the firm as well as innovation-related activities that include developmental, financial and commercial activities intending to result in an innovation.

Box 3.2. Defining Innovation from the 4th revision of the Oslo Manual, 2018

What is the Oslo Manual?

The Oslo Manual is a publication that outlines a commonly agreed upon approach to measure and report statistics on innovations. Starting in the early 1990s, the Oslo Manual was elaborated through the consensus of the OECD Working Party of National Experts on Science and Technology Indicators (NESTI) and has been adopted by over 80 countries. The guidance outlined in the manual is used by major international organisations and researchers worldwide. Its revision was conducted through consultation with both the NESTI and Eurostat's Community Innovation Survey (CIS) Taskforce.

Defining innovation

The 4th edition of the Oslo Manual distinguishes between innovation as an outcome (an innovation) and the activities by which innovations come about (innovation activities). It defines an innovation as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD/Eurostat, 2018[3]).

The major additions to the previous versions include: measuring innovation not only from businesses but also from other organisations and individuals; updates to improve harmonisation between core definitions and taxation; better accounting of globalisation, digitalisation and trends in investment in intangible assets; guidance on measuring internal and external factors influencing business innovation; prioritisation of the measurements of government policies on innovation; expansion on methodological guidelines; guidance on the use of innovation data and a new glossary.

Source: OECD (n.d.[4]), Oslo Manual 2018, https://www.oecd.org/sti/inno/oslo-manual-2018-info.pdf; OECD/Eurostat (2018[3]), *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, https://dx.doi.org/10.1787/9789264304604-en.

The original definition is broad and encompasses, without particular prejudice, all product and process innovation, which includes difficult-to-categorise innovations such as innovation in business models and social innovation. However, most indicators that are not based on surveys focus on measurable outcomes of activities regularly associated with innovation in high-technology (high-tech) and high-value industries. Unfortunately, many governments also specifically focus innovation strategies on high-tech industries, leaving innovation in all other industries and activities without the same level of support. Indicators based on surveys have the capacity to track incremental innovations and innovations that may be more standard in non-technical industries. Yet, for rural innovation, the challenge is often that surveys rarely have a large enough sample size to truly measure trends in rural areas.

The analysis in this report departs from traditional science and technology innovation measurement tools to prioritise measurement methods best suited to understanding innovation regions with rural characteristics. While encouraging innovation is a priority for many governments, gathering and analysing data on innovation specifically in rural regions is a challenge due to measurement, representativeness (survey sample size) and confidentiality concerns.

Innovation can be measured using a variety of tools, each with advantages and disadvantages for rural areas. The following types of measures are elaborated below and summarised in Table 3.1.

- **Self-reported measures of innovation** are often a useful method for understanding firm processes and outputs. While innovation surveys often directly ask for output related to innovations in the production of new goods and services, in practice, it is often easier for governments and researchers to capture *product* rather than *process* innovation and often difficult to agree on what is "new" about innovation using innovation surveys (Hall, 2011[5]). In addition to this bias, innovation surveys often suffer from limited coverage and lack of territorial representativeness in rural areas.
- **Product-level data** (for example, production or export statistics) has the potential to capture new-to-market and new-to-firm innovation in products, through innovation surveys, or through balance sheets or export product-level data. This type of data can still capture "new to firm" product innovations (vertical differentiation) and "new to market products" or diversification (horizontal differentiation) (Braguinsky et al., 2020[6]). However, accessing these sources of data is notoriously difficult on a territorially disaggregate level that allows analysis more accurately identify areas with rural attributes and are often more relevant for the manufacturing sector.
- Another popular innovation measure is **research and development (R&D) investment or jobs**. This type of measure has its advantages as it measures innovation in comparative units (currency or number of workers) but it cannot measure success or quality of input (investments and workers). In the case of start-ups receiving venture capital, R&D investment can also be considered an indicator of a low innovative capacity per input (OECD, 2020[7]). There is also apparent randomness to the outputs associated with R&D investments and jobs, as the payoffs of some types of human and capital investment take a longer time to come to fruition. Furthermore, due to headquarters bias, in most cases, R&D investment and jobs are often reported at the level of the headquarter of the firm, rather than the plant location, which leads to a systematic and territorial underestimation in rural regions. Between the two forms of indicators, R&D jobs, and in particular the share of R&D jobs within firms, is the preferred measure of the relative importance of innovation within firms.
- In the 1980s, researchers began exploring the use of **patents** as a measure of innovation success (Pakes and Griliches, 1980[8]).[3] Half a century later, patents remain one of the most commonly used measures of innovation, but are heavily critiqued for sectoral, size and territorial biases and can also be associated with anticompetitive behaviour.[4] For rural areas, patents are valuable measures if they are adjusted for relevant occupations, even if they only capture a segment of local economies.
- One of the oldest proxies for innovation is looking at firm-level outcomes such as **high growth** or **productivity** and its residual value. The measure is capable of measuring outcomes in a comparable manner but it is not clear whether growth and productivity are specifically the outcome of innovation, or changes in markets outside of the decision-making process of the firm. This measure also often suffers from headquarter bias.[5]
- **Start-up entrepreneurship** can be used as a proxy for firms that are likely to adopt new ways of producing goods and services. While no direct measure is taken of whether or not new methods and practices are adopted, new entrants have more incentives to use updated methods and tools with leaner business models and less institutional clutter. However, without production data or business surveys, it is also difficult to directly understand whether start-ups are productive and scalable, or if they are rather placeholders, fiscal havens, "zombie firms" or simply self-employed

persons on precarious contracts. In rural areas, however, focusing on start-up activities avoids at least some of the sectoral and compositional issues with other measures of innovation.

Table 3.1. Common innovation measures and relevance to rural regions

Measurement method	Advantages	Disadvantages	Suitable for rural regions	Examples
Innovation surveys	Direct measurement of activities within firms	• Subjectivity bias Headquarter bias	• Yes, if can avoid small sample bias in subnational levels	• European Union (EU) Community Innovation Survey
Production-level firm data	Measures new firm and market innovations	• Difficult access • More easily available for exporters • Bias in service innovation • Headquarter bias	• Limited suitability better for the manufacturing sector • Limited availability of territorial indicators • Data is often clustered by port of export	• United Nations Conference on Trade and Development-World Bank World Integrated Trade Solution (WITS) • *Centre d'études prospectives et d'informations internationales (CEPII)* • Atlas of Economic Complexity
R&D jobs or investment	Comparability of measures	• Expected payoffs vary • More relevant for technology and science sectors • More relevant for large firms • Headquarter bias	• Limited suitability • Rural firms are often not as large as firms in more dense areas	• OECD Regional R&D Statistics
Patents	A measure of successful innovations	• Biased towards firms that work in technology and science sectors • May also measure anticompetitive behaviour • Headquarter bias	• Yes, if able to adjust to account for the composition of firms that are likely to patent and territorial endowments	• OECD Regional Patent Indicators
Productivity or high-growth firms	Measures expected outcomes	• Cannot disentangle whether productivity or growth occurred to changes within a firm or further advantages market behaviour • Headquarter bias	• Yes, but may measure innovation absorption capacity better than innovation, and suffers from headquarter bias	• OECD Regional Productivity Indicators
Start-up activities	New entry is more likely to adopt more innovative and new approaches	• Unless you know about production and scale-up, it is difficult to disentangle innovative from non-innovative entrepreneurship	• Yes, but needs to be nuanced	• OECD Regional Database • National resources

Note: Measurement methods reported are the most commonly used measures. There may be others available that have not been discussed.

There are biases in all forms of measurement tools: innovation is not precluded from this bias. All forms of innovation measurements have positive and negative attributes. For clarity and evidence-based policy making, it is important to present the reasoning behind why some measurements of innovation are relatively less suitable for rural areas. The caveats in the suitability of each of the proposed measurement methods for use in the rural context as compared to more urbanised regions can be summarised as biases due to the following:

- **Composition bias**: Bias due to the structure or composition of the economy, including the size and sector of rural firms and the occupational structure of rural labour supply. For example, patents and R&D credits are more often filed in larger firms and those in the manufacturing sector than in smaller firms and most firms in the services and agricultural sectors. Small- and medium-sized enterprises (SMEs) are more likely to participate in incremental innovation.
- **Territorial endowment**: Bias due to pre-existing conditions and opportunities in rural regions that are different from those in denser regions.
- **Headquarter bias**: Bias due to the statistical method of gathering information that often centralises responses from multiple branches to firm headquarters. In most business statistics, data are collected on the enterprise level, associated with the location where business activities are officially declared (headquarters). Often this results in a downward bias for reported activities that is in fact occurring more frequently in less dense areas. Likewise, this includes the location of patents that are often filed at headquarters.

Because of these challenges, several of the regular science- and technology-based indicators are not well-equipped to adequately understand innovation in rural regions.

The composition bias refers to the structure of local economies based on the different characteristics of firms present in rural regions as compared to denser areas. For example, these are related to firm size, sectors and occupation characteristics within territories. Rural regions tend to have smaller firms in less diversified sectors than denser regions. On the contrary, denser areas tend to have larger firms. These larger firms in dense areas are more likely to have easier access to R&D investment, financial and human capital, including legal services, to uphold intellectual property rights. Because the economy of rural regions is composed of smaller firms, they are often less capital-intensive and have more limited access to legal resources, and by default do not demonstrate innovation in the same ways. In rural regions, innovation comes in other forms and has less of a focus on standard product innovations and a comparative advantage in the development of original or incremental innovations more adequately captured in surveys (OECD, 2020[9]; Freshwater et al., 2019[10]; Lee and Rodriguez-Pose, 2012[11]) or those identified as local and community-driven innovation that is a part of what is considered "social innovation" (Jungsberg et al., 2020[12]; Mahroum et al., 2007[13]; Markey, Ryser and Halseth, 2020[14]; Wojan and Parker, 2017[15]).

In a related manner, there are pre-existing territorial endowments that determine the access to land, accessibility to capital stock, transport costs and labour resources in spatial economics (Fitjar and Rodríguez-Pose, 2013[16]; Maloney and Valencia Caicedo, 2022[17]; McCann, 2013[18]) . The difference in endowments (for example, digital and physical infrastructure, natural resources, demographics and access to higher education) in rural versus urban areas would also suggest a downward implicit bias when using R&D and patents as a proxy for innovation. For example, if high-speed Internet connections are needed to develop digital service innovations, then evaluating the innovation capacity of rural regions as compared to denser regions with less access to high-speed connections only informs rural policy makers that more digital infrastructure is needed and not that there is an intrinsic lack of innovative potential.

Finally, headquarter bias is a bias associated with the way in which statistical agencies collect data (Bils, Klenow and Ruane, 2020[19]; OECD, 2017[20]). For some innovation measurement methods, attributing innovation proxies to headquarters is logical; however, the prioritisation of analysis at the headquarters level systematically leaves behind rural areas. For example, investment in R&D often requires capital investments that are shared among different branches of the same firm. The product of R&D investment should benefit outcomes for all branches of the firm (or inversely serve as a mechanism to remove non-productive branches from the structure of the firm).[6] With no headquarter bias, there should be no reason why employment as measured by labour surveys, and employment as measured by firms would be different. However, in many cases, the most commonly used databases do indeed suffer from this bias (OECD, 2017, pp. 27-28[20]).

There is a small but growing economic geography and innovation literature that prioritises the differences between regions as important for understanding and supporting the proliferation of innovation preconditions, processes and outcomes (Crescenzi, 2005[21]; Eder, 2018[22]). In some cases, the differences in the composition and territorial endowments of the region are quite evident. For example, Karlsson and Olsson (1998[23]) argue that large firms tend to need to rely heavily on resources in dense areas to grow, while SMEs can survive more easily in peripheral areas. Likewise, Caragliu, de Dominicus and de Groot (2015[24]) advise focusing on policies that encourage specialisation for low-density regions and diversification of activities in denser areas. In other cases, the difference is due to lower opportunities for local knowledge spill-over and adaption to a more collaborative model (Grillitsch and Nilsson, 2015[25]).

In sum, if the compositional structure and territorial endowments of rural regions mimicked those of denser economies proportionately, then there would be limited reasons why the use of statistics, whether or not they are biased towards manufacturing and science- and technology-intensive sectors, would be different in rural regions. In the sections below, the analysis will provide examples of why this is not currently the case for rural regions today.[7]

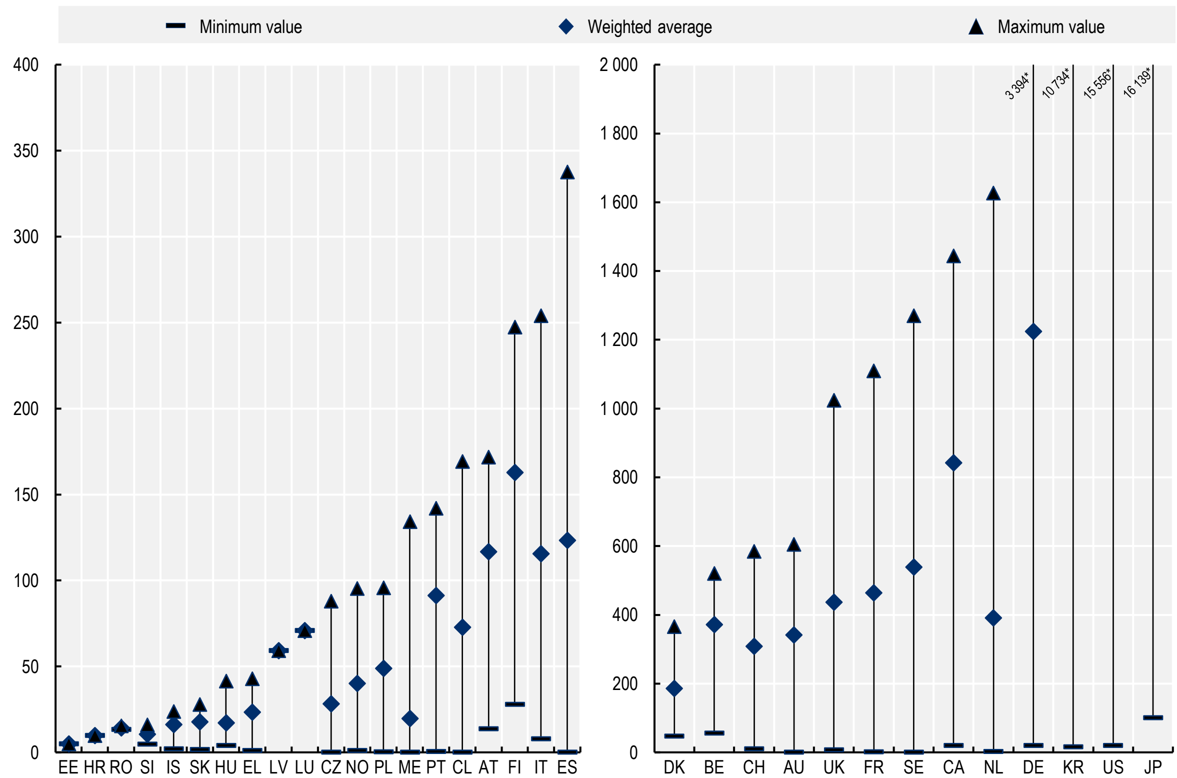
A few takeaways from this analysis have impacted the strategy of the report and can be summarised as follows:

- The selection of measurement tools for innovation in rural areas is more often associated with bias, either due to the composition or endowment-related differences across territories.
- Self-reported innovation measures are useful measures of rural innovation but, in practice, they often suffer from insufficient observations on a territorial level.
- Taking into account the structure of rural economies would require adjusting commonly used measures such as R&D and patents to account for the types of innovation that are more common in rural regions.
- Focusing on innovation proxies such as entrepreneurship and start-up activities may be better suited for understanding drivers of innovation in rural areas, as it both avoids headquarter bias and its measurement is not likely to be directly affected by the compositional characteristics of rural areas.

Better indicators can give us a more accurate picture of innovation in rural areas

Standard measures of innovation such as patents and R&D statistics are often better at measuring innovation in highly concentrated, urbanised areas. Innovation, as measured by patents, can vary substantially between countries and regions. For example, in Figure 3.2, patent applications per million inhabitants are highly dispersed across TL2 regions. Regions with the highest level of patents per application are often regions with major large metropolitan cities, with strong links with research universities, strong information technology (IT) sectors or a strong manufacturing sector. On the right side of the second panel, the regions with the highest level of patents per million inhabitants are in Bavaria (DE2) containing the manufacturing capital Munich in Germany, the capital region of Korea (KR01), California, US (US06) consisting of Silicon Valley[8], and Southern-Kanto, Japan (JPD) containing the capital Tokyo.

Figure 3.2. Patents in regions (TL2), patent applications, 2019



Note: Graphs include regional (TL2) data on OECD countries with available data. In some countries, multiple regions have zero patent applications. The data are presented separately on two graphs because of the readability of different scales. The graph on the left only presents countries with up to 350 applicants in 2019, while the graph on the right represents those with over 350 and above.
* Maximum value.
Source: OECD calculations based on European Patent Office (2019[26]), *European Patent Register*, https://www.epo.org/searching-for-patents/business/patstat.html.

However, patents, as a proxy for innovation, lack the capacity to account for the occupational and sectoral structure of rural regions**.** In the example above, the major regions with patents are either capital regions that have easier access to finance and auxiliary services, or regions with university interlinkages focusing on IT, medical and science-based work and, in the case of Germany, a strong manufacturing sector. This regional finding is also in line with national trends in sectors that are self-reported as innovative.

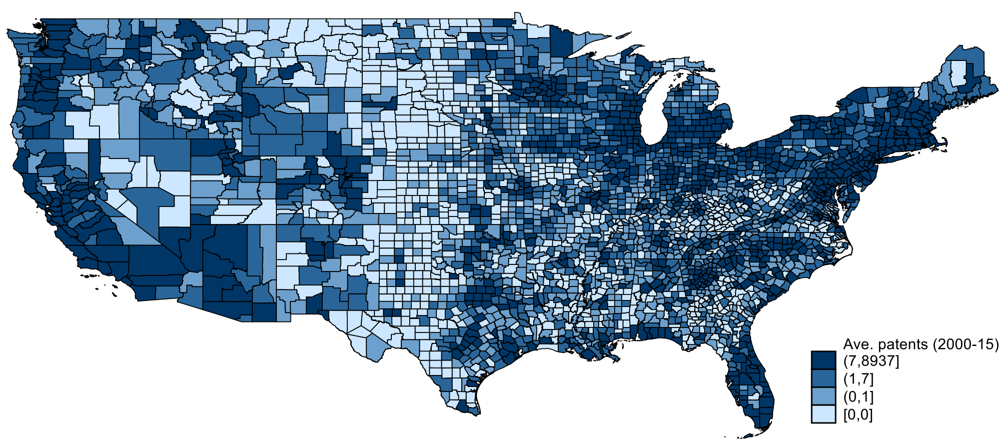
Adjusting for the occupational structure of economies improves the perception of innovation in rural regions. The general lack of innovation activity as measured through patenting could be in part due to the lack of relevant labour supply. Following the recent work by Dotzel (2017[27]) and Wojan (2021[28]) who generated classifications for occupations that showed a higher likelihood of patenting,[9] we adjust the number of patents to the occupations where professionals are more likely to patent (Annex Table 3.D.1).

On a regional (TL2) level, taking this additional step demonstrates the sensitivity of patent intensity (patent to population ratio) statistics to the structure of the economy (Annex Figure 3.D.2). However, the regional (TL2) level only shows part of the picture. While descriptive, the regional (TL2) level demonstrates that the degree to which patent intensity relates to the share of rural in each TL2 is increasingly negative when patent intensity is adjusted by occupation. In both adjusted and non-adjusted cases, the relationship is not statistically different from zero. This is likely due to the fact that the regional (TL2) level may be too aggregate to determine if the adjustment can make a difference.[10] Further diving into the level of smaller regions (TL3), evidence from the US demonstrates that the picture for rural regions changes (Figures 3.3 and 3.4).

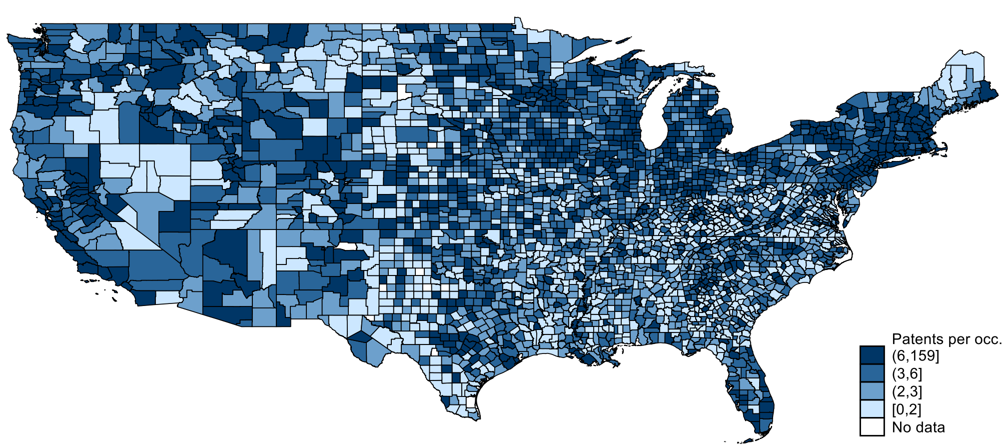
Patenting intensity is strongly associated with the occupational choices of individuals. The greater the number of individuals with occupations that participate in registered inventions in a small TL3 region, the more likely the region will have registered inventions**.** The territorial share of occupations involving inventive activities does a better job at targetting geographical disparity of innovation capacity than patent applicants alone. In Figure 3.3, the map of the US is filled with the average yearly number of patents (Panel A) and the average yearly number of patents per occupation where individuals have incentives to register patents (Panel B). Both maps demonstrate that there is some clustering of activities. However, the differences in the density of this measure of innovation diffuses across space as we move from the initial pure patent-based measures to adjusted measures that account for the territorial distribution of occupations where patents are commonplace.

Figure 3.3. Patents and inventive occupations in the US

A. Yearly average of patents filed on a county level, 2000-15



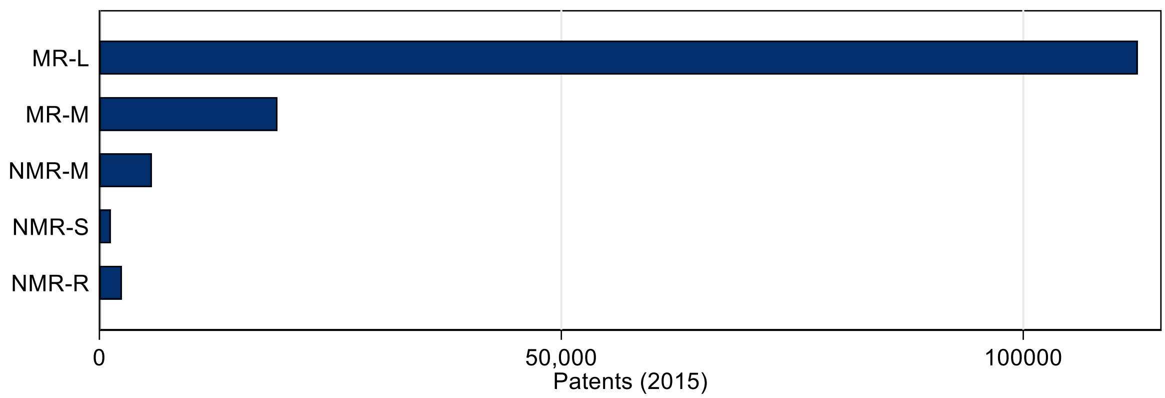
B. Yearly average of patents filed per inventive occupation on a county level

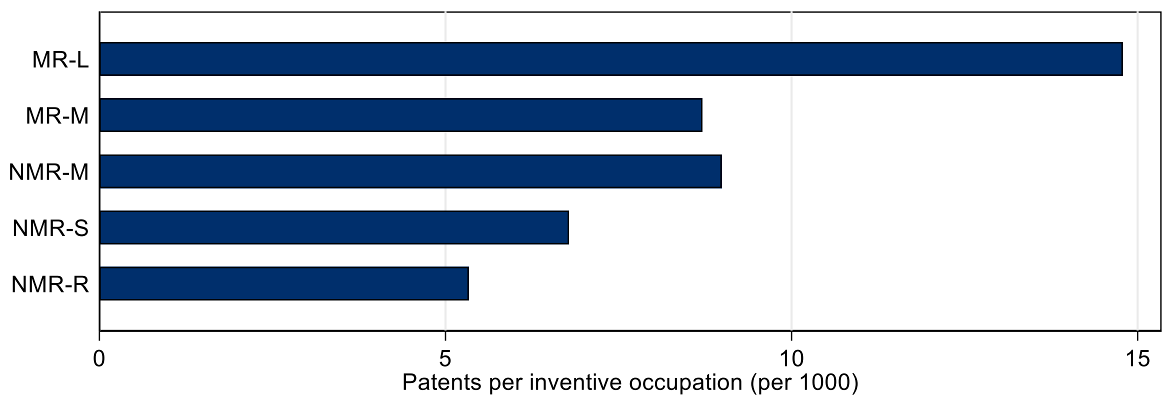


Note: Inventive occupations as defined by Dotzel and Wojan (2021[28]).
Source: Wojan, T. (2021[28]), "An occupational approach for analyzing regional invention", https://ncses.nsf.gov/pubs/ncses22202/assets/ncses22202.pdf.

Figure 3.4. Patents and inventive occupations in the US, by typology

Patents filed, 2015, versus the ratio of patents filed per 1 000 individuals with inventive occupations





Note: Inventive occupations as defined by Dotzel and Wojan (2021[28]). MR-L refers to large metropolitan regions that have 50% or more of the population that lives in an FUA with 1.5 million inhabitants or more; MR-M refers to metropolitan regions with a population of 250 000 inhabitants and where 50% or more of the regional population lives in an FUA; NMR-M refers to non-metropolitan regions with access to an FUA within a 60-minute drive and less than 250 000 inhabitants; NMR-S refers to regions where 50% or more of the regional population lives within 1-hour access to a small- or medium-sized city; NMR-R refers to a non-metropolitan region where 50% or more of the regional population does not have access to an FUA within a 60-minute drive. Patents filed in 2015 were 112 379 (MR-L), 19 264 (MR-M), 5 670 (NMR-M), 1 220 (NMR-S) and 2 427 (NMR-R). The patents per inventive occupation (per 1 000 individuals) rates are the following: 14.8 (MR-L), 8.7 (MR-M), 9.0 (NMR-M), 6.7 (NMR-S) and 5.3 (NMR-R). The typology is based on aggregating data from the county level.
Source: Dotzel, K. and T. Wojan (2021[28]), "An occupational approach for analyzing regional invention", https://ncses.nsf.gov/pubs/ncses22202/assets/ncses22202.pdf.

There is a 16-fold decrease in the disparity between non-metropolitan regions and metropolitan regions when adjusting the patent intensity to account for occupational distributions. Grouping metropolitan and non-metropolitan classifications together, regions in large and medium metropolitan regions (MR-L and MR-M) in the US have approximately 13 times more patents than non-metropolitan regions (NMR-M, NMR-S and NMR-R in Figure 3.4). When we adjust for the occupations prominent in territories, the disparity falls starkly to close to 0.8.

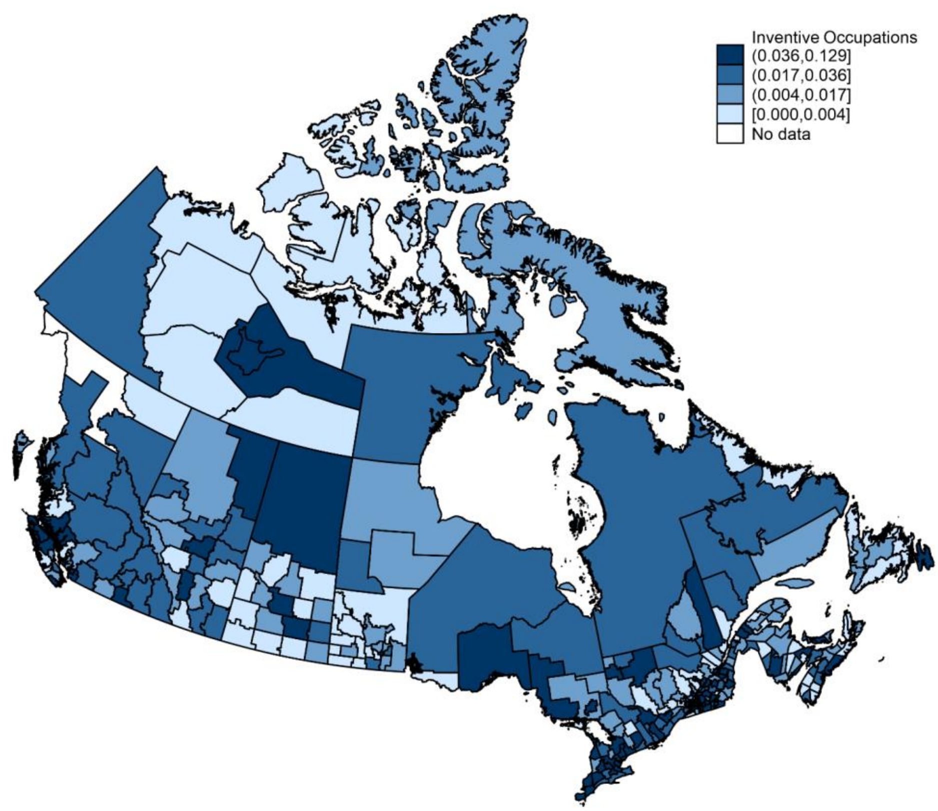
Out of 1 000 individuals with inventive occupations in non-metropolitan regions close to cities, 9 individuals filed for patents, in 2015. In comparison, in medium-sized metropolitan regions, 8.7 patents were filed. However, a gap remains between individuals in non-metropolitan regions and large metropolitan areas. Inventive individuals in non-metropolitan regions on average produced six less patents than those in large metropolitan regions.

This simple accounting practice demonstrates how the structure of rural economies is important when determining how to measure innovation. Rural regions have different resources and opportunities and are by definition different from more dense areas where there are higher shares of occupations with inventors who are more likely to patent. Firms in rural regions tend to more often be small, in some cases, older, and have a close connection to natural resources, either in agriculture or those based on natural resources (mining, agri-tourism, etc). In understanding rural innovation, patent ratios should be adjusted for the structure of the rural economy.

Rural regions are structured differently, both in occupations and sectors. Occupations in which applying for patents is commonplace are not evenly distributed across territories. In the US, the inventive class (occupations in sectors with a high association with inventions) is clustered on the coasts and in the northeastern region (Figure 3.3).[11] There is a much higher share of inventive jobs per inhabitant in metropolitan areas as compared to non-metropolitan regions with various levels of access to urbanised cities.

In Canada and the US, most individuals in occupations that participate in the process of applying for patents are located in larger metropolitan regions (Figure 3.5 in Canada and Annex Figure 3.D.1 in the US). In metropolitan areas of the US, for every 1 000 individuals in the active labour force, there are close to 20 more who have occupations in which patents are more common practice, as compared to non-metropolitan regions. For those who have such occupations, the act of patenting (or trademarking) can be as a result of claiming intellectual property rights over pure or incremental innovations or alternatively be due to anticompetitive behaviour or as part of a human resource key performance indicator practice within firms.

Figure 3.5. Inventive occupations in Canada, 2019



Note: Inventive occupations are defined by Dotzel and Wojan (2021[28]).
Source: OECD calculations based on Statistics Canada (2016[29]), *Census of Population*, Statistics Canada Catalogue no. 98-400-X2016295.

The implications of an unequal distribution of occupations across territories are important for innovation policies. Focusing on policies to increase innovation that are frequently associated with patents (i.e. R&D subsidies or tax breaks) in regions where there are few to no individuals in such occupations, is misguided. It is equally misguided to consider that areas with no or very few patents are not innovative because there are no patents in the region.

A viable solution is to focus on encouraging the framework conditions to enhance the innovation processes and activities that are more common in rural areas. Whenever possible, focusing on relevant indicators of innovation in rural areas and on framework conditions or entrepreneurship should be prioritised. If this is not possible, it is important that traditional indicators account for the intensity of such activities relative to the appropriate shares of sectors or occupations. Individuals in rural regions have a comparative advantage in entrepreneurship and different forms of innovation are more common in the periphery (Rodríguez-Pose and Fitjar, 2013[30]; Mayer, 2020[31]; Shearmur and Doloreux, 2016[32]).[12]

A few important takeaways can be understood from this territorial analysis on innovation indicators.

- **Traditional stories on patents do not give a precise image of innovation in rural regions**. Rural regions are simply structured differently than dense regions: therefore, how we measure innovation matters. Governments and researchers need to use relevant statistics for comparing innovation measures and population parameters.
- **Individuals' occupations are important drivers of innovation**. The types of activities people do matter. Encouraging the retention or attractiveness of individuals with occupations where invention is more frequent can spur innovation-driven growth in rural regions.
    - For rural innovation, policy makers should focus on encouraging innovation in activities that have more opportunities to **adapt to the comparative advantages of rural regions**.

Beyond the national science and technology framework for innovation in rural regions

When we are looking to understand and promote rural innovation, **the way we measure innovation matters**. Conventional definitions and measures are often better suited for product (rather than process) innovation occurring in large firms. Definitions and measures of innovative activities are often a better match for innovations in large firms that engage in product rather than process innovation, are focused on the manufacturing or R&D intensive sectors and depend on heavier capital and resource expenditures. However, a larger share of firms in rural regions are often small and focused on the service or natural resource sectors (Freshwater et al., 2019[10]) where innovation is incremental or is characterised by strong use of social and human capital (Shearmur, Carrincazeaux and Doloreux, 2016[33]; Simonen and McCann, 2008[34]; 2010[35]).

Continuing to overlook the geography of innovation is a missed opportunity, has exacerbated pre-existing territorial divides and overlooks some of the prime opportunities for growth. In addition to the findings of this report, forthcoming analysis from field studies also finds important evidence to continue to reinforce the importance of integrating geography into innovation studies.

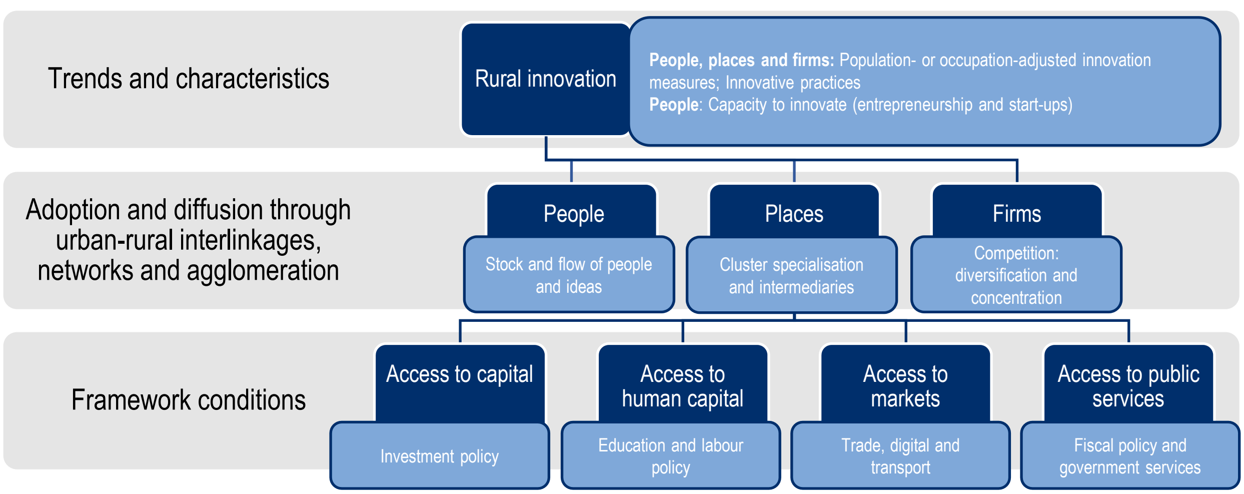
- From Switzerland, using territorial indicators demonstrates that investment in traditional innovation activities such as R&D are associated with more jobs and inward expenditures in rural regions, while this is not the case in metropolitan areas. For example, in 2019, close to 35 cents per Swiss franc spent on R&D was outsourced; in rural regions, only 4 cents per Swiss franc left the firm for R&D expenses (OECD, forthcoming[36]).

- Using innovation surveys for measuring innovation in Scotland shows that while geography impacts the structure of the economy, innovators are inherently the same across regions. The age (young) and size (large) of firms are important in determining whether they innovate or not. Furthermore, national innovation and productivity can be increased by focusing on rural regions that still have strong opportunities to grow and where the return to innovation is still relatively large (OECD, forthcoming[37]).

Lastly, policy makers and academics focus on rents and networks to understand innovation clusters and locational choices for firms, but *people* clustering is also critical since individuals are the true drivers of innovation, as demonstrated earlier with patent statistics in Canada and the US and several academic studies (Florida, 2002[38]; McCann and Arita, 2006[39]; Van Oort, 2017[40]). The pre-existing focus on national science, technology and innovation (STI) measures is partially due to data limitations and the difficulty involved in measuring innovation, but sometimes can also be explained by a lack of contextual prioritisation.

In light of this, the structure of the analysis in this report prioritises a territorial, individual capacity-based approach to innovation (creation and adoption) on three different levels, as outlined in Figure 3.6. This report suggests a new framework that overcomes some of the biases outlined above. It moreover focuses on measurement and policies to improve the capacity to innovate, by looking at the characteristics of entrepreneurs that are more likely to innovate.

Figure 3.6. Analytical framework for understanding the drivers of innovation in rural regions



Note: Public services include direct support mechanisms.

As described in the analytical framework and in line with the literature and the relative importance of innovation diffusion and adoption in rural regions, the subsequent publications will also address: the approach to understanding network and agglomeration effects and how they amplify innovation adoption through rural-urban interlinkage mechanisms and include the role of different actors such as academia, industry and the public sector; and the framework conditions that are vital to the proliferation of the creation of new products and processes as well as the diffusion of innovation across territories, including through advanced business services specifically targeted at innovation and SMEs.

In sum, there are two main takeaways from this analysis. First, common perceptions of rural areas with low innovation merit further contextual reflection. Second, precisely measuring innovation in rural areas is a challenge. Second-best measurement methods should be nuanced to capture structural and resource endowments in rural regions. When possible, using survey-based innovation measures with a large enough sample of observation from firms and individuals in rural regions should be prioritised. When this is not available, adjusting indicators to reflect the relevant sectoral, size and occupation structure should be reinforced. Lastly, as will be explored further below, individuals' capacity to innovate by looking at drivers of entrepreneurship and new firms should be explored. For many rural regions, supporting young entrepreneurship can be particularly advantageous.

The following chapter explores innovation in rural regions and areas, prioritising a capacity approach to innovation that include factors associated with innovation such as inventors, firm demographics, entrepreneurship and social innovation. It follows with a brief chapter on outcomes closely associated with innovation including high growth and productivity.

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Notes

[1] Within OECD countries, the territorial classification of rural areas are often contingent on similar criteria including density and distances. However, each OECD country bases classifications on different cut-off points and it is not uncommon for ministries and departments within countries to not have a unified definition of rural. Often, classifications of rural areas are strongly determined by local policies and political agendas, such that the choice of using one definition over another has political implications. By using the harmonised OECD definition, the precision of rurality is not as accurate but we avoid issues arising from non-symmetrical incentives within countries.

[2] The OECD uses classification of administrative regions for territorial level analysis. Territorial level 2 (TL2) refer to large regions, while Territorial level 3 (TL3) refer to small regions. For European countries, they are aligned with the NUTS classification system of regions.

[3] In part, this was in order to overcome part of the sample size challenges associated with innovation surveys as well as the tangibility of outcomes associated with R&D investment and jobs.

[4] Hall (2015[41]) argues that "patent thickets" or heavily patented activities are associated with a reduction of patents for first time filers and increase for more technologically complex products. This type of anticompetitive behaviour raises entry costs that lead to less entry of firms into economic activities regardless of a firm's size. More recent research on regional innovation systems suggests that patents may not be as relevant for development as the literature currently suggests (Hall, 2020[42]).

[5] The headquarter bias refers to a measurement challenge where multi-plant enterprises that may have plants operating in different locations, but report all activity in one central location (usually at headquarters in large cities).

[6] In the case of R&D investment, while outcomes may change over time (benefits can perceived be in the short, medium or long term), input can be measured at a point in time and finds a premise to be territorially attributed to activity in the firm's headquarters. Another example is the use of patents. For example, patents that are developed at branches of different firms are often filed with the address of the firm's headquarters. While this is useful for legal reasons, it is clear that such measures systematically remove innovative activities from plants located outside of headquarter offices.

[7] Notwithstanding measurement critiques, it is hard to find alternatives with a good level of representativeness in rural areas. For this reason, survey-based data using the Oslo Manual's definition of innovation are a gold standard for understanding trends in innovation and its diffusion. However, in practice, for rural areas, the limited representativeness of this survey makes the use of such data close to impossible.

[8] California has several innovation hubs in addition to Silicon Valley that it draws from, including those at Silicon Beach and several research universities such as CalTech (including the NASA Jet Propulsion Laboratory campus), Stanford, UC Berkeley, UC Los Angeles and the other major University of California branches specialising in science (including maritime and agricultural research), IT and medical research universities.

[9] For more descriptions of the occupations that are identified as patentable, further information is available in Annex 3.D.

[10] The degree of rurality is an aggregate share value that captures the share of the population living outside of the FUA within each TL2. While it is a coarse indicator of rurality, it allows some classification on rurality.

[11] This is in line with trends in the rise of the new creative class, argued by Richard Florida (2002[38]) displayed in Annex Figure 3.F.1.

[12] Some authors refer to these forms of innovation as "slow innovation" and "reverse innovation", two types of innovation that occur more frequently in the periphery but are more difficult to capture in a comparable way in standard innovation statistics (Rodríguez-Pose and Fitjar, 2013[30]). Slow innovation refers to processes that do not quickly lose value over time (no rush to market) and develop more easily in peripheral areas (Mayer, 2020[31]). Such types of innovation take time to develop and are more dependent on non-market-sourced information (Shearmur and Doloreux, 2016[32]). Reverse innovation refers to innovations

in the periphery of the global business environment. Popularised in developing countries but relevant for local economies in industrialised areas, this type of innovation targets the production of new goods and services to the demands of local markets in rural regions. In some cases, it substitutes more expensive production costs with cheaper local alternatives from local value chains, while keeping most of the functionality. It captures marginal changes in production that are more targeted to local markets (Govindarajan and Euchner, 2012[43]; Taglioni and Winkler, 2016[44]).

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