

Development
Studies

Assessing the Innovation Capabilities of Bhutan

Innovation Capabilities

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EXECUTIVE SUMMARY

This study of Bhutan's innovation capabilities maps capabilities across 626 different fields of innovation and assesses the state of the country's know-how to offer strategic advice that strengthens its innovation ecosystem and encourages collaboration amongst stakeholders. It is an input for the Committee on Development of IP (CDIP) project 26/4: "Systematization of statistical data and the design and implementation of a methodology for developing impact assessments on the use of the intellectual property system".

The key **takeaways** from Bhutan's innovation capabilities study are:

1. **Diversity.** Bhutan's data on international patenting and scientific publication points to a low contribution across the board, making it fail to master any type of innovation capabilities in these technological and scientific domains. In addition, the missing data on product and services exports also makes it impossible to identify any production-based capability. Consequently, the report focuses on 2012, which was the last period with complete data. During this timeframe, the country mastered 1% of all the possible innovation capabilities, all of them coming from fields of innovation related to production domains.

2. **Complexity.** The lack of current capabilities puts Bhutan at the bottom of the complexity spectrum. However, when it did have capabilities, the Bhutanese innovation ecosystem used to rank low alongside countries like Cabo Verde, Djibouti, Eritrea, Equatorial Guinea, Guinea-Bissau, Haiti, Liberia, Maldives, Sierra Leone, Somalia, Syria, Turkmenistan, and East Timor.

3. **Opportunities.** Bhutan's first step toward any smart diversification strategy is to solidify its current skills. This can be done by attaining capabilities in fields that are close to reaching critical mass. These are architecture, tropical medicine, biodiversity conservation, parasitology, and forestry. Looking into the past, when Bhutan registered production capabilities, there were travel, physics, oils and fats, and fuels.

4. **Potential.** The Bhutanese untapped technological potential is low across the board. Based only on the region's scientific outputs, there could be around 14 additional yearly patents coming from the country, mainly from the biopharma domain.

Bhutan has currently no innovation capabilities... but used to have 7.

Figure 1A – Bhutan’s innovation outputs across 3 dimensions of innovation, 4-year period.

Dimension	Outputs	Unit	Trend	World Rank (of 164)	World Share (%)
Production	288	Million USD in exports		154	0.00
Science	491	Scientific publications		159	0.00
Technology	33	International patents		144	0.00

Figure 1B – Bhutan’s last innovation capabilities across 3 dimensions of innovation, 39 domains, and 626 fields.



Bhutan's innovation capabilities

Innovation ecosystems thrive on fostering robust interactions among their scientific, technological, and productive stakeholders. Innovation capabilities represent the **ability of an ecosystem to deliver competitive outputs** in a certain field of the innovation process. This study maps 626 innovation capabilities coming from 11, 13 and 15 scientific, technological and production domains, respectively. These capabilities are matched to more than 150 WIPO member states.

The World IP Report 2024 shows that innovative outcomes are highly concentrated in just a few countries. Over the past 20 years, the top eight countries account for 50 percent of exports, 60 percent of scientific publications and 80 percent of international patenting.

The Asian country represents 0.01% of the global GDP, however, as seen in Figure 1A, **it's share is lower for all innovative outputs**. Namely, it's contribution is close to zero across all three dimensions (global exports, scientific articles in international peer-reviewed journals and international patent applications¹).

These low participations result in Bhutan not having innovation capabilities for the latest periods in the analysis. However, this is (most certainly) because **the country has not reported its export data on goods** since 2012. Therefore, for much of the study, the description of capabilities will be about this period, assuming that the most recent exports follow a similar pattern.

In fact, when looking at the latest period with goods exports data, **Bhutan had 7 innovation capabilities**. Figure 2B shows that all of these came from the production dimension, and were obtained by being relatively specialized, meaning that its outputs in those fields were high, relative to what the rest of the world produced. These include **pig iron** (109 times the average country share), **electric current** (77×), **inorganic chemicals** (74×), **stone, sand and gravel** (57×) **crude minerals** (37×), **fuel wood and charcoal** (27×) and **iron and steel bars** (9.1×).

For many of the remaining fields, the **Bhutanese innovation outputs are currently lower than the critical mass needed to be an internationally comparable capability**. For instance, in the field of **environmental sciences**, Bhutan had 24 international

¹ See definition in Annex.

scientific publications, but the critical mass to reach the capability of this field is 1.800 publications in the same period.

The innovation capabilities that are closest to Bhutan's current outputs are in the scientific domains. These include **architecture** (Bhutan had 67% of the necessary publications), **tropical medicine** (44%), **biodiversity conservation** (23%), **parasitology** (19%), and **forestry** (17%).

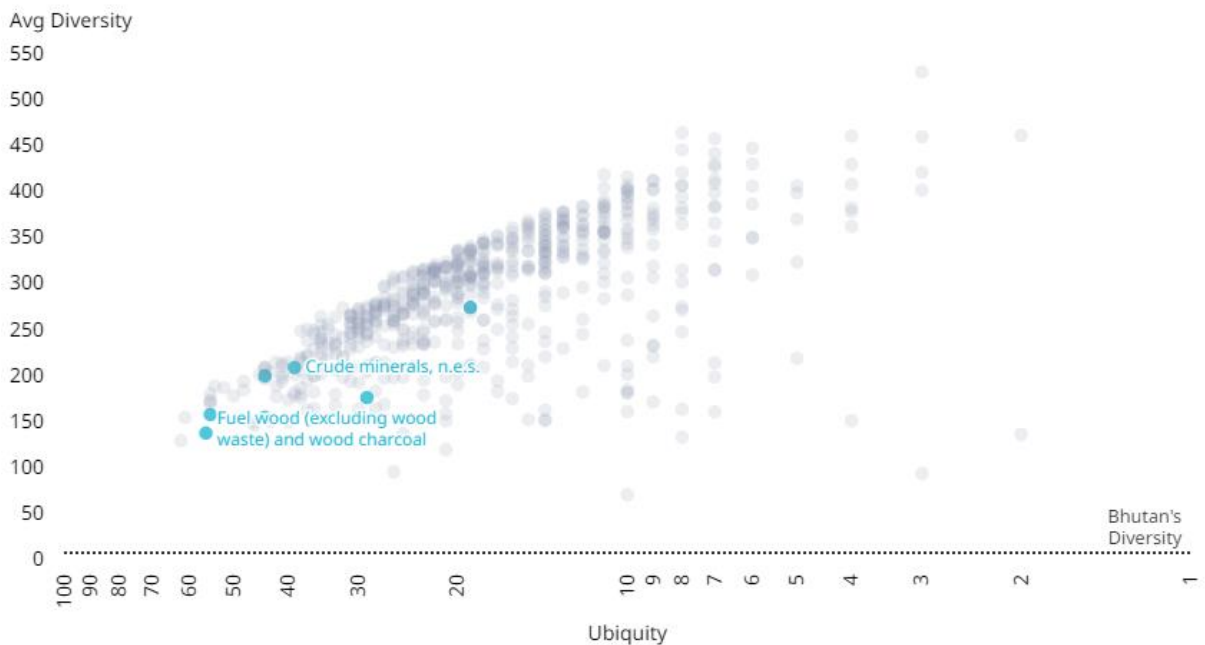
How can these capabilities help decision makers? Identifying the region's knowledge is the first step to assess its position in the global innovation network. This information is crucial to find strategic paths that unlock their innovative potential.

Bhutanese capabilities were, on average, found in 41 other countries.

Figure 2A – Number of capabilities (diversity) of innovation ecosystems and average capability rareness (ubiquity)² for Bhutan's last seen innovation capabilities.



Figure 2B – Capability rareness (ubiquity) and average diversity of innovation ecosystems that have them for Bhutan's last seen innovation capabilities.



² See definitions in Annex.

Who shares capabilities with Bhutan?

As countries become more diversified in general their capabilities become less common across other countries. This is portrayed on Figure 2A. Germany, for instance, is specialized in more than 500 capabilities, and on average less than 22 other countries can compete on these capabilities. On the other end, Congo is specialized in just two capabilities which are very common, as around 42 countries are also specialized in them. **Bhutan's innovation capabilities were common, as, on average, they were found in 41 countries.**

These 41 countries are not always the same. **The countries that had the most similar capabilities were found all around the world**, led by Albania (proximity of 0.5), Kyrgyz Republic (0.28), Lao PDR (0.28), Montenegro (0.28), and Paraguay (0.21).

Figure 2B shows that **Bhutan's capabilities also differed in term of their rarity, ranging from the most common (fuel wood), present in 56 other countries, to inorganic chemicals, present in only 19.** Additionally, all (100%) capabilities are present in countries that are more diversified than Bhutan (above the dotted line). **Inorganic chemicals**, for instance, is a production capability that tends to appear in countries that have 273 other capabilities, while **fuel wood** (137), and **stone, sand and gravel** (158) and **natural gums** (70) appeared in countries that are less diversified, with the latter being below Bhutan's current diversity.

The overall trend of Figure 2B implies that **as capabilities get rarer, they appear in more diversified countries.** Is it desirable to develop these rare capabilities? For instance, an innovation capability might be scarce because demand is low and thus the incentives to develop them are low. Likewise, there may be widespread capabilities, the rewards of which are high enough to motivate their development in an ecosystem, even at a high cost. Complexity indicators aim to solve this issue.

Bhutan's innovation capabilities are low complex production based.

Figure 3 – Innovation capabilities ranked by complexity, grouped by domains.

Dimension ● Science ● Technology ● Production ● Unattained



How rewarding were Bhutan's capabilities?

Innovation **complexity indicators capture the amount and sophistication of know-how** required to generate an outcome in each field. It is calculated based on how many other countries can generate outcomes in that field and the complexity of those ecosystems.

Economies attaining technologically **complex production structures typically see higher economic performance**. However, attaining these rewarding capabilities is not a simple task. The most complex fields often require to be nurtured by complementary knowledge to be sustainable over time.

Figure 3 shows the distribution of the complexity of all innovation capabilities, comparing the Republic of Korea with Bhutan. Republic of Korea shows a wide set of capabilities that covers most of the domains, including the most complex ones. It is specialized in all fields related to [semiconductors](#), [ICTs](#) and [audiovisual](#) technologies.

In contrast, **Bhutan's current capabilities lie on the lower end of the complexity spectrum**. This means that most of the know-how currently based in the region is widespread and tends to require less complementary know-how to be sustained. Some notable mentions for the country's most rewarding skills are [inorganic chemicals](#) (rank 443rd of 626), and [iron and steel bars](#) (554th).

The innovation complexity helps to benchmark the current capabilities of an ecosystem. However, these are not set in stone: **when ecosystems gain and lose capabilities, their complexity levels change**. How can stakeholders of ecosystems choose which capabilities to pursue? Its current capabilities can indicate which capabilities are safer to pursue relative to others, and the complexity of these targets can help measure the potential rewards of these decisions.

Most opportunities to increase complexity remain in science and production

Figure 4A – Complexity and relatedness mapping for Bhutan’s unattained capabilities.



Figure 4B – List of top 10 opportunities for Bhutan, sorted by relatedness.

Domain	Field	Rel. Density	Rank (of 626)	Best Match	Safe Match
Travel services	Other modes of transport	2.15%	587	North Macedonia	Ukraine
Animal and vegetable oils, fats and waxes	Fixed vegetable fats and oils (other than soft), crude, refined or fractionated	1.01%	608	Papua New Guinea	Netherlands
Physics & Math	Physics, Particles & Fields	1.85%	529	Montenegro	South Africa
Physics & Math	Physics, Nuclear	1.85%	532	Georgia	South Africa
Crude materials, inedible, except fuels	Wood, simply worked and railway sleepers of wood	1.75%	576	Bosnia and Herzegovina	Slovak Republic
Technology	Nuclear Science & Technology	1.71%	511	Ghana	Russia
Beverages and tobacco	Tobacco, unmanufactured; tobacco refuse	1.29%	623	North Macedonia	Bulgaria
Manufactured goods	Aluminum	1.69%	493	Montenegro	South Africa
Chemistry	Materials Science, Paper & Wood	1.67%	560	North Macedonia	South Africa
Food and live animals	Fruit preserved, and fruit preparations (excluding fruit juices)	1.6%	570	Bosnia and Herzegovina	South Africa

Which were Bhutan's opportunities?

The principle of relatedness states that economies tend to diversify incrementally, moving into activities that have similar skills to those they currently possess. Consequently, **Bhutanese opportunities to increase complexity lie mostly in scientific and production domains.**

Why isn't [audiovisual information storage](#) an opportunity? The relatedness of Bhutan to it is too low. Windows of **opportunities to leapfrog into unrelated knowledge are often too narrow and risky.** This is because ecosystems often lose those capabilities that are isolated from their related skills.

Combining relatedness and complexity indicators (seen in Figure 4A) helps innovation ecosystems such as Bhutan's measure risks and rewards and decide their diversification paths. **High relatedness relates to lower risks of adoption, while higher complexity points towards higher rewards.** For the country, this means consolidating its current capabilities and looking for new ones by partnering with other ecosystems.

The average relatedness of a country to an attained field of innovation is close to 45%. This means that when a country has a skill, it often has about half of its related knowledge. However, countries manage to gain capabilities with a wide range of relatedness.

Bhutan's average relatedness to the capabilities it had was of around 2%, All of the capabilities of the country (7 of 7) are lowly connected to related knowledge, hence, the fragility of their status points to a need to nurture them avoid their disappearance.

The smart diversification strategy points to **opportunities to develop new capabilities that will increase the country's complexity,** and where the relatedness density of the country is high enough to consider that the risk of pursuing them is relatively low (countries with similar relatedness have managed to attain it). These can be identified in the upper right quadrants of Figure 4A and exemplified as a list in Figure 4B.

Bhutan's relatedness is often higher for low complex fields. This is why its opportunities mostly appear in scientific and production fields that rank low on the complexity spectrum.

Additionally, Figure 4B shows for each opportunity the countries that obtained each capability and had compatible knowledge sets to Bhutan's. **The most frequent possible partners are Ukraine, Latvia, North Macedonia and Nigeria.** However, for some of these countries the capabilities might be fragile, indicating that they may disappear there in the future. The same opportunities can be found in countries where the capability is solidified, and this is the case for **Belgium, South Africa, Brazil, and India,** amongst others.

Bhutan's science points towards potential technological inventions

Figure 5A – Yearly technological outputs vs. untapped potential. Comparison between Sweden and Bhutan

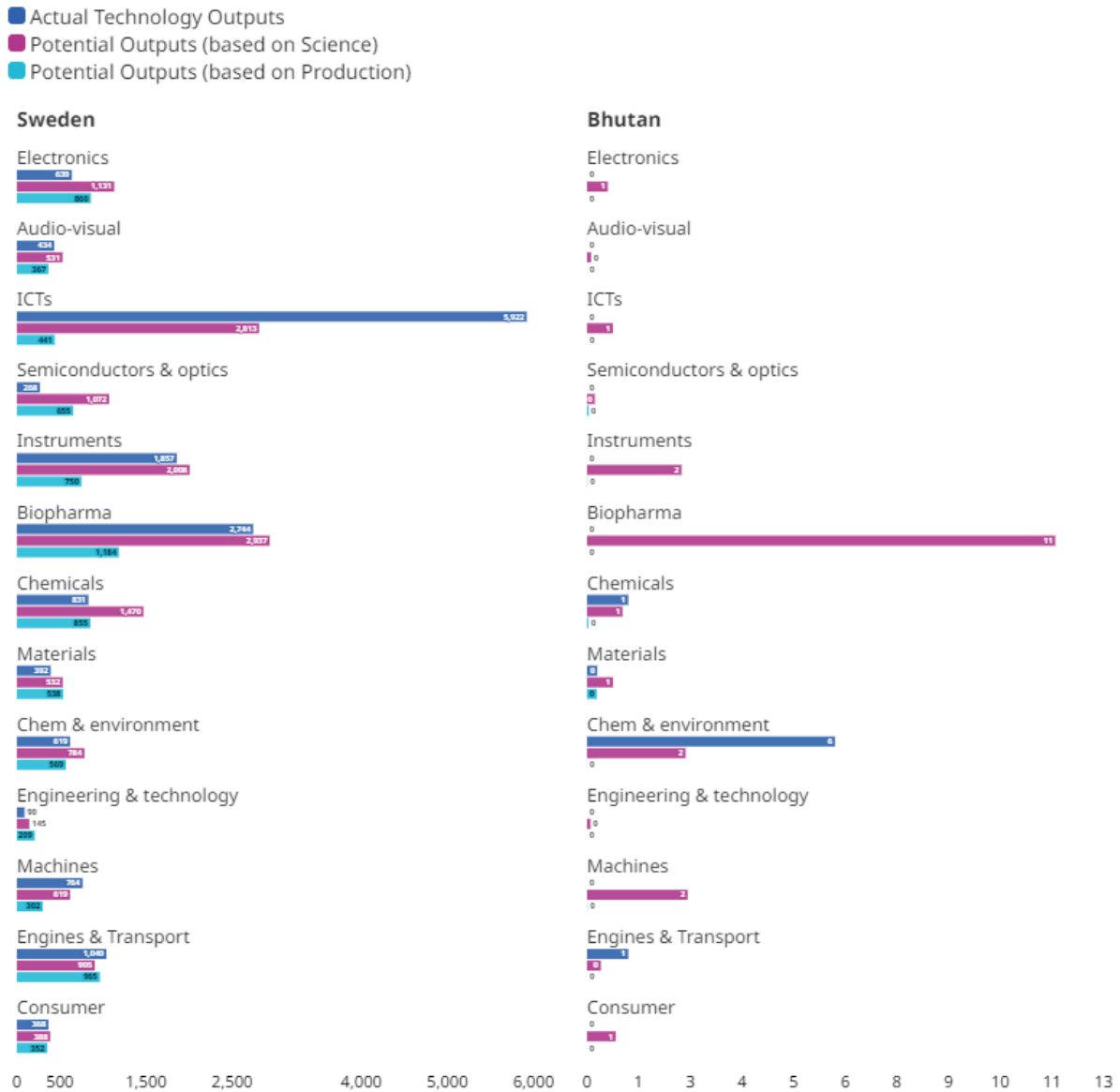
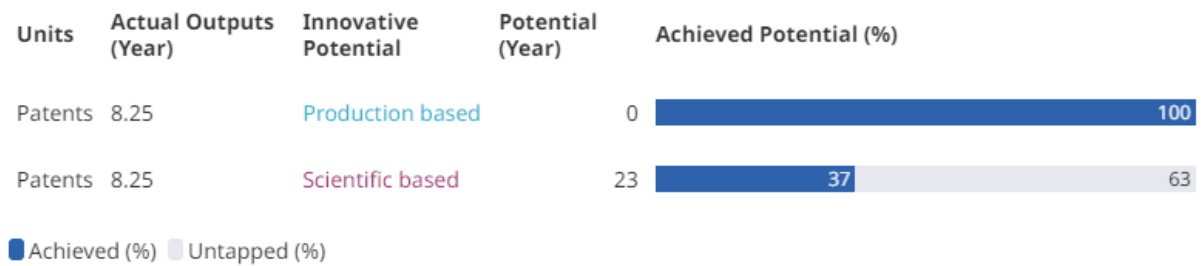


Figure 5B – Summary of Bhutanese untapped potential



National innovation potential

National and regional innovation policies can also exploit the relatedness between capabilities of different dimensions. Indeed, ecosystems are specialized in very different areas when it comes to trade, patents, and scientific publications. These connections, illustrated in Figure 5A, can shed light on the untapped innovative potential.

For example, with its scientific output, Sweden produces around half as many patents per year in [electronics](#) and [chemicals](#) compared to the average developed economy. In contrast, with the same scientific output, the European country manages to reach its potential patents for [instruments](#), [biopharma](#), and [engines](#), and even greatly surpass it for [ICTs](#).

In the case of Bhutan, the technological potential based on production is virtually nonexistent for all technological domains. The scientific potential is relatively much higher. In other words, the country has scientific know how that could turn into patentable technologies. Nonetheless, the numbers are still low. For instance, the potential in [electronics](#), [ICTs](#), [chemicals](#) and [consumer](#) technologies is, of one yearly patent each. Notably, **the [biopharma](#) technological domain has the highest of all potentials, with between 11 yearly extra patents** based on scientific activities.

The lack of data concerning its production activities during the latest periods may be hiding additional potential in this and other domains. Indeed, for the last period with available goods trade information, the technological potential based on these activities tripled the scientific one. This may indicate that **the country's technological potential may actually be between 23** (as seen in Figure 5B with the original estimations) **and 69 yearly patents**.

Conclusion

In conclusion, the resurgence of industrial policies globally underscores the need for strategic choices in scientific and technological fields. This direction shapes innovation by channeling resources and incentives into beneficial industrial activities. The study of Bhutan's innovation capabilities highlights the current state and potential for growth of the innovation ecosystem. **The country shows no current innovation capabilities, most probably due to its missing data on the production dimension.** For the remaining ones (science and technology), Bhutan's outputs are not sufficiently high to reach the critical mass needed to gain a capability that meets international standards.

The country's path to enhancing its innovation potential lies in focusing on developing those capabilities whose outputs are close to meeting the threshold. Once some capabilities are attained, Bhutan can make use of **smart diversification strategies**, leveraging related fields of knowledge to build on existing capabilities while mitigating risks.

Definitions

Scientific publication data

Scientific progress, the bedrock of human knowledge, is reflected in international scientific publications. The report uses the data on scientific articles published in internationally recognized academic journals and compiled in the Web of Science, Science Citation Index Expanded (WoS SCIE) collection, which are grouped into 169 distinct scientific subjects serving as scientific fields. These fields are grouped into 11 scientific domains. Countries are assigned scientific publications based on the university affiliation address. Fields in the social sciences and humanities were excluded from the analysis.

International patent data

Technological advancement is encapsulated in international patent family data sourced by combining WIPO patent databases and the European Patent Office's (EPO) PATSTAT. The report applies the definition of international patent families, which considers the first filings of those patent families that have sought protection in a country other than the applicant's country of origin. Patent data are grouped into 172 technology fields according to the international patent classification (IPC). Inventors' addresses provide the information to assign a country. These technology fields are grouped into 14 technological domains.

International trade data

Product innovation can find its expression in international manufactured exports. Products that are competing in the international market have assured a certain degree of competitiveness that can be related to an innovative product. We have used the UN COMTRADE database to trace the global journey of 274 distinct product fields for all countries and years. These fields are grouped into 15 production domains.

Innovation capabilities

Innovation capabilities are the scientific, technological and production know-how – tacit or codifiable – that exist in each country or region. They essentially represent the ability of a country to deliver competitive outputs in a certain field of the innovation process. In many cases, outputs include the skills and knowledge embedded in tools,

procedures or computer codes that can be easily shared or shipped around the world. However, quite often they are tacit, meaning they are embedded in individuals and are not readily codifiable and hence not easily transferrable.

Country's specialization and diversification

This relates to the number of capabilities in which an economy specializes. The more innovation capabilities in which a country specializes, the more diversified is that country. Conversely, the fewer the innovation capabilities in which a country specializes, the more specialized is that country.

Capability ubiquity and rareness

This represents how many economies specialize in each scientific, technological and production field (i.e., capability). The more countries that specialize in a given capability, the more that capability is ubiquitous. Conversely, the fewer the countries that specialize in a given capability, the rarer that capability.

Capabilities proximity

This represents the connectedness between any pair of scientific, technological and production fields (i.e., capabilities). For any given pair of fields, proximity represents the probability that an average country will specialize in both fields at the same moment in time. It is based on the statistically significant co-occurrences of two capabilities in all countries.

Innovation complexity (capabilities)

This captures the amount and sophistication of know-how required to generate an outcome in each field (innovation capability). It ranks the diversity and sophistication of the know-how required to generate each field and is calculated based on how many other countries can generate outcomes in that field and the complexity of those countries. In effect, it captures the amount and sophistication of know-how required to generate an innovative outcome.

Innovation complexity (countries)

This captures the amount and sophistication of innovation know-how embedded in a country. It ranks a country based on how complex are its innovation capabilities. Countries that are home to a great diversity of know-how, particularly complex

specialized know-how, can generate a great diversity of sophisticated innovation outcomes (i.e., science, technologies, and products). High complexity countries specialize – in absolute or relative terms – in the most complex innovation capabilities.

Relatedness density (country)

This measures a country's ability to enter a specific field. It provides a distance (from 0 to 1) capturing the extent of a country's existing capabilities to generate outcomes in this field, and measures how close that field is to the country's current innovation outcomes. Moving to a "nearby" field has a greater likelihood of success, as it has more of the required related capabilities. Relatedness density measures the probability that a country generates outcomes in capability A given that it has a set of capabilities. Relatedness formalizes the intuitive idea that the ability to generate outcomes in scientific, technological or production fields can be revealed by looking at which other capability outcomes it can generate. Current capabilities can indicate where to go next. This is known as the principle of relatedness. Economies tend to diversify incrementally, moving into activities that have skills similar to the ones they currently possess.

Untapped innovation potential

This refers to potential output in a capability given the current outcome on related capabilities. It is calculated using the proximity connections between scientific, technological and production capabilities in the economies from cluster 1 in WIPR 2024, Figure 2.6 (i.e., a selection of advanced innovation ecosystems). These proximities are used to estimate the transformation weights of outputs from scientific capabilities to outputs from the technological capabilities depicted in WIPR 2024, Figure 2.16.

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