

Innovation Capabilities

Introduction to concepts of smart diversification

Clement Sternberger, Maria de las Mercedes Menéndez

Innovation Economy Section - WIPO



Innovation Ecosystems group highly specialized individuals to produce sophisticated outputs

Infrastructure

Research Centers

Institutions

IP Community

Policymakers

Companies

Entrepreneurs

Universities

Market

Source: Harvard Growth Lab, WIPO

A large, abstract pink shape in the top right corner of the slide, consisting of several connected geometric forms.

Main indicators

How can Innovation Capabilities inform policy?

Innovation Capabilities

A man in a black shirt is leaning forward, looking intently at a drummer playing a drum set in a dimly lit room. The drummer is wearing a black t-shirt and blue jeans, and is captured in the middle of a rhythmic performance. The background shows a wooden wall and other musical equipment, creating a professional studio atmosphere.

The **ability** of an innovation ecosystem to **deliver competitive outputs** in a certain field of innovation.

Identified by **specialization** patterns:

- **Absolute**: being a leader in a field.
- **Relative**: having a high participation, compared to the world average.

Usually measured as a **binary** variable.

Types of indicators

Based on what they describe

Characteristics of:

- Innovation Ecosystems
- Innovation Capabilities

Relationships between:

- Ecosystems and Capabilities
- Different Ecosystems
- Different Capabilities



Main indicators for Ecosystems (1)

Diversity

Measures the number of innovation capabilities an ecosystem masters.

| Ecosystem | Share of fields | Rank |
|---------------|-----------------|-----------------------|
| Honduras | 4% | 4 th |
| Mexico | 27% | 2 nd |
| Canada | 54% | 1st |
| Singapore | 24% | 3 rd |



Canada has 54% of all innovation capabilities, the highest amongst all selected ecosystems...

Main indicators for Ecosystems (2)



Average Ubiquity

Reflects how common are the capabilities of an innovation ecosystem.

| Ecosystem | Share of ecosystems | Rank |
|------------------|---------------------|-----------------------|
| Honduras | 70% | 4 th |
| Mexico | 50% | 3 rd |
| Canada | 35% | 2 nd |
| Singapore | 30% | 1st |

... however, Singapore's capabilities are the rarest across all selected innovation ecosystems.

Main indicators for Capabilities (1)

Ubiquity

Indicates how common a capability is across innovation ecosystems.

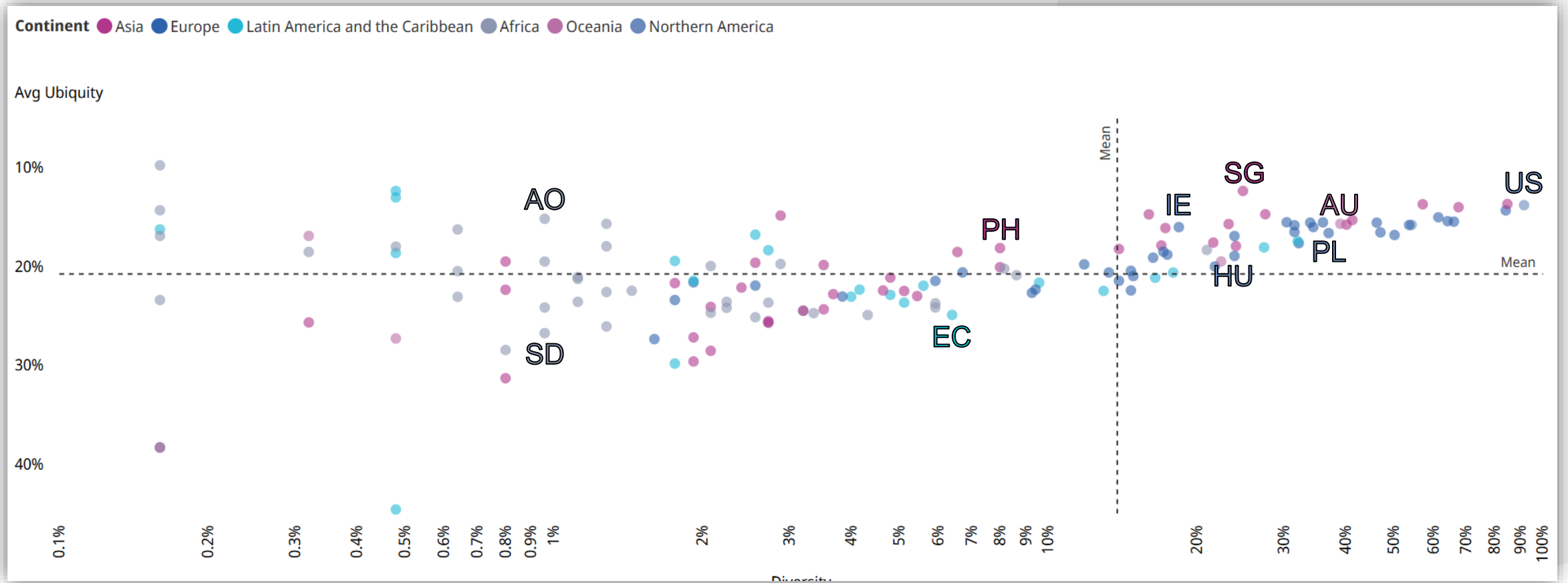
| Capability | Share of Ecosystems | Rank |
|-------------|---------------------|-----------------------|
| Coffee | 21% | 4 th |
| Cork | 3% | 1st |
| Optics | 5% | 2 nd |
| Nanoscience | 5% | 2 nd |



Cork is the rarest capability that an ecosystem can master...

Diversity vs. ubiquity by national ecosystems

Based on capabilities co-occurrence of 626 scientific, technological and product fields, 2020.



Source: [WOS SCIE](#), [EPO PATSTAT](#), [UN COMTRADE](#) • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data. Income levels follow the World Bank's classification of economies by income.

Main indicators for Capabilities (2)

Average Diversity

Reflects how diverse are the ecosystems that master each capability.

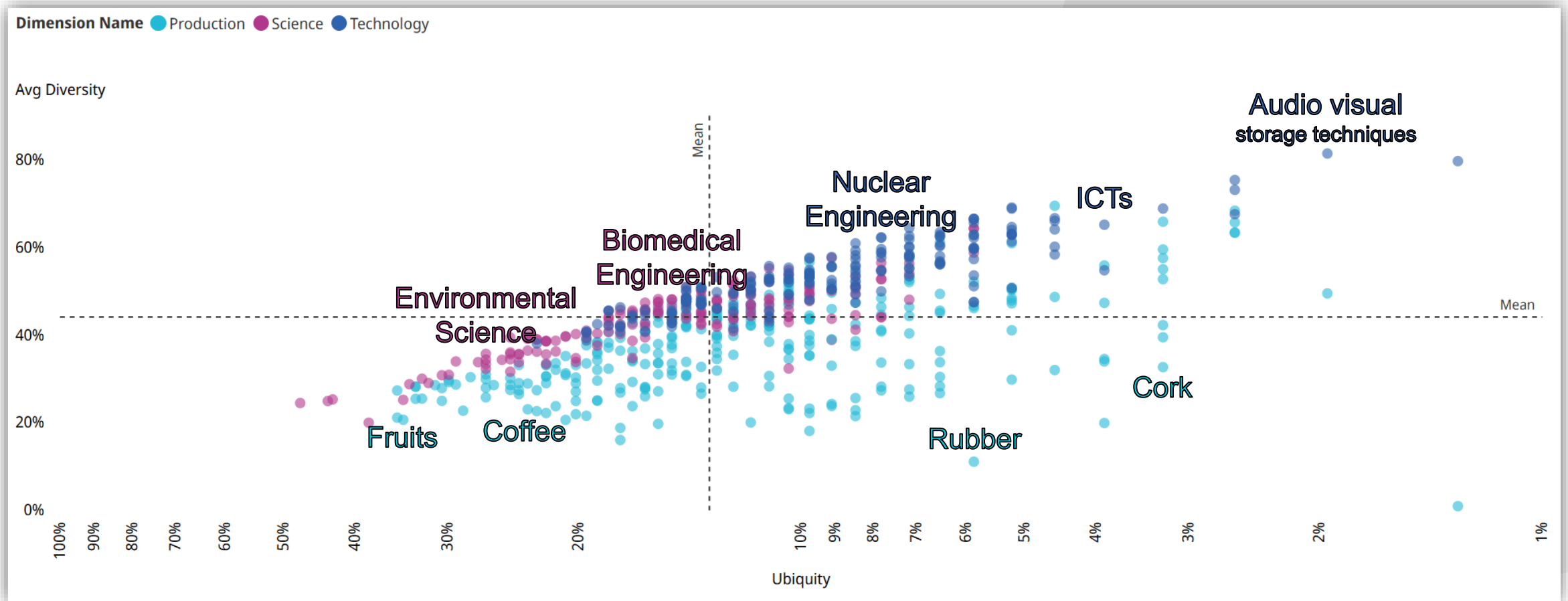
| Capability | Share of fields | Rank |
|---------------|-----------------|-----------------------|
| Coffee | 23% | 4 th |
| Cork | 32% | 3 rd |
| Optics | 63% | 1st |
| Nanoscience | 59% | 2 nd |



... however, Optics is mastered only in places with many skills. Cork may be rare, but easier to master.

Ubiquity vs. diversity by field of innovation

Based on capabilities co-occurrence of 626 scientific, technological and product fields, 2020.



Source: [WOS SCIE](#), [EPO PATSTAT](#), [UN COMTRADE](#) • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data. Income levels follow the World Bank's classification of economies by income.

Main indicators within Capabilities

Proximity of fields

Indicates how often two types of knowledge coincide in one place.

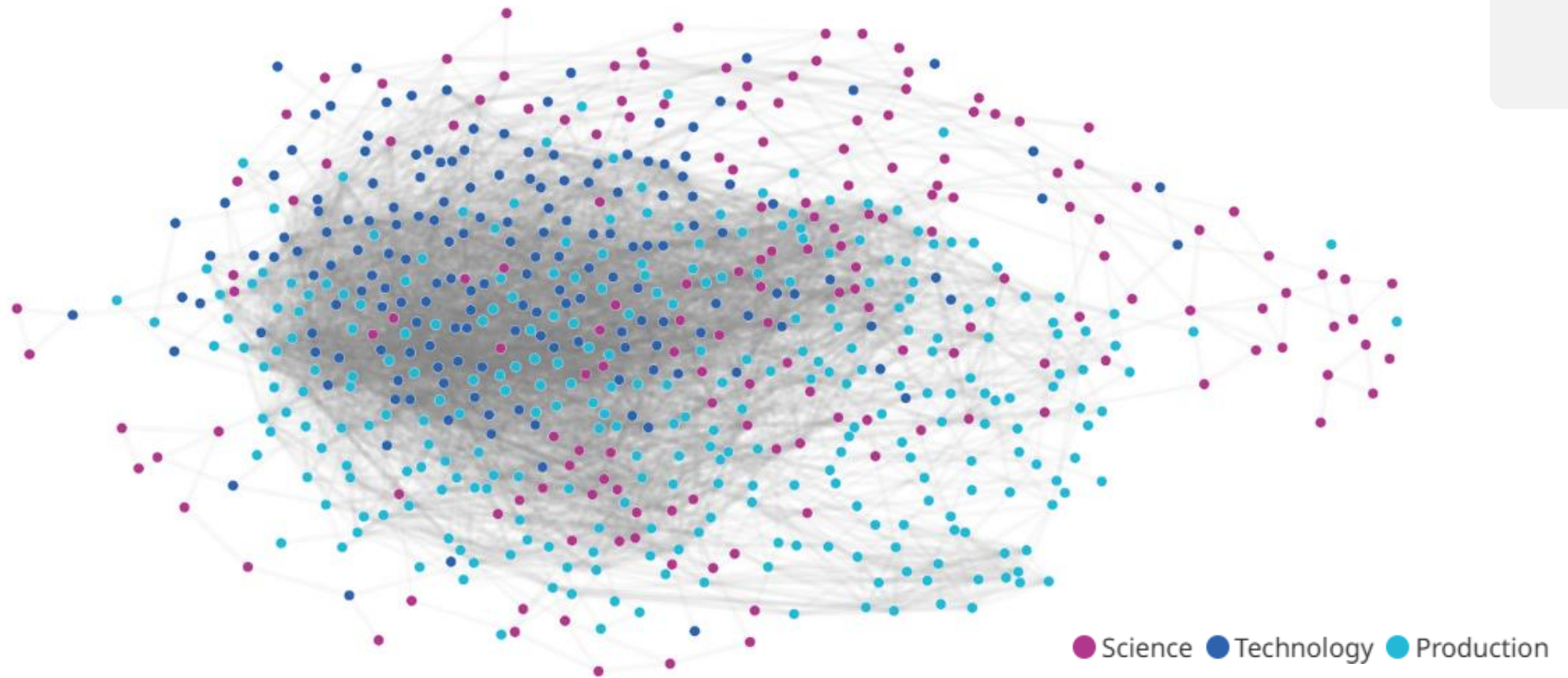
| Field A | Field B | Proximity |
|-------------------|-------------------|-----------|
| Materials | Applied physics | 92% |
| Agronomy | Tropical medicine | 49% |
| Printing machines | Petroleum oils | 5% |



Materials and applied physics tend to appear together in most of the times. Printing machines are not as connected to petroleum oils.

The innovation capability space

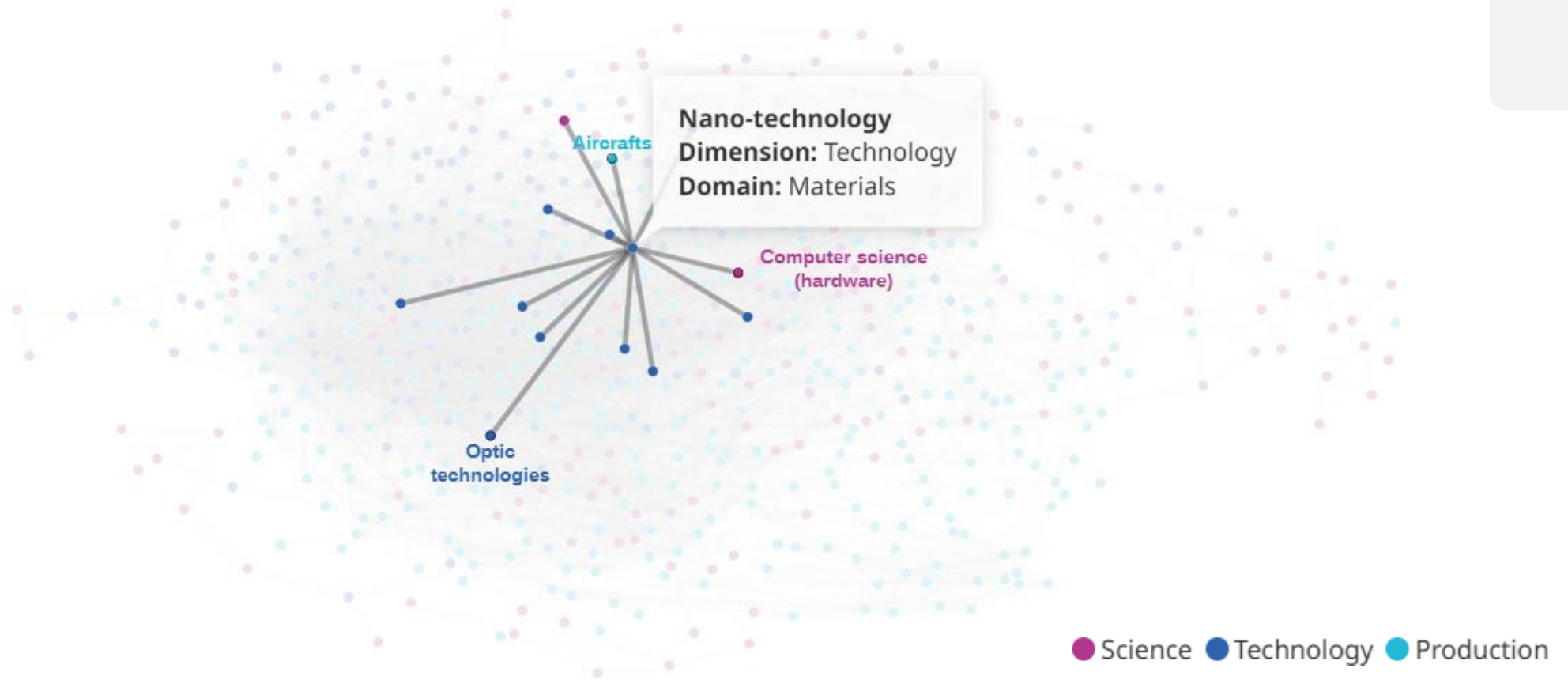
Using co-occurrence to measure the proximity between capabilities.



Source: [WOS SCIE](#), [EPO PATSTAT](#), [UN COMTRADE](#) • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data. Income levels follow the World Bank's classification of economies by income.

The innovation capability space

Using co-occurrence to measure the proximity between capabilities.



Source: [WOS SCIE](#), [EPO PATSTAT](#), [UN COMTRADE](#) • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data. Income levels follow the World Bank's classification of economies by income.

Main indicators within Ecosystems

Proximity of ecosystems

Reflects how often two ecosystems coincide in one capability.

| Ecosystem A | Ecosystem B | Proximity |
|---------------|-------------|-----------|
| United States | China | 87% |
| Belgium | Canada | 54% |
| Peru | Switzerland | 9% |

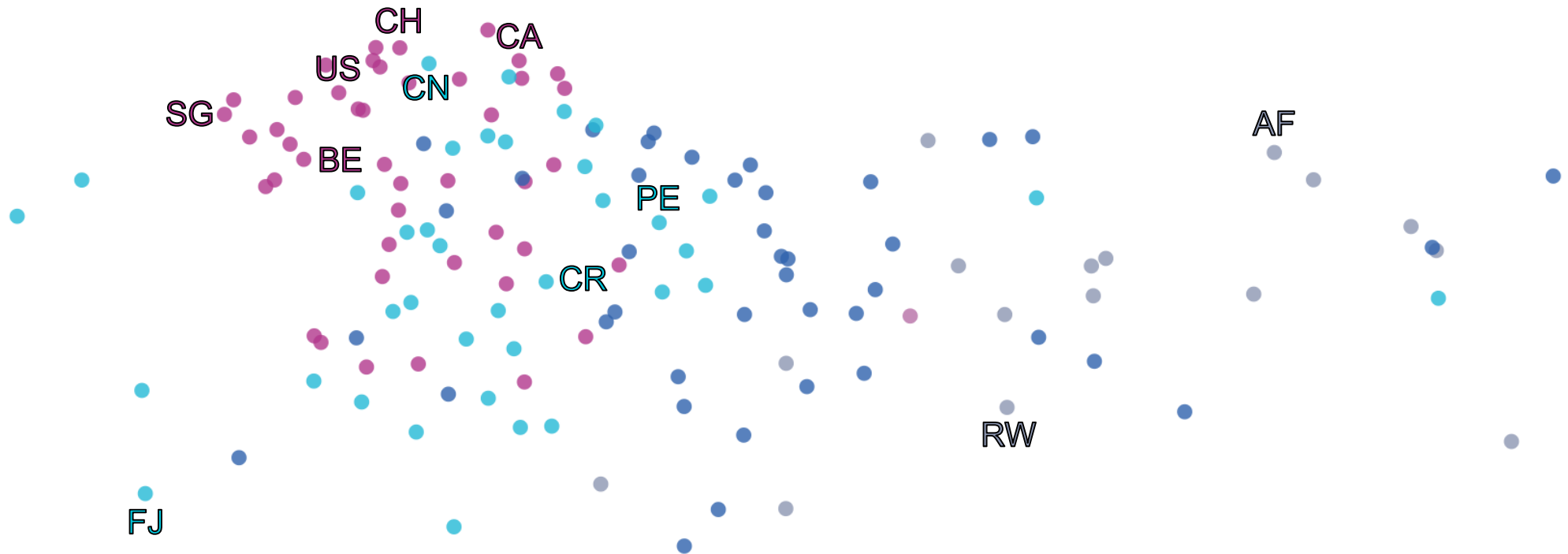


China and the US share 87% of their innovation capabilities. Switzerland and Peru have very different skills.

The innovation ecosystem space

Using co-occurrence to measure the proximity between ecosystems.

Income Group ● High ● Upper-Middle ● Lower-Middle ● Low



Main indicators between Capabilities and Ecosystems (1)

Relatedness

Indicates how close are the skills of an innovation ecosystem to an innovation field.

| Ecosystem | Field | Relatedness |
|-----------|--------|-------------|
| Italy | Optics | 60% |
| Egypt | Optics | 14% |
| Italy | Coffee | 74% |
| Egypt | Coffee | 26% |

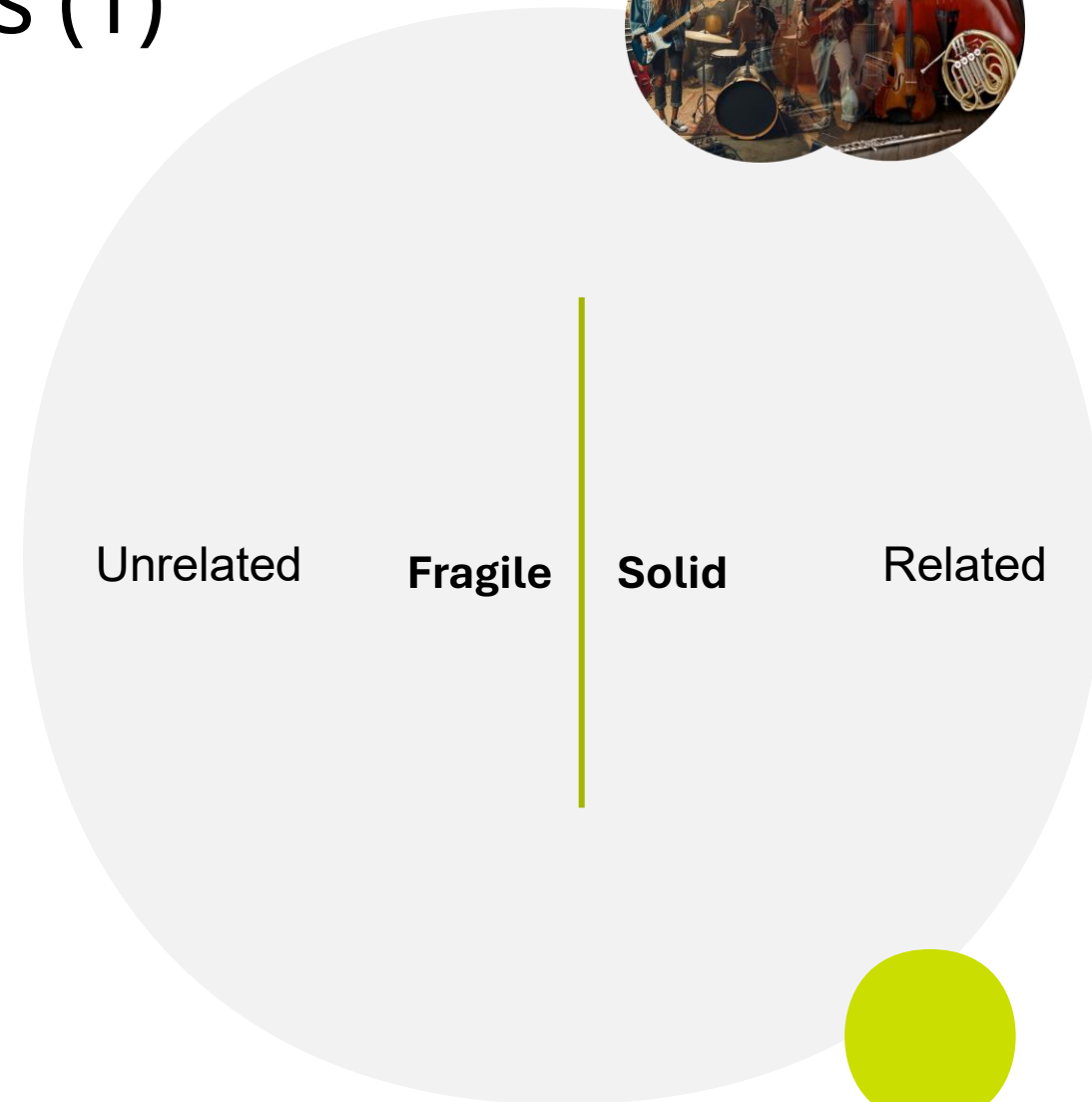


Despite for both ecosystems, its relatedness to coffee is higher than to optics, for Egypt the relatedness of coffee almost doubles the optics one, while for Italy, this difference is narrower.

Interpreting the main indicators (1)

For ecosystem current capabilities

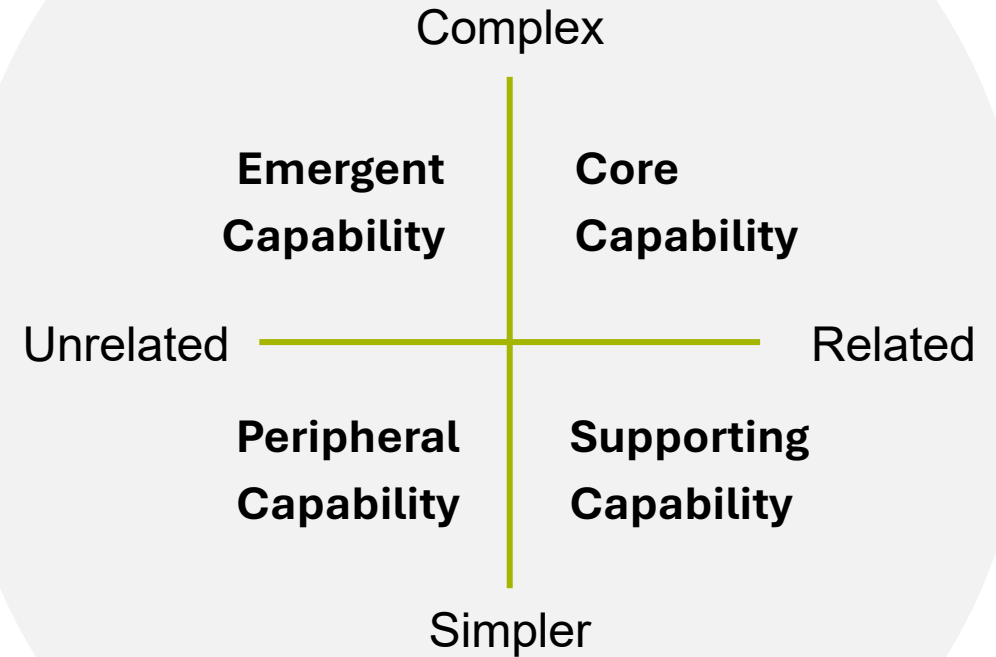
- **Solid capabilities.** Current capabilities that are surrounded by complementary skills. Ecosystems tend to keep them.
- **Fragile capabilities.** Current capabilities that are not surrounded by complementary skills. **73% of lost capabilities are fragile.**



Interpreting the main indicators (1)

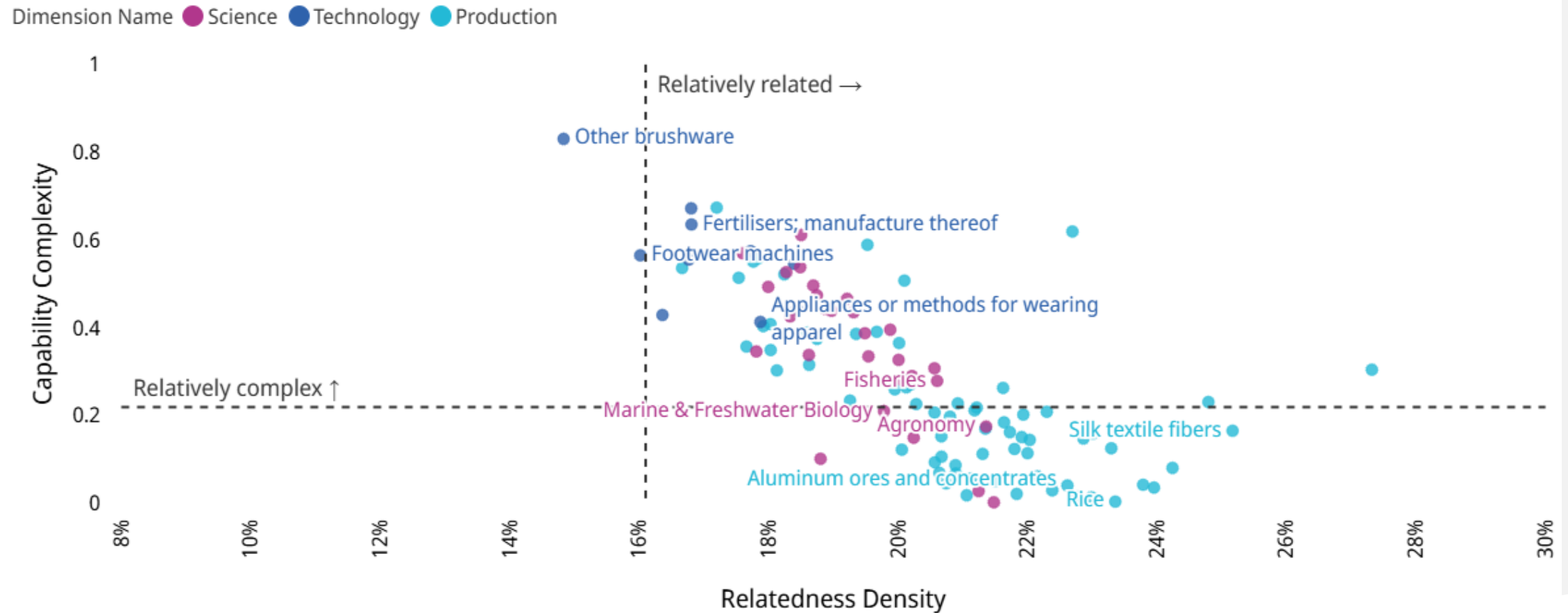
For ecosystem current capabilities

- **Established capabilities.** Current capabilities that are surrounded by complementary skills. **Ecosystems tend to keep them.**
 - Core. Complex for the ecosystem.
 - Supporting. Simpler for the ecosystem.
- **Fragile capabilities.** Current capabilities that are not surrounded by complementary skills. **73% of lost capabilities are fragile.**
 - Emergent. Complex for the ecosystem.
 - Peripheral. Simpler for the ecosystem.



Assessing the strengths of an ecosystems

Based on capabilities co-occurrence of 626 scientific, technological and product fields, 2020.



Source: [WOS SCIE](#), [EPO PATSTAT](#), [UN COMTRADE](#) • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data. Income levels follow the World Bank's classification of economies by income.

Interpreting the main indicators (2)

For ecosystem current capabilities

- **Lower-risk opportunities.** Unattained capabilities closely related to current ones. **Ecosystems tend to diversify into these 90% of the times.**
- **High risk ventures:** Unattained capabilities requiring unrelated ones, making them hard to master and keep on the longer term.

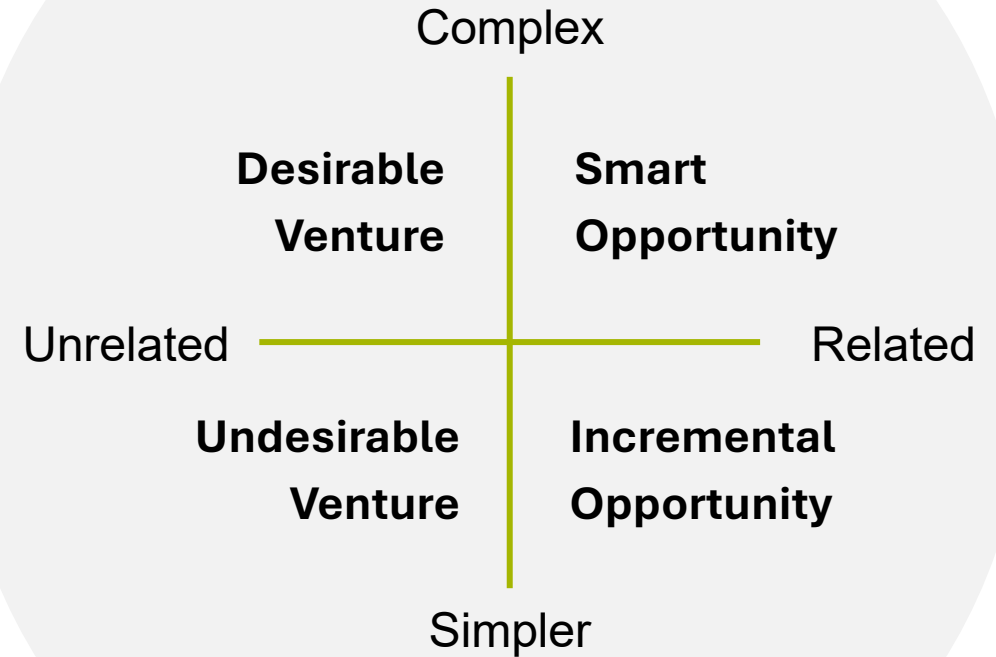


Unrelated **Ventures** **Lower-risk** Related

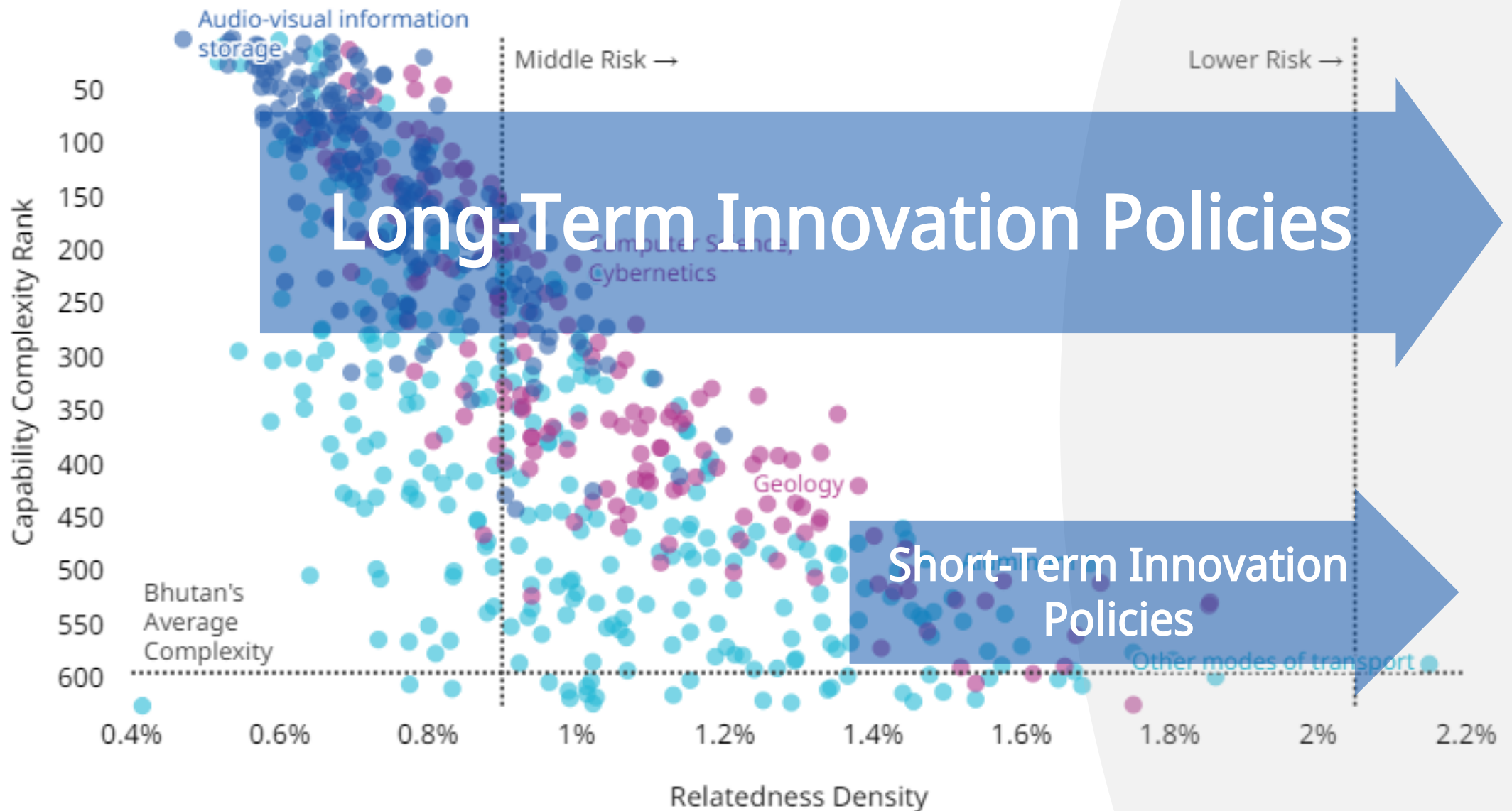
Interpreting the main indicators (2)

For ecosystem unattained capabilities

- **Lower-risk opportunities.** Unattained capabilities closely related to current ones. **Ecosystems tend to diversify into these 90% of the times.**
 - Smart opportunities. Complex for the ecosystem.
 - Incremental opportunities. Simpler for the ecosystem.
- **High risk ventures:** Unattained capabilities requiring unrelated ones, making them hard to keep.
 - Desirable ventures. Complex for the ecosystem.
 - Undesirable ventures. Simpler for the ecosystem.



Complexity and relatedness mapping for Bhutan's unattained capabilities



Main indicators between Capabilities and Ecosystems (2)



Potential

Reflects what an ecosystem could produce in an innovation field, given its current skills.

| Ecosystem | Field | Potential |
|-----------|--------|-----------------|
| Italy | Optics | + 140% patents |
| Egypt | Optics | + 2110% patents |
| Italy | Coffee | - 70% exports |
| Egypt | Coffee | + 760% exports |

Italian scientific and productive capabilities could generate an extra 140% extra optical patents in the ecosystem...

Unveiling technological potential

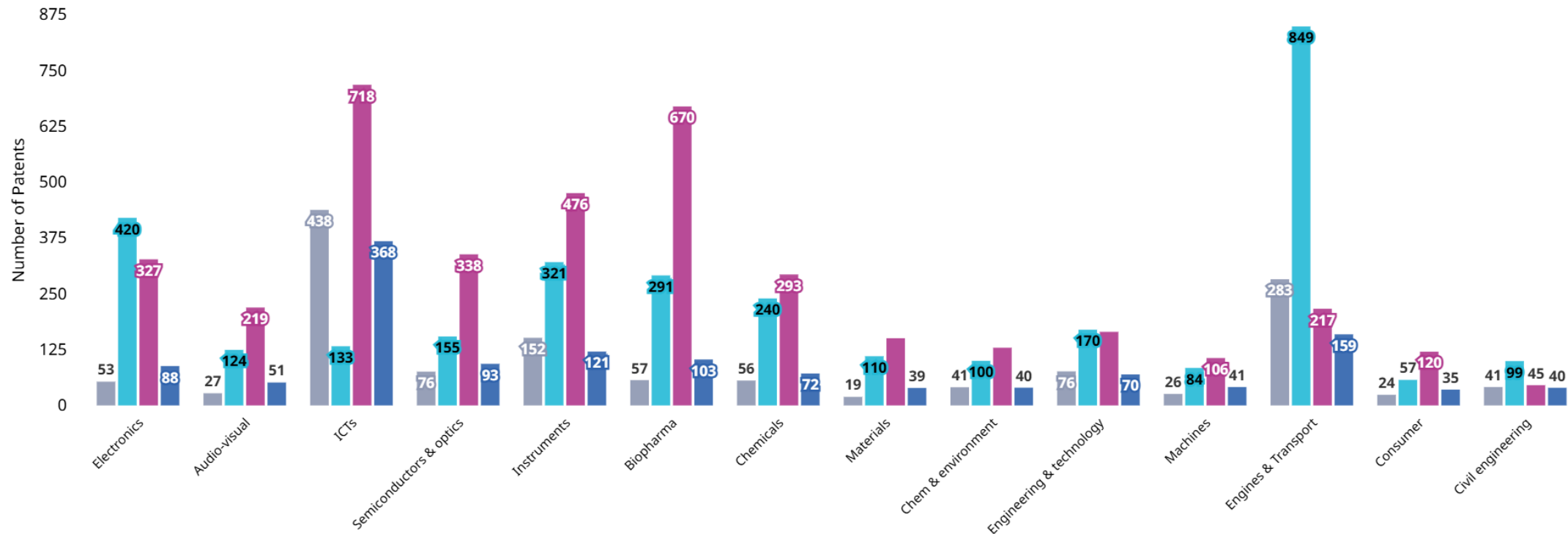
Every innovation ecosystem harbors unseen innovation potential—unlocking it could spark groundbreaking advancements and growth.

The tapped and untapped technological potential

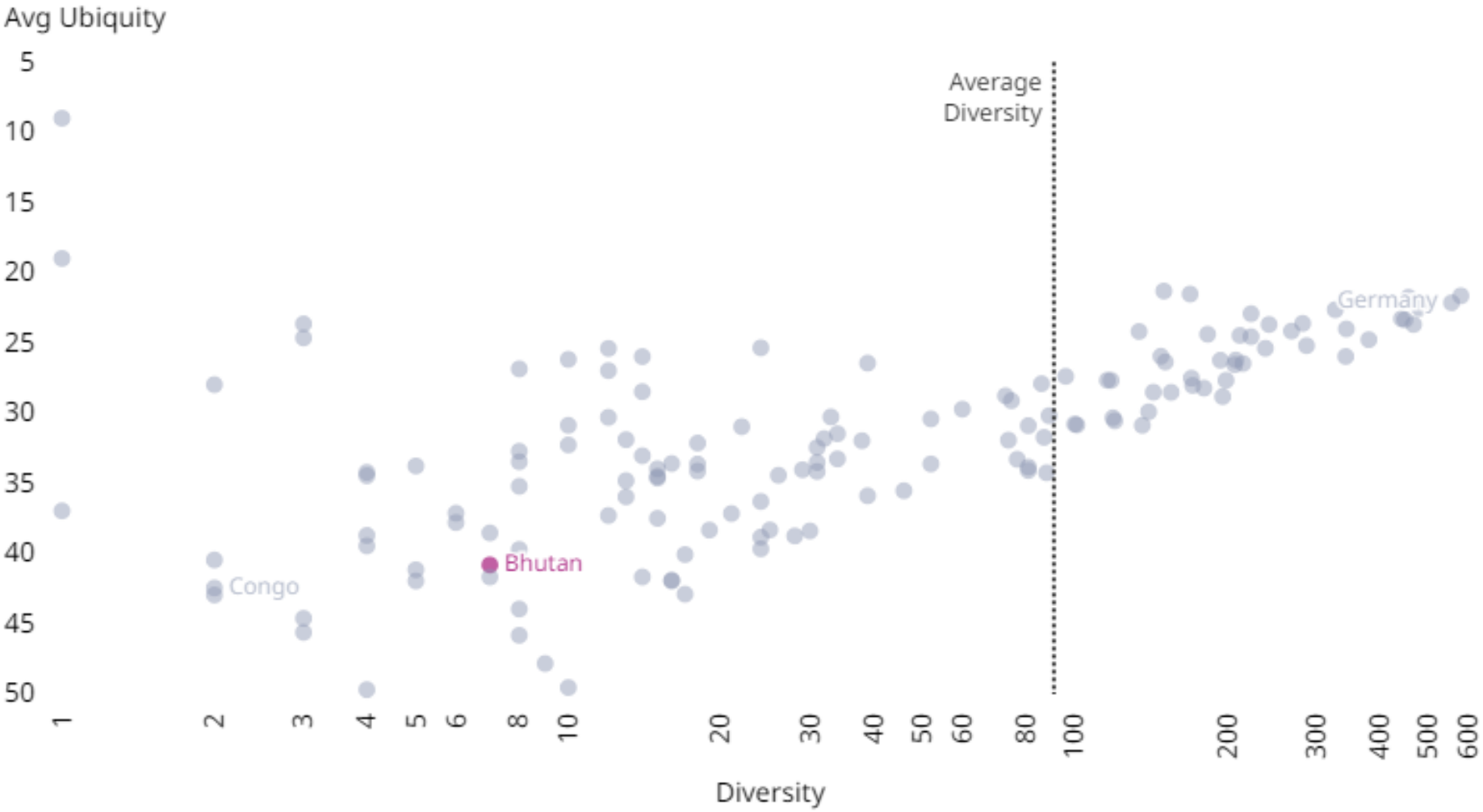
Average yearly technological outputs by domain, with their corresponding potentials

Country Romania

Actual Technology Outputs Production based Potential Scientific based Potential Technology based Potential

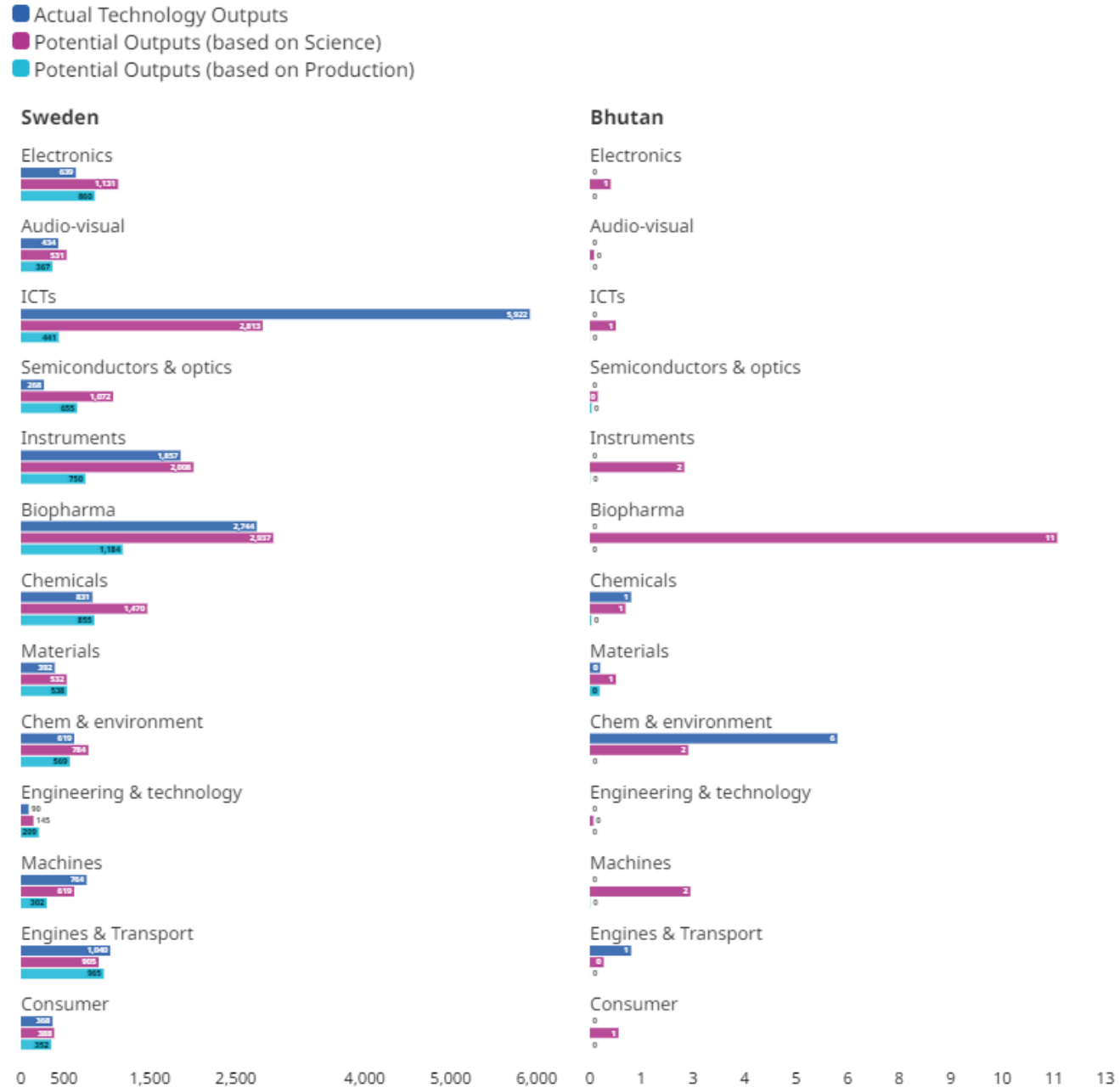


Bhutan capabilities



Bhutan's science points towards potential technological inventions

Yearly technological outputs vs. untapped potential. Comparison between Sweden and Bhutan



Key takeaways

Mapping innovation capabilities can help policymakers implement innovation policies.

- Risk-reward framework
- Assess their development path
- Identify and solidify strengths
- Find missing links and new opportunities



A large, solid pink shape in the top right corner of the slide, with a jagged, stepped edge that tapers towards the top right.

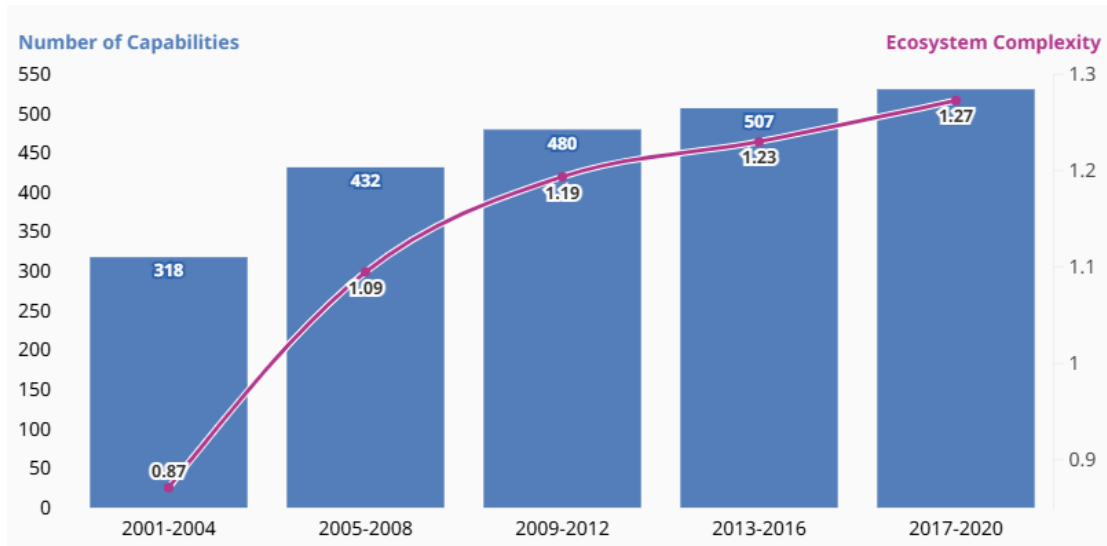
Activity

Interpreting Innovation Capability Indicators

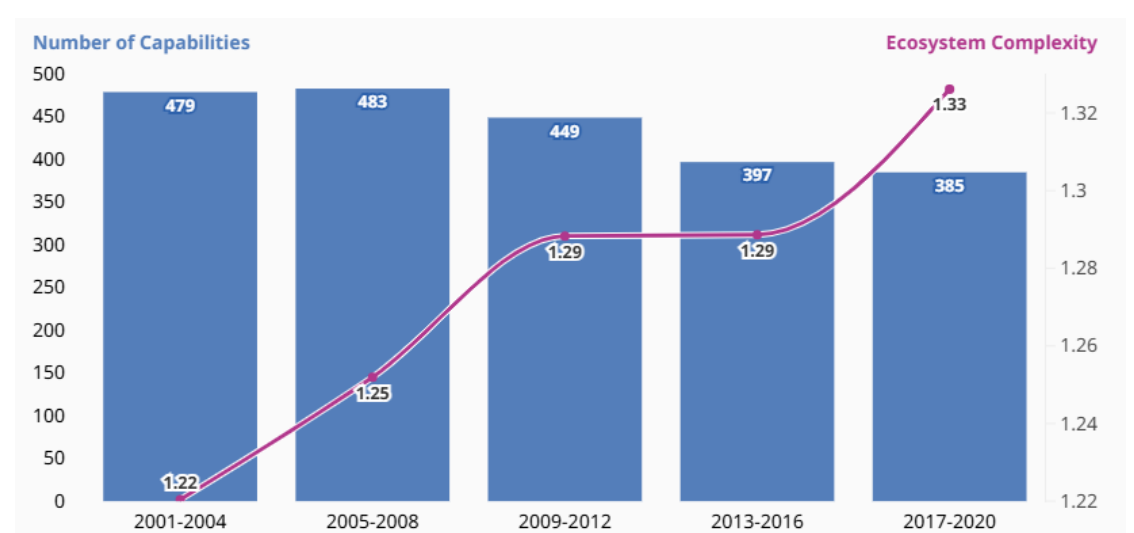
Unfolding the capability path (1)

Examining the evolution of the ecosystem's performance can help identify if the path to development is on the right track.

China



United Kingdom

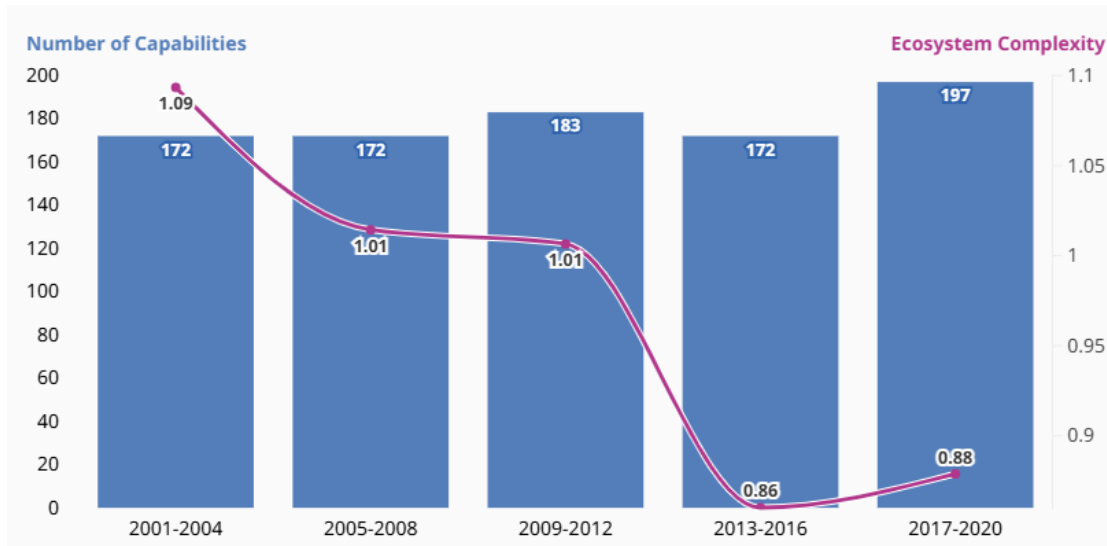


Unfolding the capability path (2)

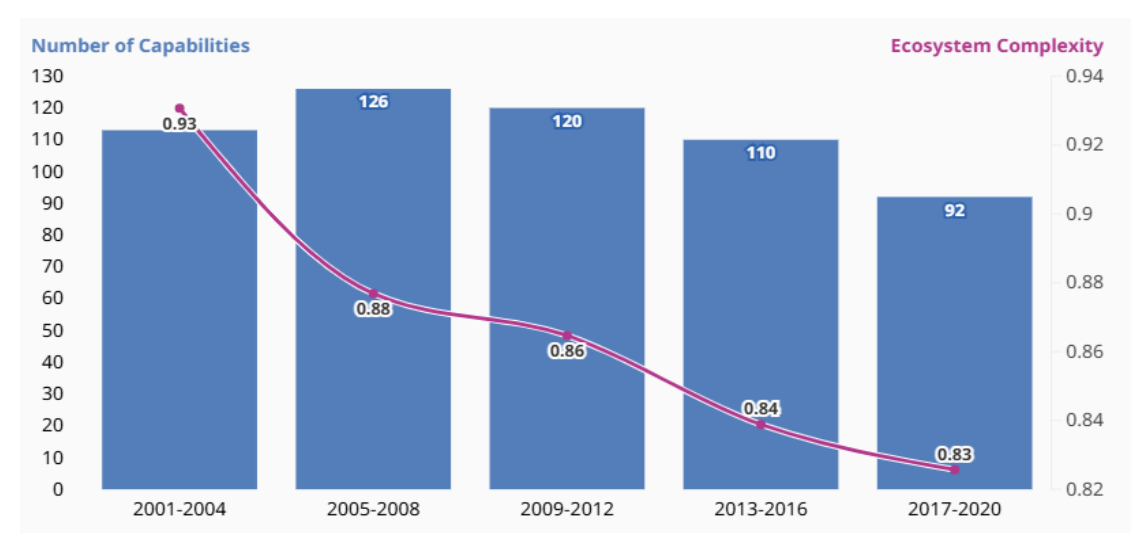
Innovation intensity measures the types of fields an ecosystem prioritizes for its innovation outputs.

Complex ecosystems tend to concentrate their specializations in more complex fields of innovation.

Russia



Slovenia

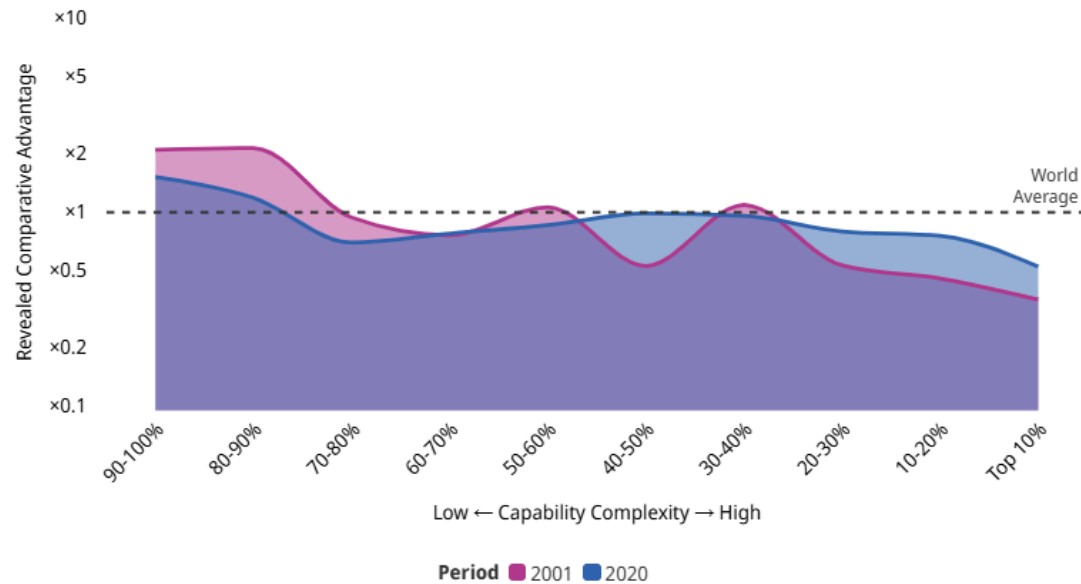


Optimizing innovation (1)

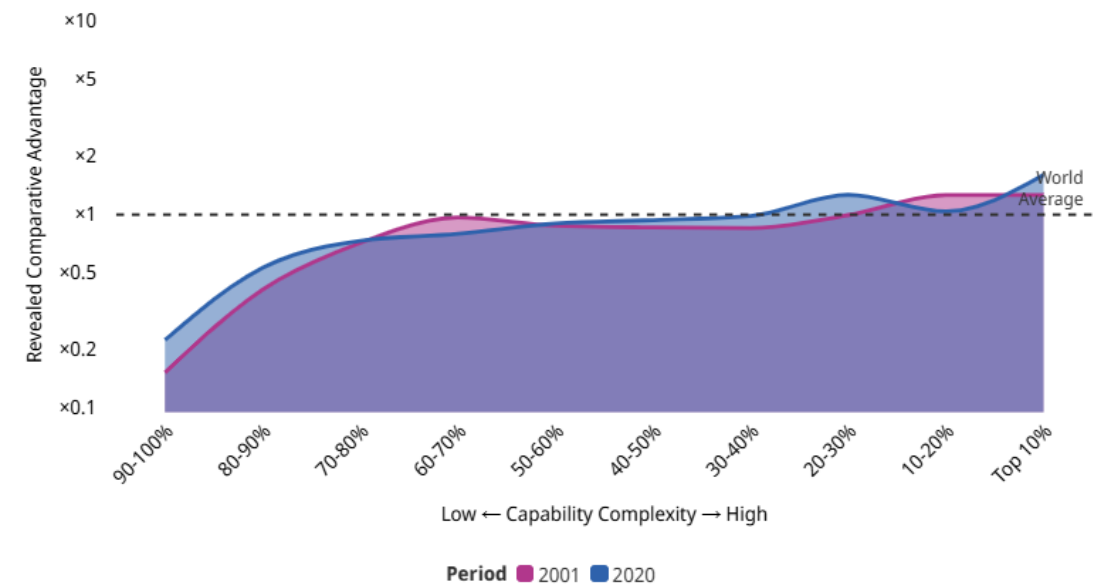
Innovation intensity measures the types of fields an ecosystem prioritizes for its innovation outputs.

Complex ecosystems tend to concentrate their specializations in more complex fields of innovation.

India



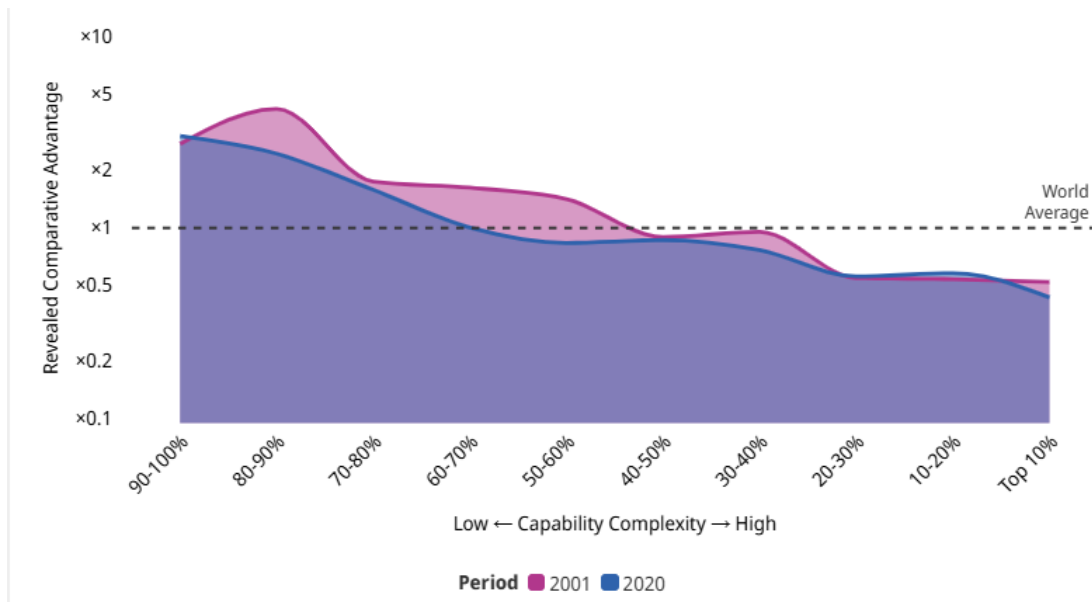
Japan



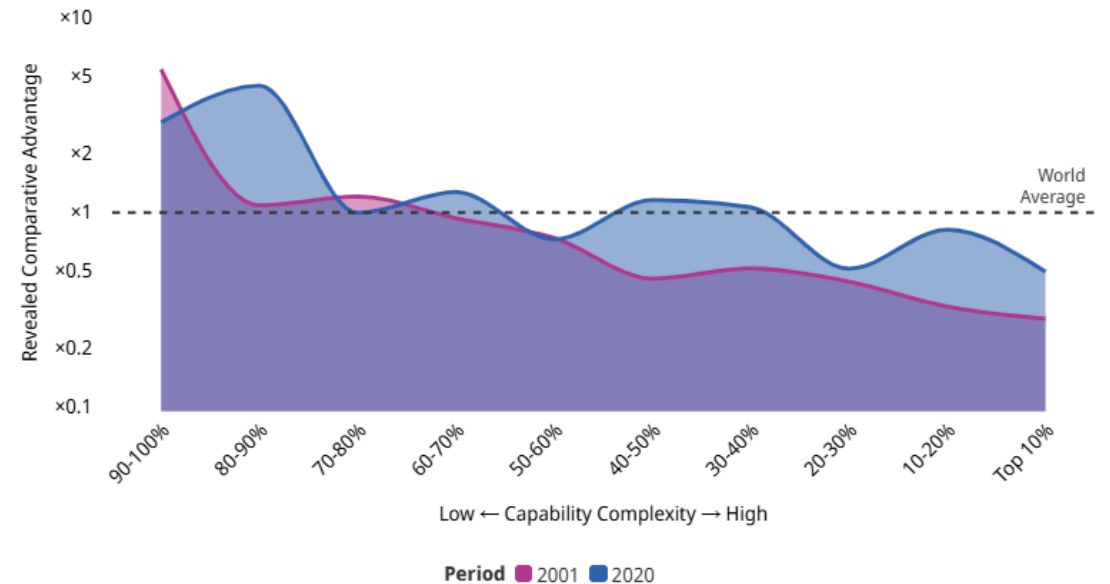
Optimizing innovation (2)

Examining the evolution of the ecosystem's performance can help identify if the path to development is on the right track.

Argentina



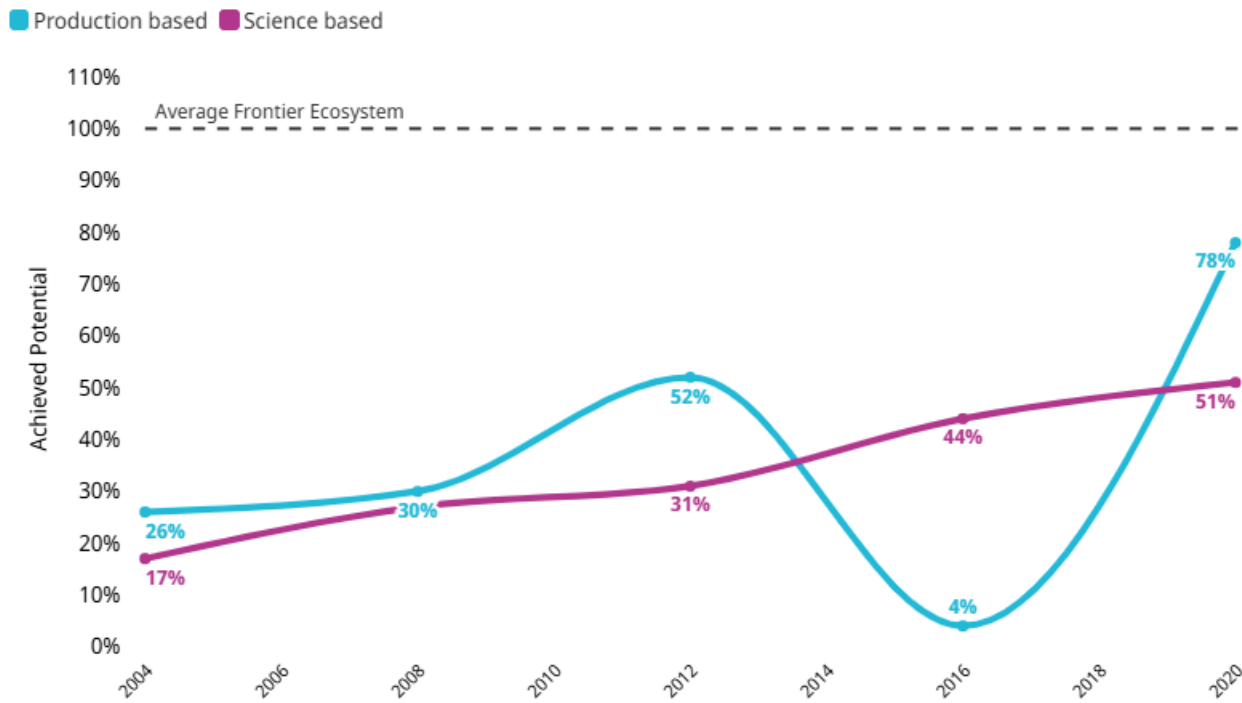
Morocco



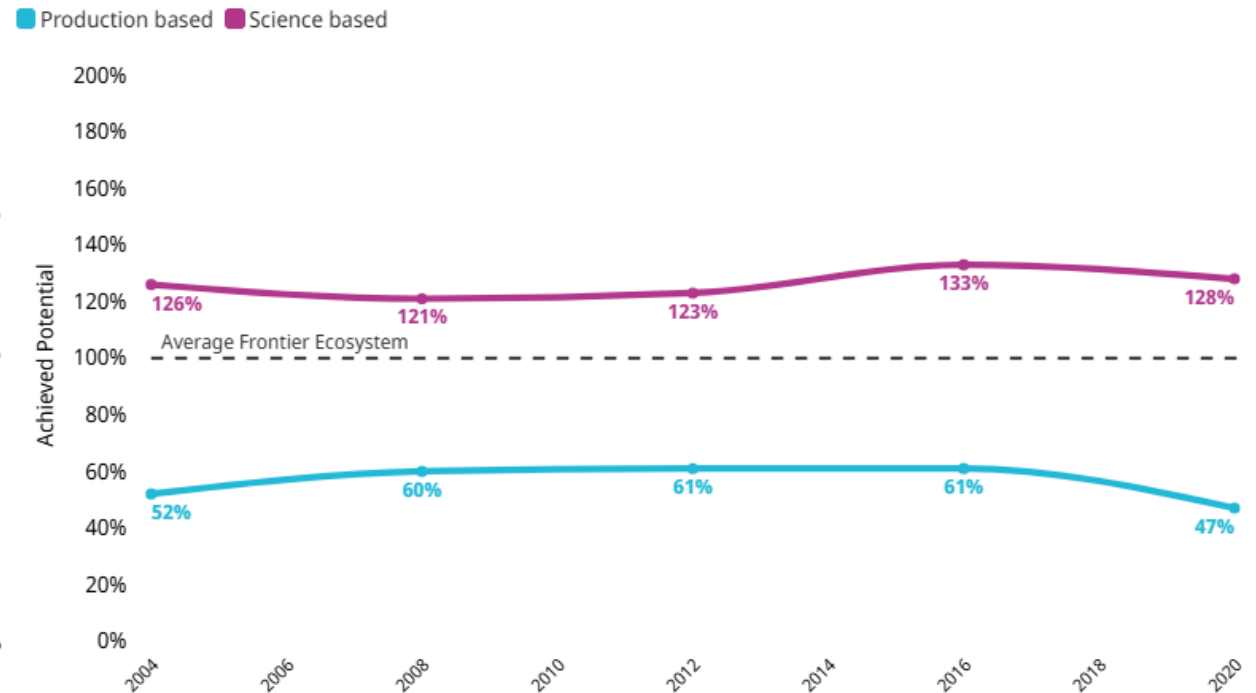
Tapping potential (1)

Science and Production can shed light into untapped Technological Potential

Chile



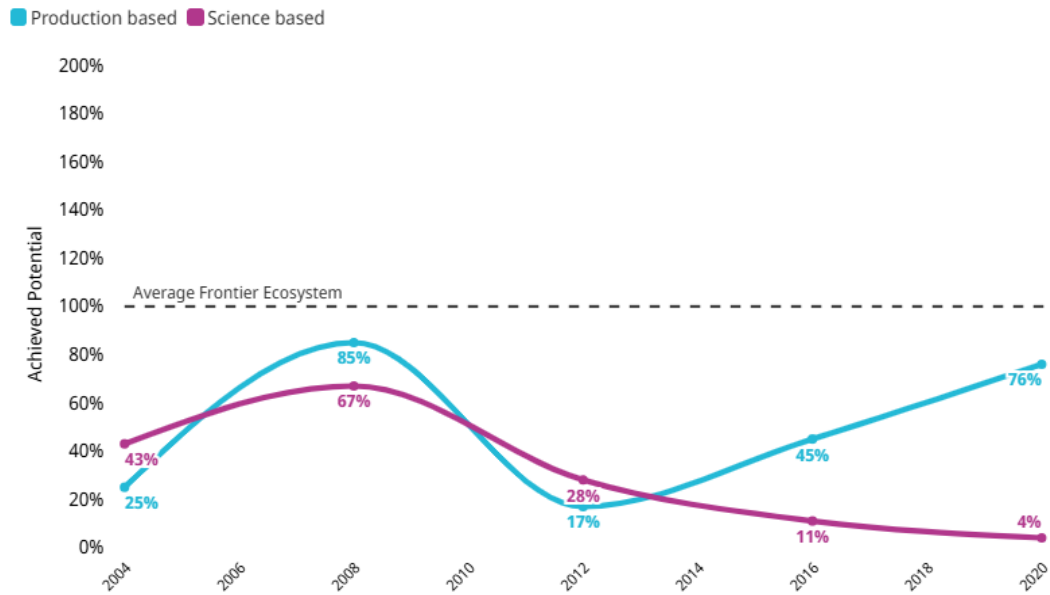
Netherlands



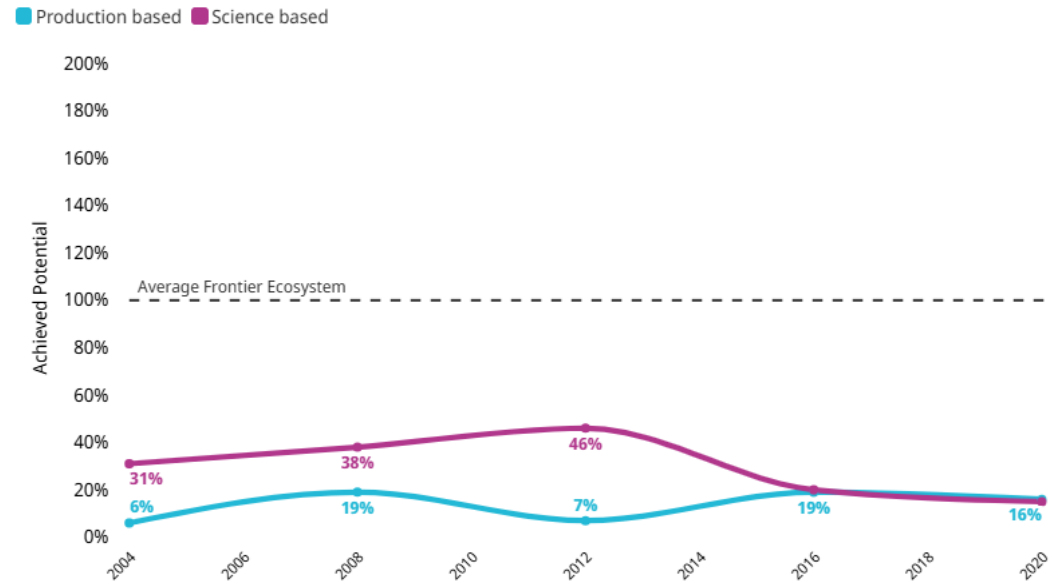
Tapping potential (2)

Science and Production can shed light into untapped Technological Potential

Pakistan



Qatar



Exploring the world capabilities




Thank you!

chief.economist@wipo.int



© WIPO, 2025

 Attribution 4.0 International (CC BY 4.0)

The CC license does not apply to non-WIPO content in this presentation.

Photo credits: Getty Images



Main indicators

For ecosystems



Diversity

Measures the number of innovation capabilities an ecosystem masters.

| Ecosystem | Share of fields | Rank |
|----------------|-----------------|-----------------------|
| Cascadia | 4% | 4 th |
| Lumindale | 27% | 2 nd |
| Meridia | 54% | 1st |
| Millbrook | 24% | 3 rd |

Note: Complexity can be derived from diversity and ubiquity. Average ubiquity is the first iteration of the algorithm that defines the complexity of ecosystems.

Main indicators

For innovation capabilities

Ubiquity

Indicates how common a **capability** is across innovation ecosystems.

| Capability | Share | Rank (of 626) |
|-------------|-------|-------------------|
| Coffee | 21% | 571 st |
| Cork | 3% | 16 th |
| Optics | 5% | 44 th |
| Nanoscience | 5% | 64 th |

Average Diversity → Complexity

Reflects how diverse are the ecosystems that have each capability.

| Capability | Share (of 626) | Rank (of 626) | |
|-------------|----------------|-------------------|----------------|
| Coffee | 23% | 605 th | E ¹ |
| Cork | 32% | 516 th | D ² |
| Optics | 63% | 29 th | X ⁸ |
| Nanoscience | 59% | 57 th | K ⁵ |

Note: Complexity can be derived from diversity and ubiquity. Average diversity is the first iteration of the algorithm that defines the complexity of capabilities.



Main indicators

Between capabilities and ecosystems



Relatedness

Indicates how close are the skills of an innovation ecosystem to an innovation field¹.

| Ecosystem | Field | Relatedness |
|-----------|--------|-------------|
| Italy | Optics | 60% |
| Egypt | Optics | 14% |
| Italy | Coffee | 74% |
| Egypt | Coffee | 26% |

Potential

Reflects what an ecosystem could produce in an innovation field, given its current skills².

| Ecosystem | Field | Potential |
|-----------|--------|-----------|
| Italy | Optics | 1.4 |
| Egypt | Optics | 21.1 |
| Italy | Coffee | - 0.7 |
| Egypt | Coffee | 7.6 |

¹ Note: Despite for both ecosystems, its relatedness to coffee is higher than to optics, for Egypt the relatedness of coffee almost doubles the optics one, while for Italy, this difference is narrower.

² The potential exercise places all the capabilities of an innovation ecosystem in a frontier economy, where the connections between the actors of the ecosystem are well established.

Main indicators

Within capabilities and ecosystems



Proximity of fields

Indicates how often two types of knowledge coincide in one place.

| Capability A | Capability B | Proximity |
|-------------------|-------------------|-----------|
| Materials | Applied physics | 92% |
| Agronomy | Tropical medicine | 49% |
| Printing machines | Petroleum oils | 5% |

Proximity of ecosystems

Reflects how often two ecosystems coincide in one capability.

| Ecosystem A | Ecosystem B | Proximity |
|---------------|-------------|-----------|
| United States | China | 87% |
| Belgium | Canada | 54% |
| Peru | Switzerland | 9% |

Unfolding the capability path

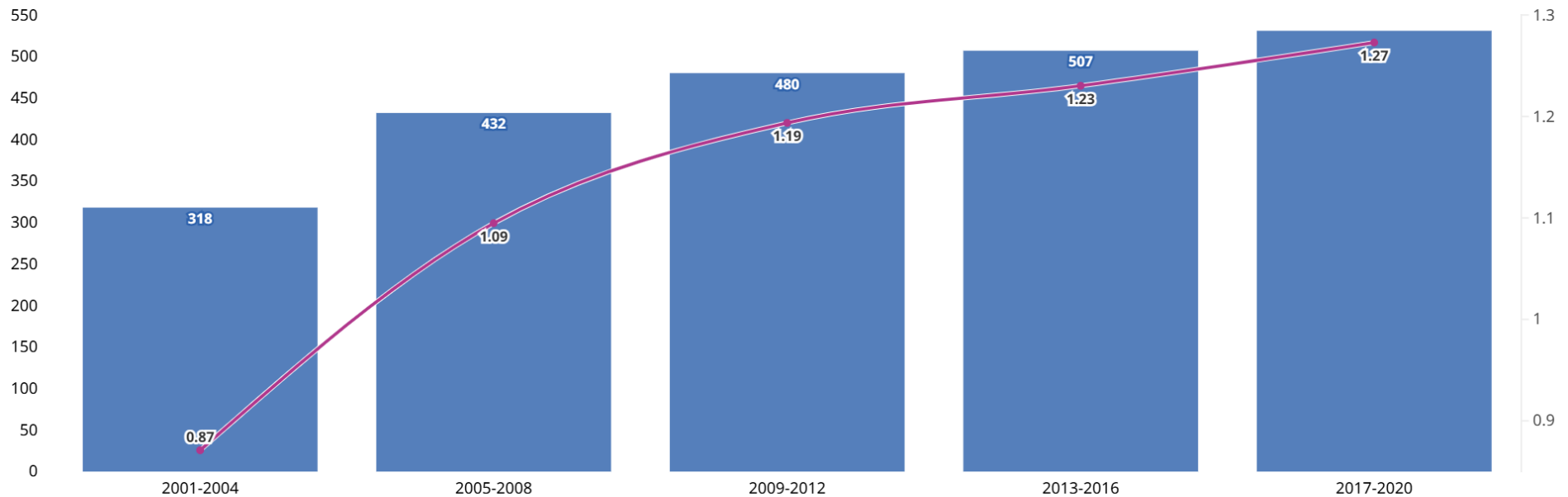
Examining the evolution of the ecosystem's performance can help identify if the path to development is on the right track.

As ecosystems diversify, they tend to adopt more complex capabilities

Evolution of Diversity and Complexity, 2001-2020

China

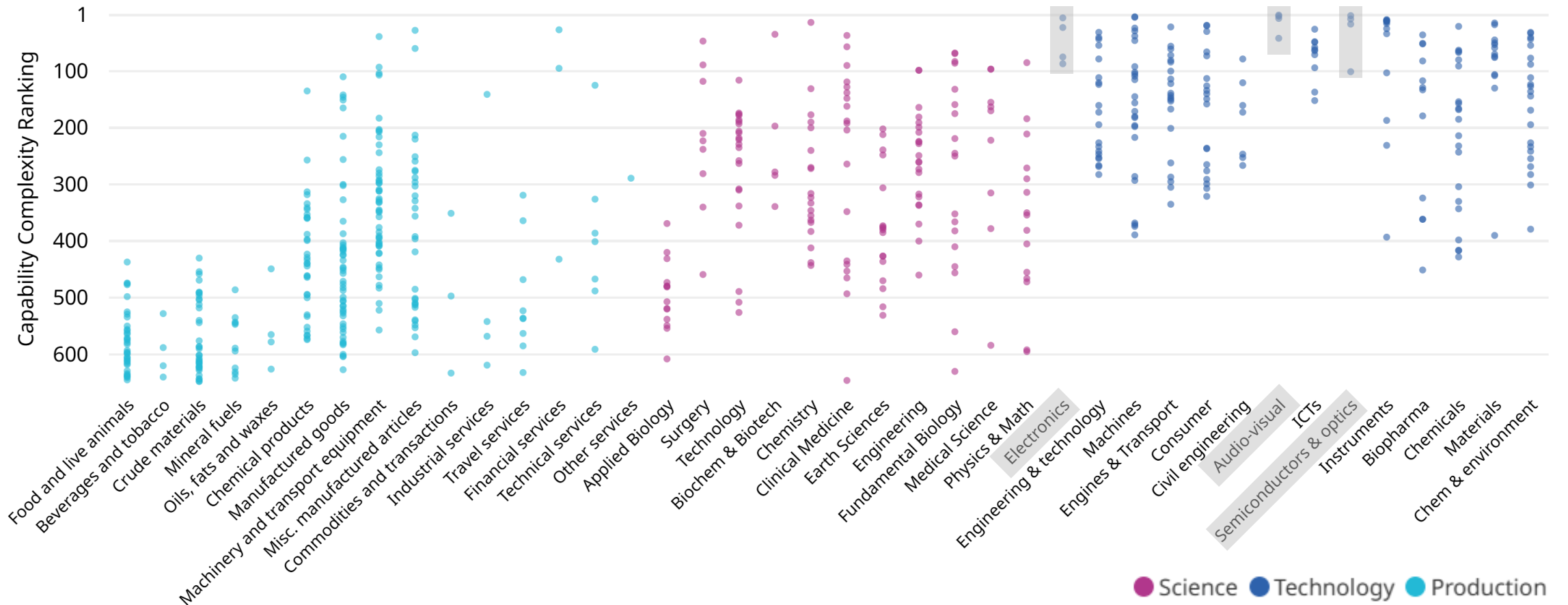
Number of Capabilities



Source: WOS SCIE, EPO PATSTAT, UN COMTRADE • 626 innovation capabilities based on scientific fields, IPC subclasses and product classification in scientific publications, international patent applications and exports data.

The complexity spectrum

All 626 world innovation capabilities, ranked by complexity levels



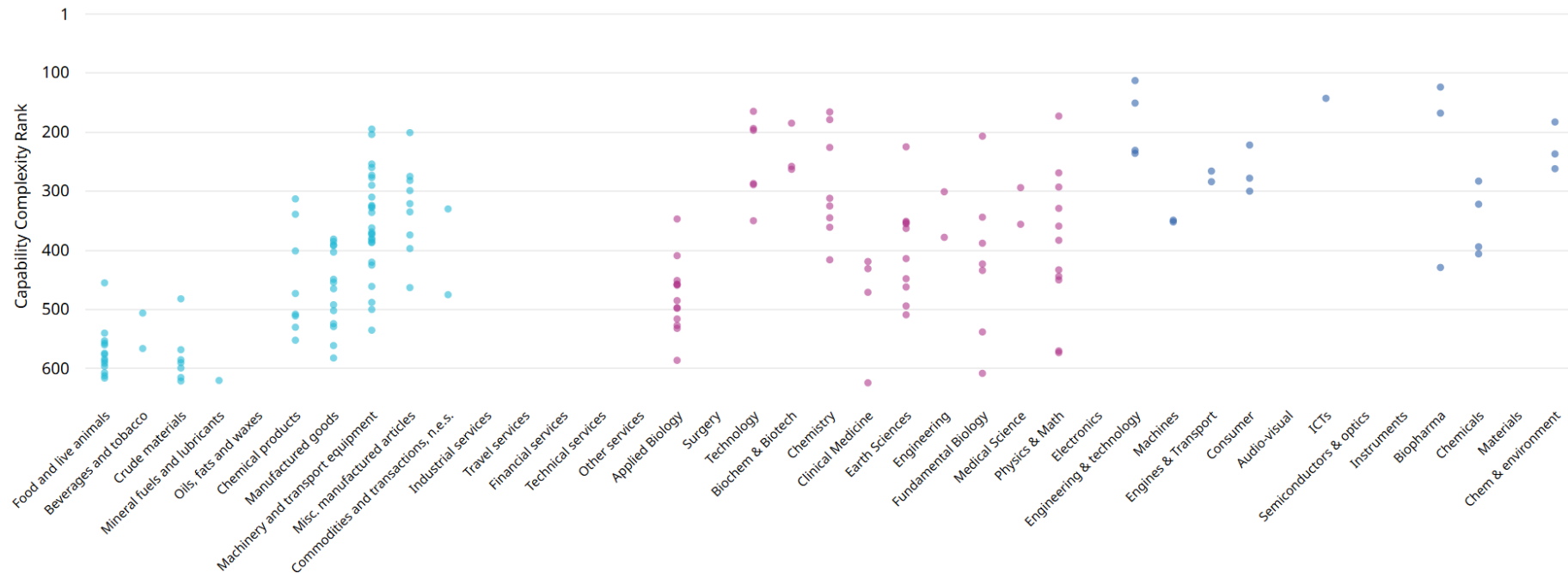
Assessing current capabilities

Ecosystems can understand which of their actual capabilities are the most precious and look into ways of nurturing them.

The complexity of innovation capabilities
626 capabilities, grouped by domain

Ecosystem Mexico

Dimension ● Science ● Technology ● Production



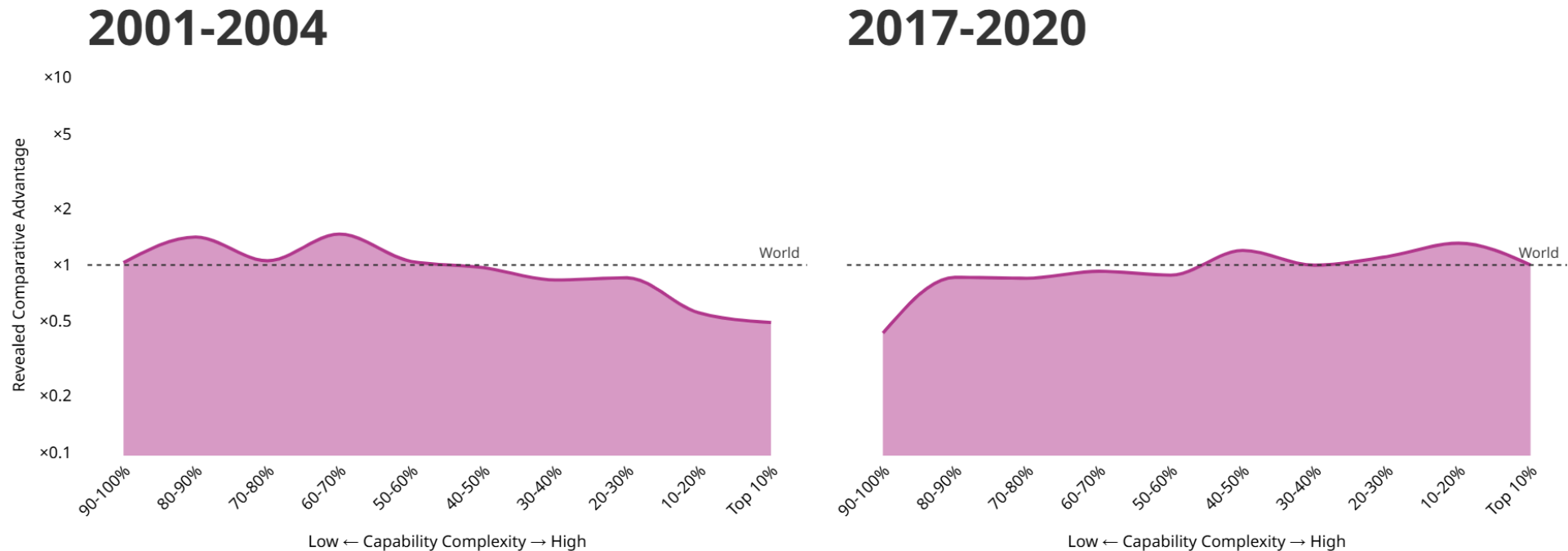
Optimizing innovation outputs

Innovation ecosystems that master complex skills face a new challenge: optimizing their outputs by strategically focusing on their most valuable capabilities.

The Intensity of an Innovation Ecosystem's Outputs

Specialization levels of innovation ecosystems by capability complexity, 2004 vs 2020.

Ecosystem



Innovation intensity measures the types of fields an ecosystem prioritizes for its innovation outputs. Complex ecosystems tend to concentrate their specializations in more complex fields of innovation.

Finding new opportunities

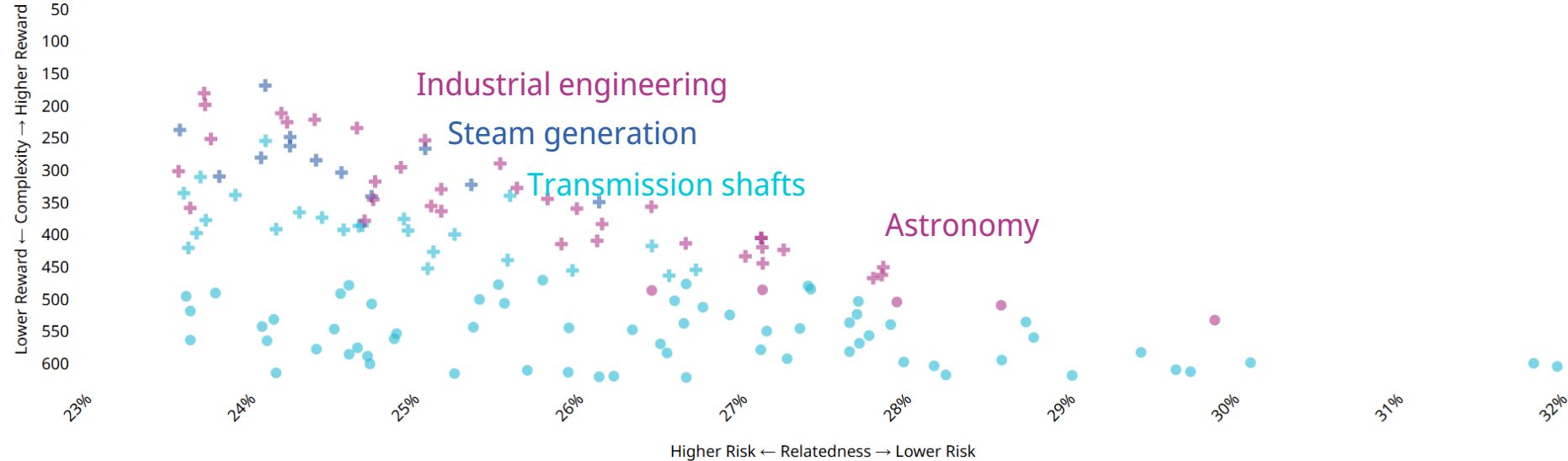
By identifying their capabilities, innovation ecosystems can find where to look for new areas to develop and prioritize the most promising ones.

Ecosystem Opportunities for Smart Diversification

Relatedness and Complexity mapping for unattained capabilities

Thailand

Dimension Name ● Production ● Technology ● Science



Source: WIPR 2024 • Capabilities marked with + are relatively complex to the innovation ecosystem. Capabilities marked with • are relatively simple to the ecosystem. The chart only shows capabilities that are relatively highly related to the ecosystem.

Unveiling technological potential

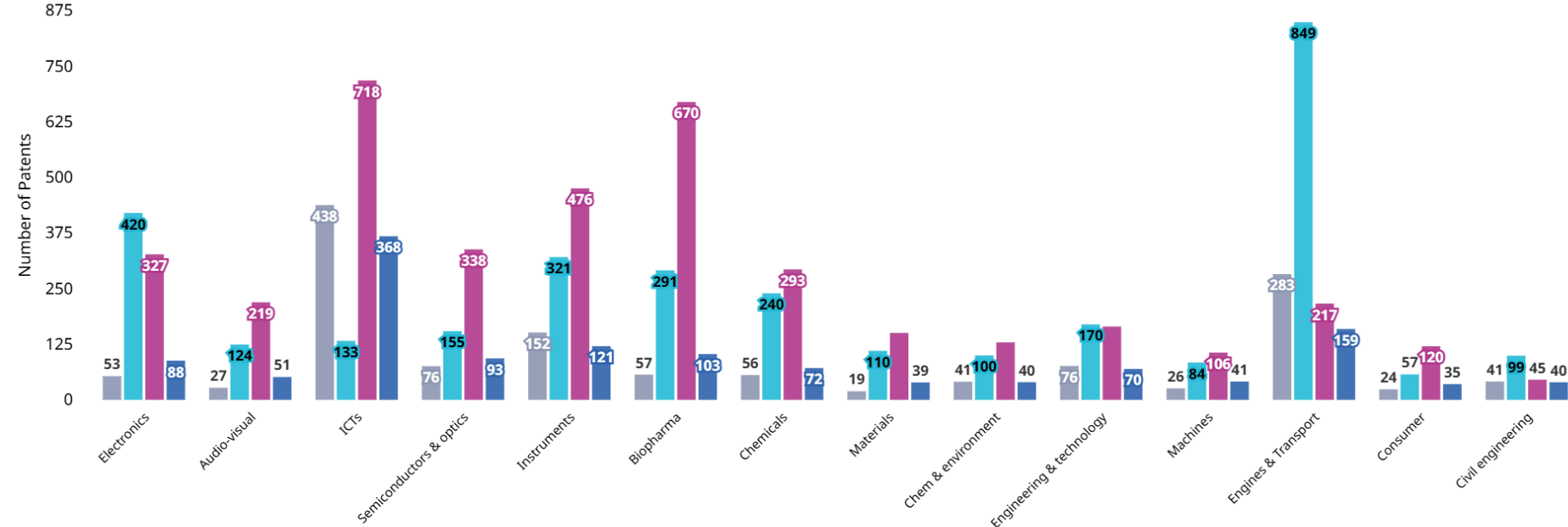
Every innovation ecosystem harbors unseen innovation potential—unlocking it could spark groundbreaking advancements and growth.

The tapped and untapped technological potential

Average yearly technological outputs by domain, with their corresponding potentials

Country Romania

Actual Technology Outputs Production based Potential Scientific based Potential Technology based Potential



Source: [WIPR 2024](#)

Unveiling technological potential

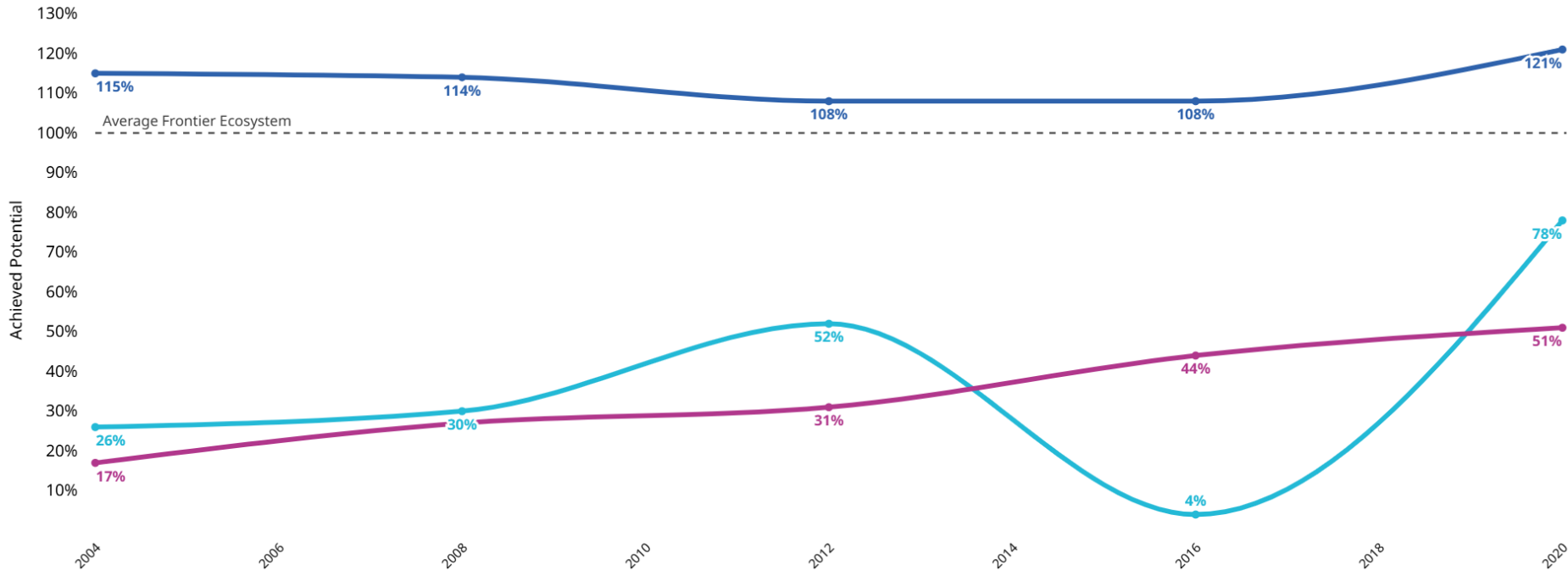
In innovation ecosystems, scientific research and industrial production converge to create technologies that drive economic growth. Can we measure whether this transformation is becoming increasingly effective?

Science and Production can shed light into untapped Technological Potential

Evolution of the technological potential of innovation ecosystems.

Ecosystem

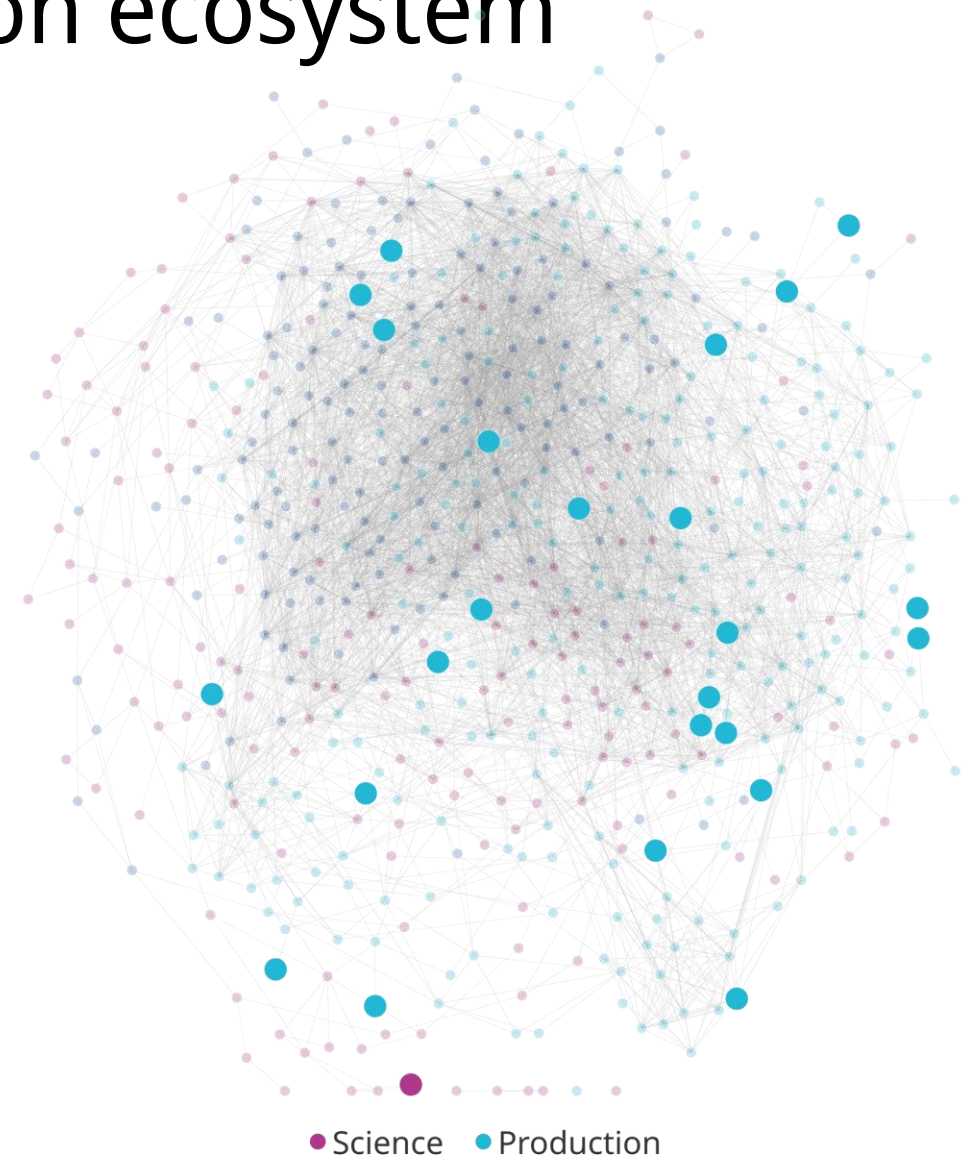
■ Production based ■ Science based ■ Technology based



The snapshot of an innovation ecosystem

Key figures – Example: Dominican Republic

- The Dominican Republic has 4% of all innovation capabilities (ranked 77th↑).
 - Most from production fields .
 - Mainly disconnected.
 - Low complexity capabilities, in line with the region.
- The country traded complex capabilities for simpler ones during the last 2 decades (ranked 96th↓).
- Higher optimization of complex outputs (ranked 74th↑).
- 3 smart diversification opportunities in low complexity production fields (pottery, household equipment, works of art).
- Untapped technological potential in biopharma and instruments (+300 yearly patents).



Finding new opportunities

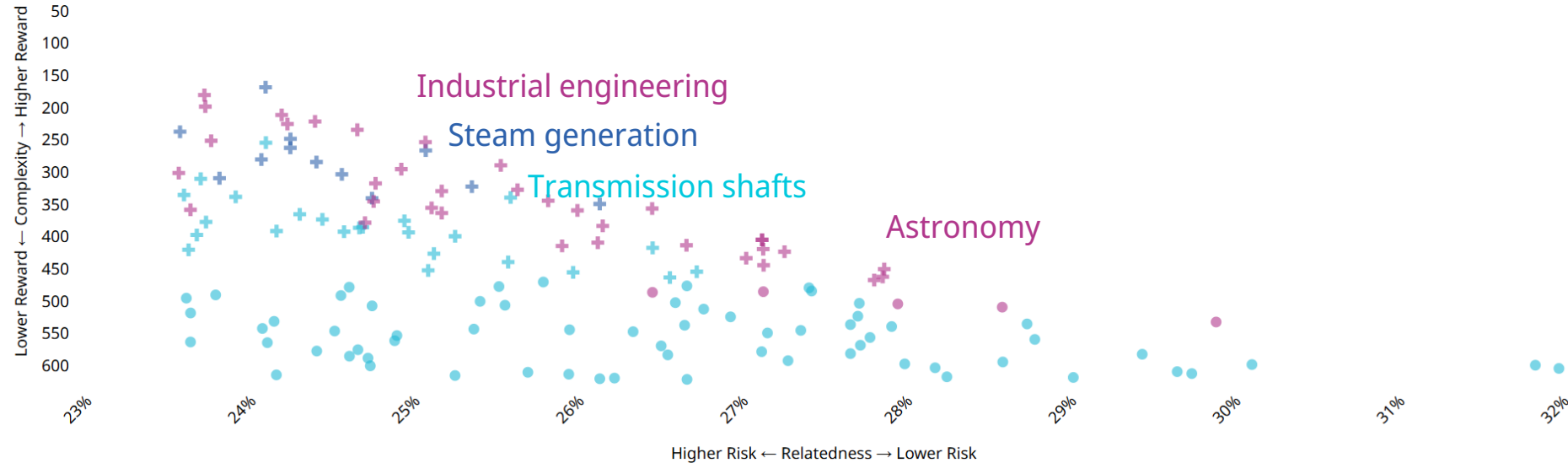
By identifying their capabilities, innovation ecosystems can find where to look for new areas to develop and prioritize the most promising ones.

Ecosystem Opportunities for Smart Diversification

Relatedness and Complexity mapping for unattained capabilities

Thailand

Dimension Name ● Production ● Technology ● Science



Source: WIPR 2024 • Capabilities marked with + are relatively complex to the innovation ecosystem. Capabilities marked with • are relatively simple to the ecosystem. The chart only shows capabilities that are relatively highly related to the ecosystem.