

Innovation Capabilities

International Training on IP and Innovation:
Economic Concepts and Metrics for Policymakers

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Outline of this training

- **1: Why map Innovation Capabilities?**
- 2: How can Innovation Capabilities inform policy?
- 3: How to build innovation capability indicators.
- 4: Applications



Innovation boosts economic growth through various mechanisms...

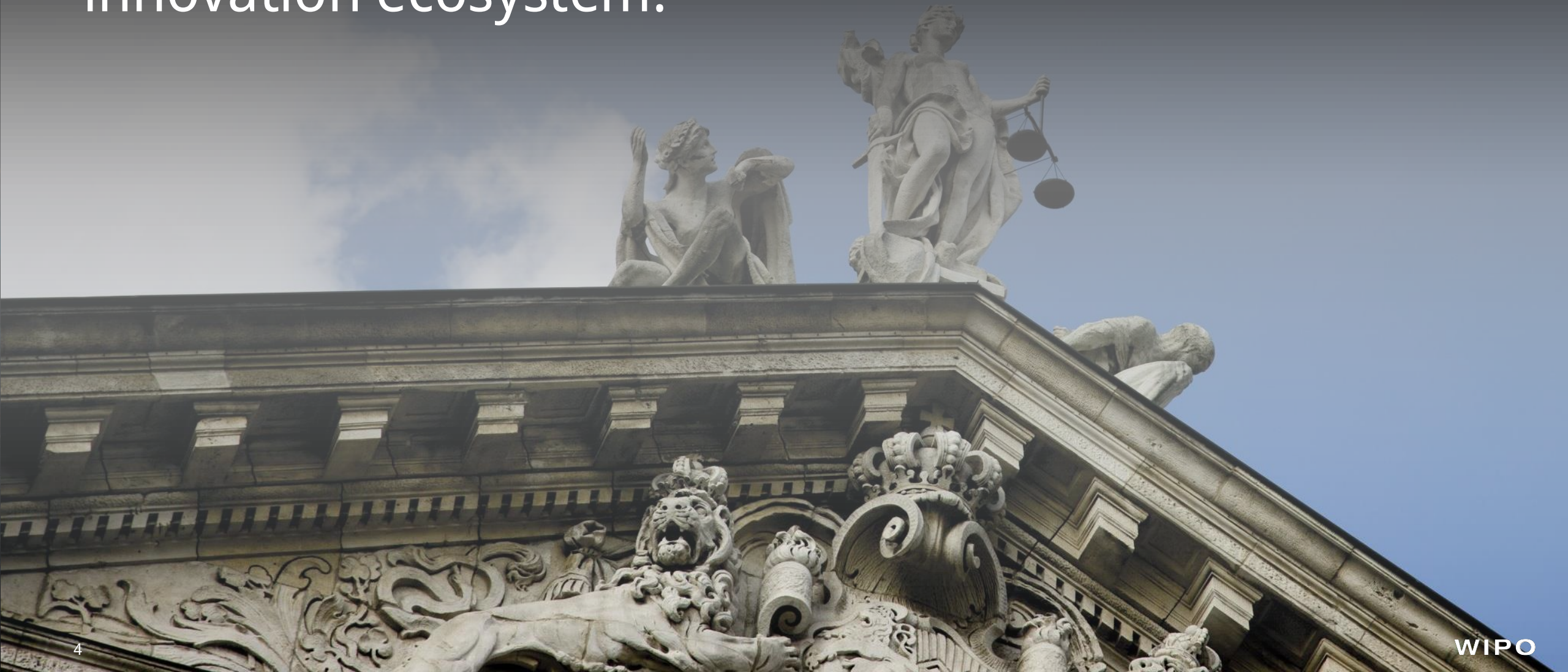
- Capital **intensification**.
- Improvement of **human capital**.
- Higher firm **productivity**.
- **Structural** changes.

“the invention of all those machines by which labor is so much facilitated and abridged seems to have been originally owing to the **division of labor**.”

Source: Adam Smith, Wealth of Nations, 1776



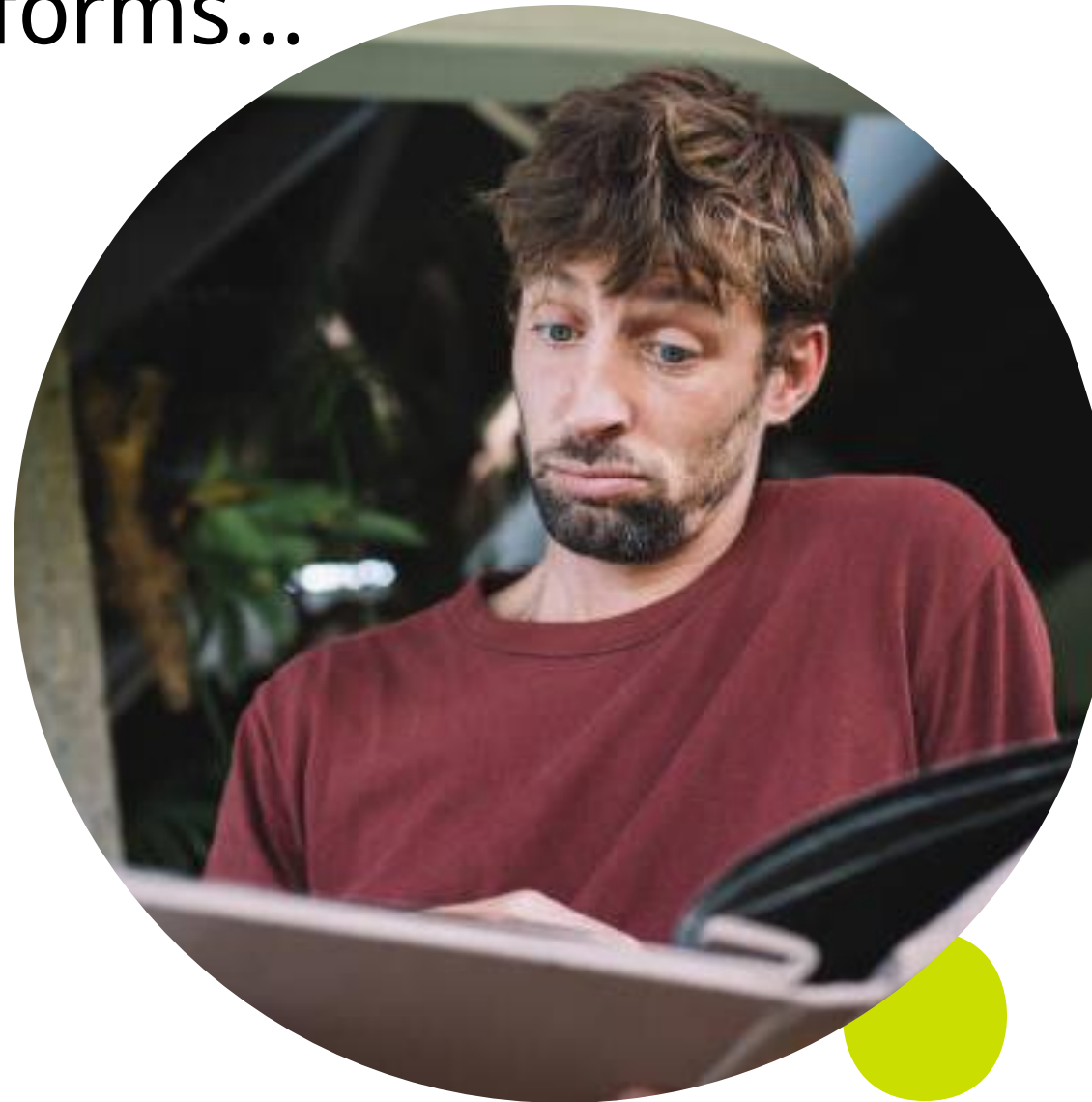
Innovation policies aim to promote new ideas, inventions, processes and technologies within an innovation ecosystem.



Innovation policies take many forms...

- IP instruments.
 - Patents / utility models / industrial designs
 - Trademarks / copyrights / trade secrets
- Skilled migration.
- R&D subsidies.
- Education grants.
- Investments in infrastructure.
- International cooperation.

Typically,
with public
funds



One size fits all policies tend to lead to missed opportunities and wasted resources.





Policies work best when based on local capabilities of innovation ecosystems.

... and fine tuning them can be challenging

- Which **policies** should I implement?
- Which **places** should I focus on?
- What **technologies** should I target?
- **How long** should I implement them?



Why map Innovation Capabilities?

Help policymakers implement **informed** innovation policies.

- **Map** their skills at an internationally comparable level.
- **Evaluate** them and help them solidify the most strategic ones.
- **Guide** where to find new opportunities and potential collaborations.

Why map innovation capabilities: <https://www.wipo.int/en/web/economics/innovation-capabilities>



What are Innovation Capabilities?

*They represent the abilities of an **innovation ecosystem** to deliver competitive outputs in the different fields of innovation.*

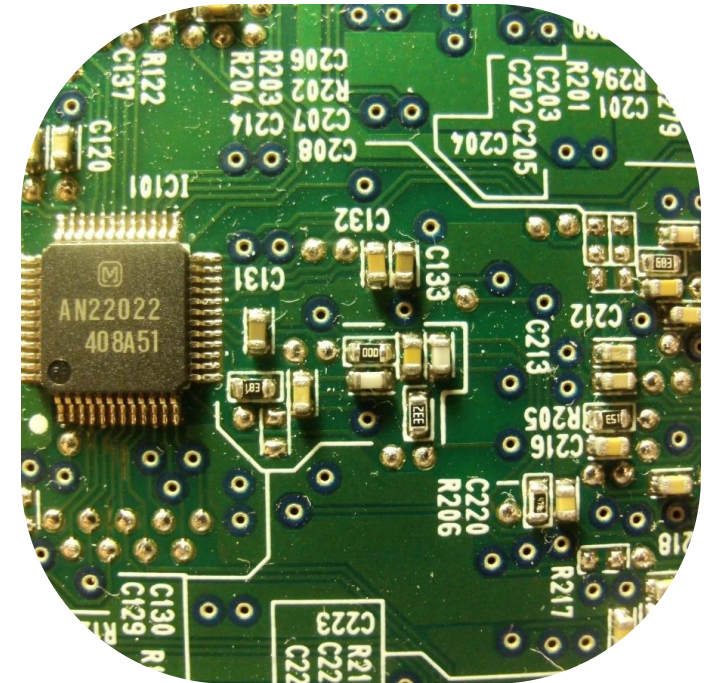
Precision manufacturing



Biotechnology

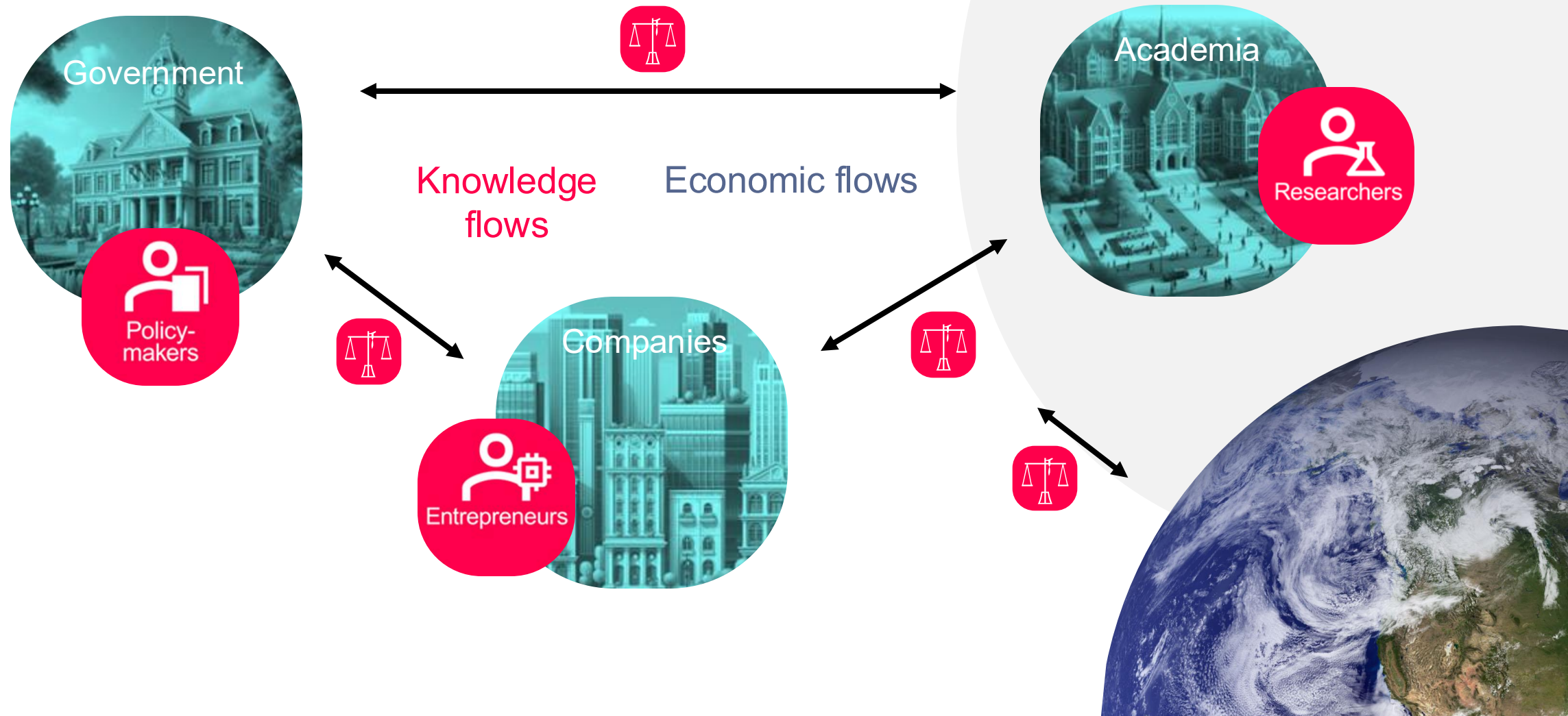


Electronics



Innovation Ecosystems

Individuals and organizations that facilitate the generation, acquisition and diffusion of new knowledge.



Knowledge flows

They improve the *capacity* of places to absorb, create and apply new knowledge.

Tools can be shipped...

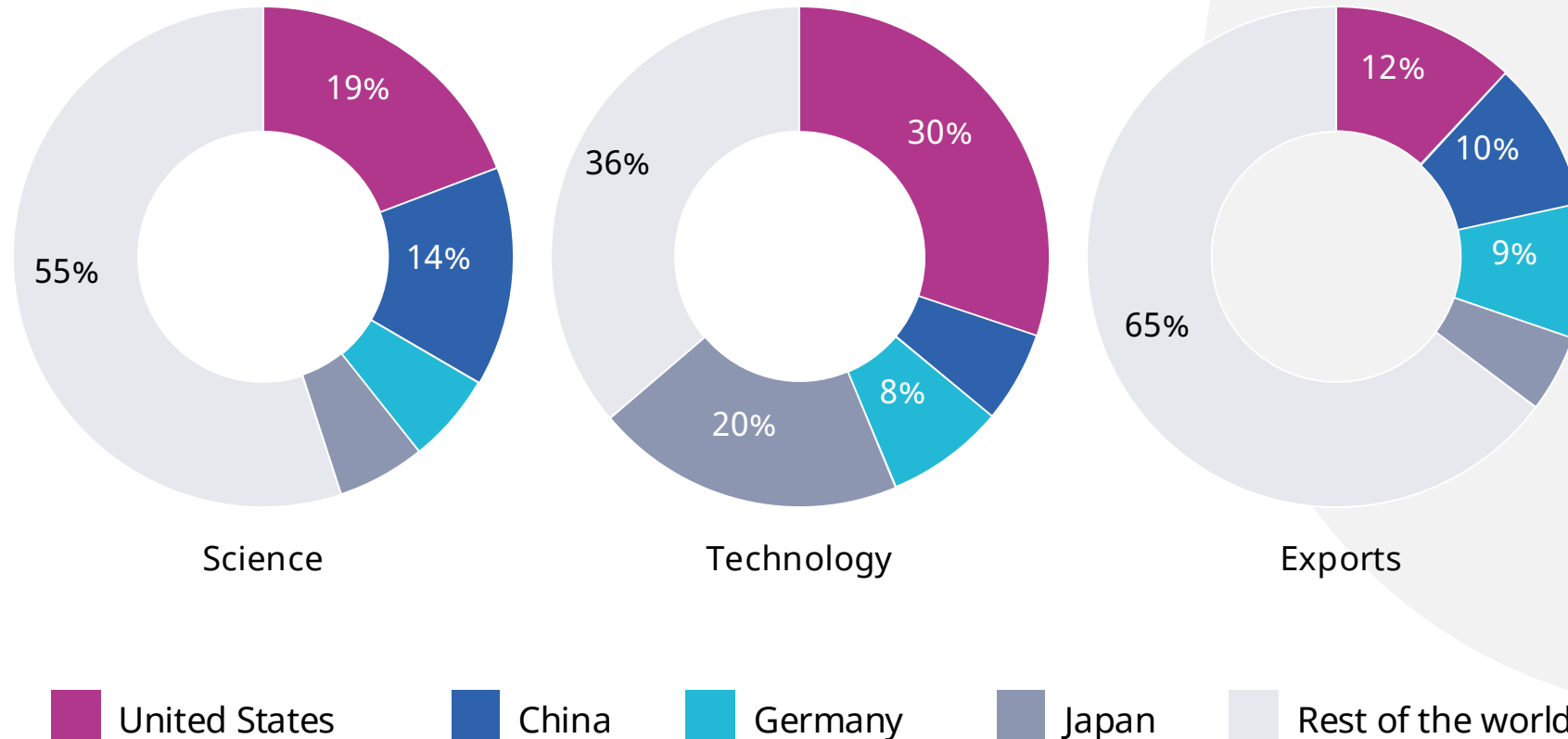


... and codes can be shared...



Innovation is multidimensional, but highly concentrated

Just 4 countries dominate the world share of scientific papers, international patents and exports.



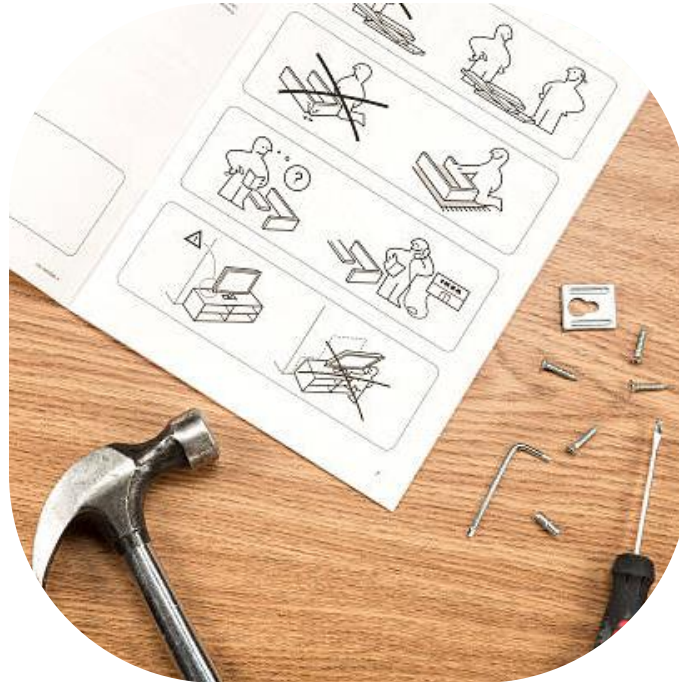
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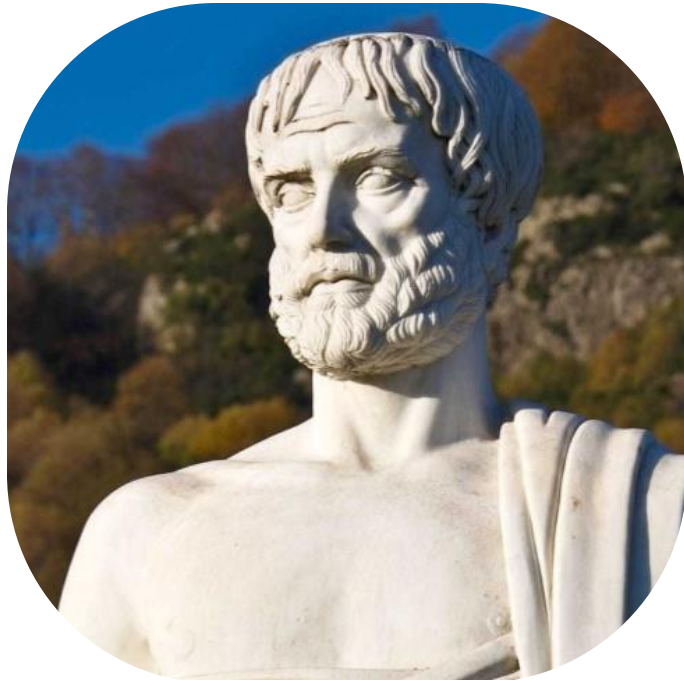
... but capabilities are in **brains**



... and brains have limited capacity

*Knowledge growth makes it **harder to master** something.*

Individuals used to be able to excel in many different areas...



... today, this is almost impossible...



... the solution is to **specialize**.



Complex 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

Ecosystems specialize in different fields of innovation



Up-and-coming ecosystems are less diversified,
making it harder to consistently deliver sophisticated
innovations

Source: Harvard Growth Lab, WIPO

The principle of relatedness

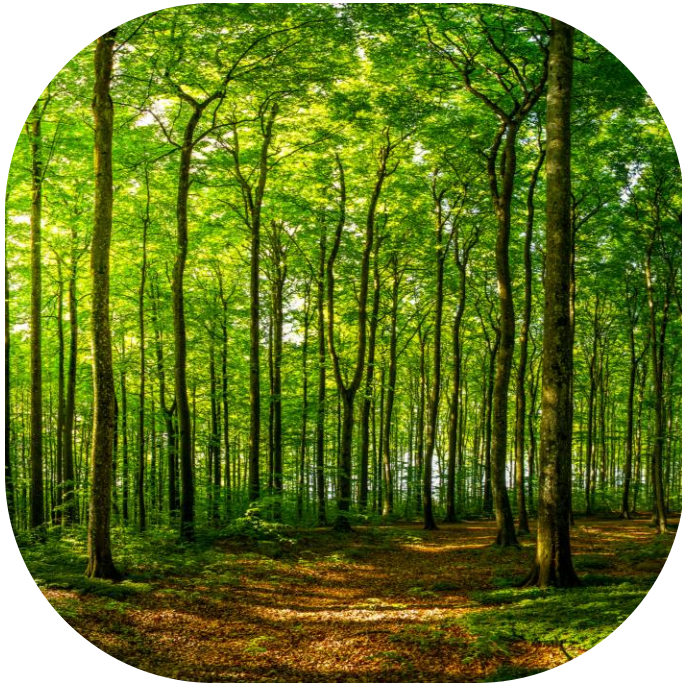
Ecosystems tend to diversify into related activities.



Sources: WIPO, Harvard Growth Lab

The principle of relatedness

Even when sharing similar capabilities ecosystems can follow different specialization paths.



Sources: WIPO, Harvard Growth Lab

The principle of relatedness

Even when sharing similar capabilities ecosystems can follow different specialization paths.



*Unrelated activities
tend to disappear!*

Why does relatedness matter?

Brief review

- Relatedness informs the **likely trajectories** of ecosystem diversification
- Relatedness indicators help **predict the potential success** of diversification moves.
- These measures help **map complementarities** within innovation ecosystems.
- Relatedness measures help assess the **resilience** of innovation ecosystems.
- These measures provide insights into the **absorptive capacity** of firms and regions.

Find how these indicators can help achieve the SDGs here: <https://www.wipo.int/web/economics/w/blogs/complexity-achieving-sdgs>

Complexity

The level of *know-how* embedded in fields of innovation... and ecosystems.



Fields

Ecosystems

Simpler

Complex

Simpler

Complex



Find which are the world's most complex capabilities in this interactive story: <https://www.wipo.int/web/economics/w/blogs/which-are-the-world-s-most-complex-capabilities>

Why does complexity matter?

Brief review

- Economies attaining technologically complex productive structures typically see **higher economic performance**.
- Countries with higher complexity are also more likely to be resilient by observing **longer-run patterns** of economic performance.
- Innovation ecosystems that have high complexities relative to their income level **grow faster** than those that underperform in terms of complexity.
- Income **inequality** is lower in countries that export more complex goods.
- Economically complex countries have lower **greenhouse emissions**.

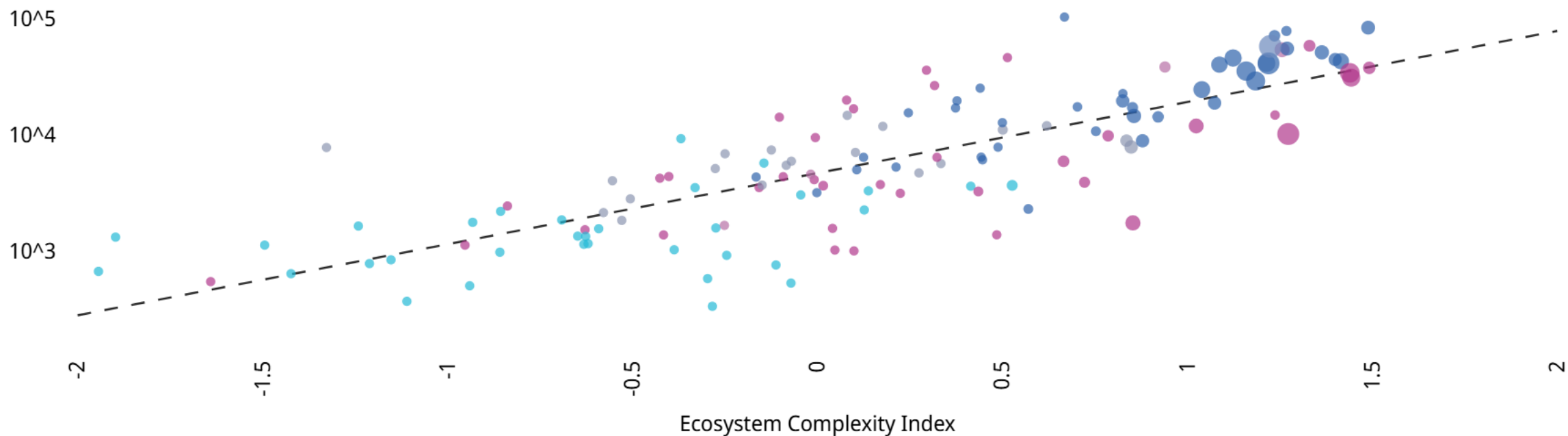
Measuring Innovation Complexity—and Why It Matters: <https://www.wipo.int/web/economics/w/blogs/measuring-innovation-complexity>

Ecosystem Complexity is positively correlated to GDP per Capita

Complexity of Innovation Ecosystems vs. GDP per capita, 2020.

Continent ● Asia ● Europe ● Africa ● Latin America and the Caribbean ● Oceania ● Northern America

GDP per Capita (USD)



Sources: WIPR 2024, World Bank Indicators • The logarithmic scale (base 10) allows for a more compact representation of a wide range of GDP values. A GDP per Capita of 10³ equals 1,000 while a value of 10⁵ corresponds to 100,000. Point sizes indicate the number of capabilities of the innovation ecosystem.

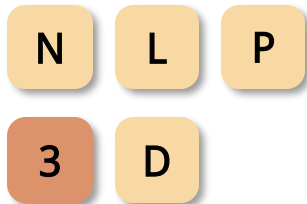
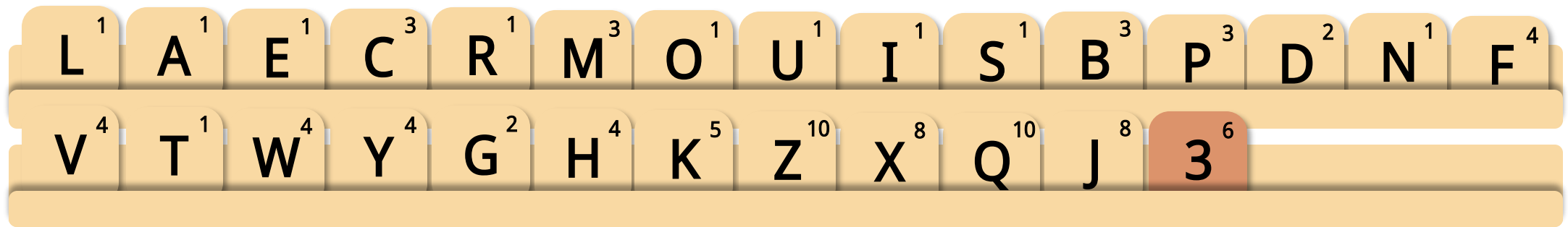
Find this interactive chart here: <https://www.wipo.int/web/economics/w/blogs/measuring-innovation-complexity>

How Can Scrabble Guide Policymaking?



What happens in the frontier?

Searching for new words... and new letters!



Watch Professor Hausmann explain how can Scrabble Guide Policymaking here: <https://www.wipo.int/web/economics/w/blogs/scrabble-guide-policymaking>

How to get new letters?

Economies tend to develop capabilities that are *related* to the ones they currently have.



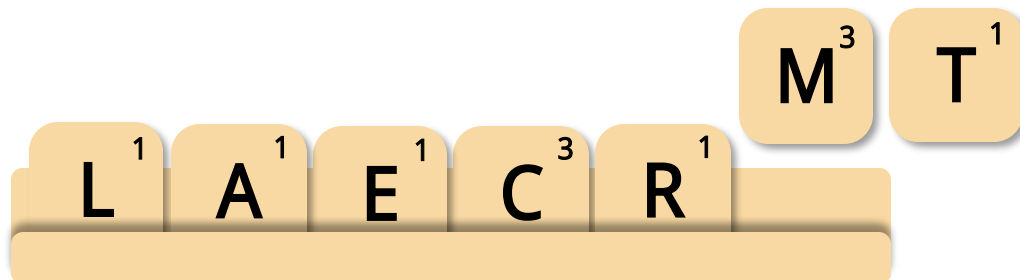
Principle of relatedness



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How to pick letters?

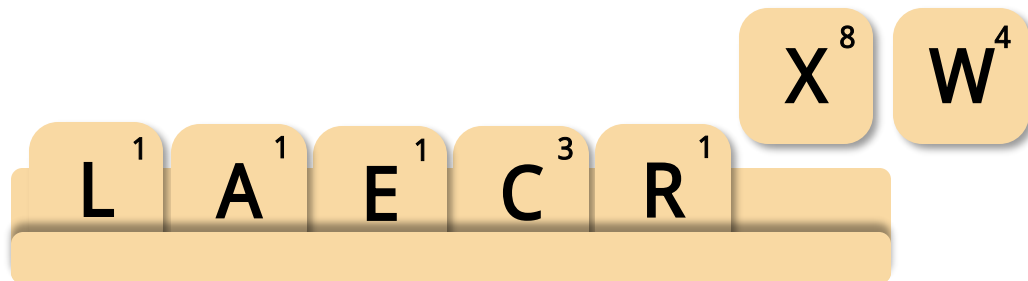
Smart diversification strategies look to add capabilities understanding their risks and rewards.



Watch Professor Hausmann explain how can Scrabble Guide Policymaking here: <https://www.wipo.int/web/economics/w/blogs/scrabble-guide-policymaking>

How to pick letters?

Leapfrogging into high value skills to soon is risky. Timing is key, as it may end up in wasted resources.



Watch Professor Hausmann explain how can Scrabble Guide Policymaking here: <https://www.wipo.int/web/economics/w/blogs/scrabble-guide-policymaking>

How to find words?

Sometimes, ecosystems can have the letters, and yet they can't put the words together. This speaks of an *untapped potential*.



Sources: Harvard Growth Lab, WIPO

Key takeaways?





0 response submitted

What is the main challenge for ecosystems to accumulate know-how?

Scan the QR or use
link to join



<https://forms.office.com/e/CBHbTDrBQc>

 Copy link

The easy access to
information, codes,
and instructions.

The ability to
purchase capital
goods such as
tools and
machinery.

The know-how that
resides in its
population.

All of the above.

Treemap

Bar



1 of 5



Show correct answer

Key takeaways

Know-how is tacit and sticky. It is a critical characteristic of innovation ecosystems.

- Individuals specialize. Ecosystems diversify!
- Diversification tends to follow the relatedness path.
- Successful ecosystems manage to combine their diverse skills to produce complex and rewarding outputs.



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Main indicators

How can Innovation Capabilities inform policy?

Innovation Capabilities



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.

Source: <https://www.wipo.int/en/web/economics/innovation-capabilities>

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



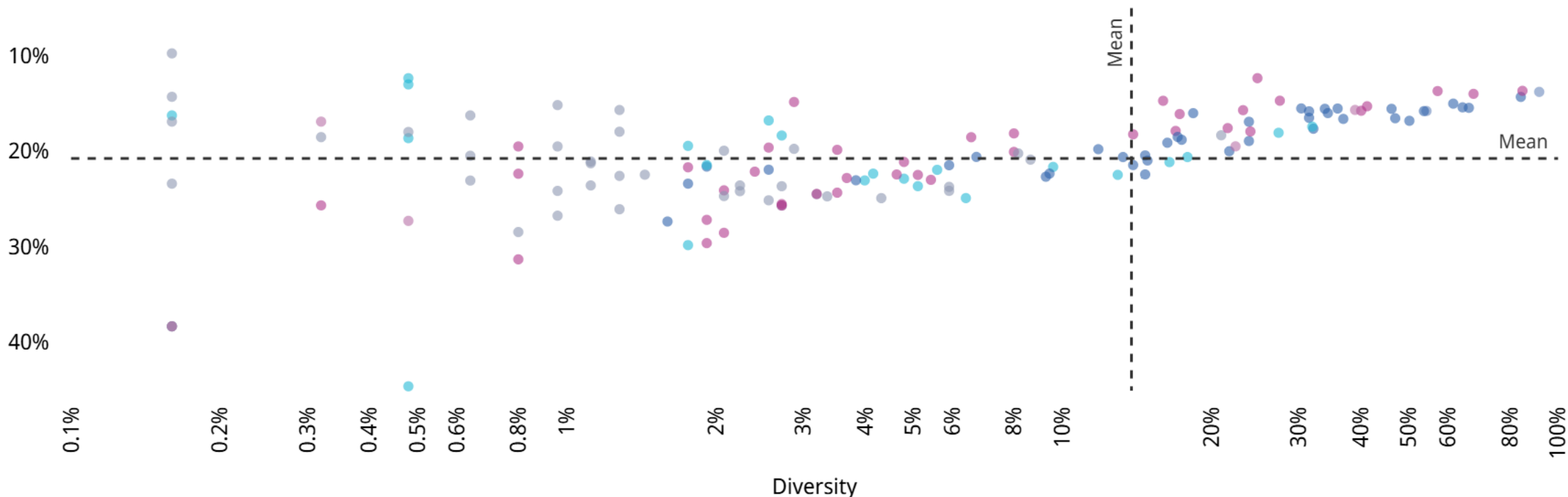
... however, Singapore's capabilities are the rarest across all selected innovation ecosystems.

Diversity vs. ubiquity by national ecosystems

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

Continent ● Asia ● Europe ● Latin America and the Caribbean ● Africa ● Oceania ● Northern America

Avg Ubiquity



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 (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...

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



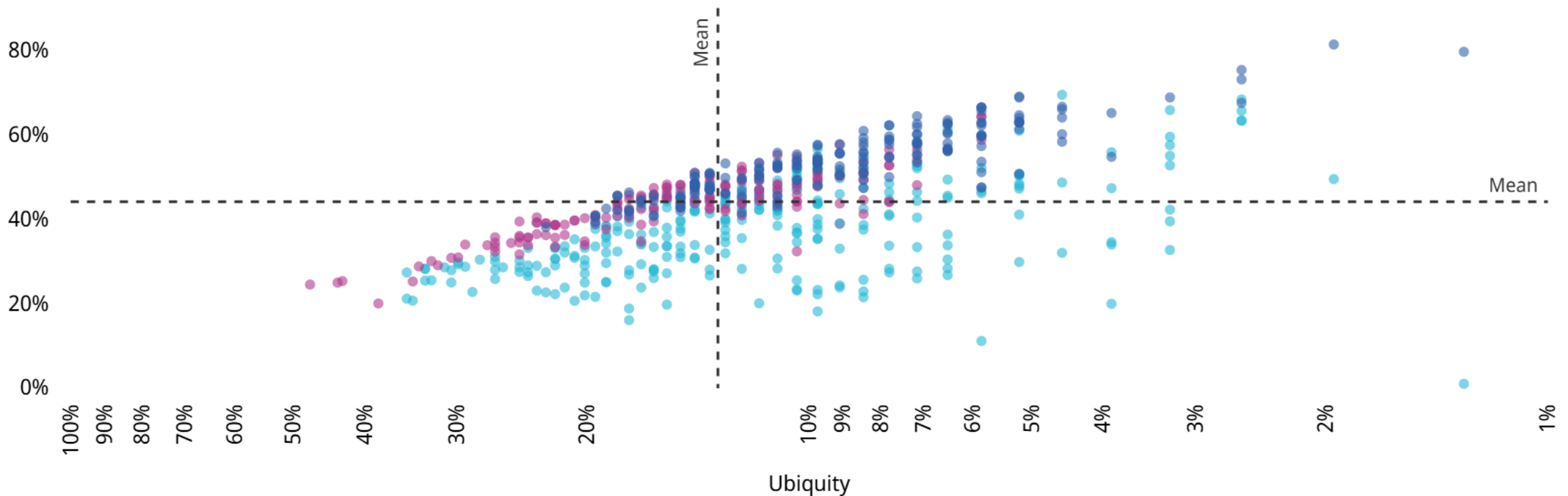
... however, Optics is mastered only in places with many skills. Cork may be rare, but easier to master.

Ubiquity vs. diversity by field of innovation

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

Dimension Name ● Production ● Science ● Technology

Avg Diversity



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

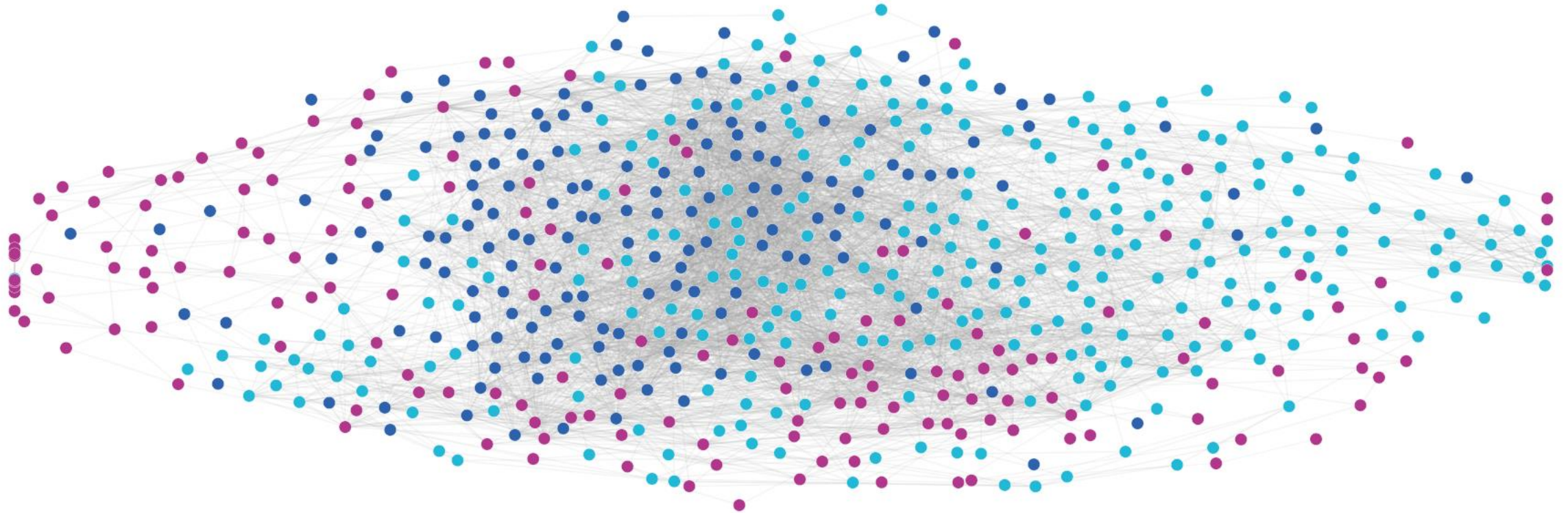
Indicates how often two types of knowledge coincide in one place.

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



● Science ● Technology ● Production

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.



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 between Capabilities and Ecosystems (1)



Relatedness

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

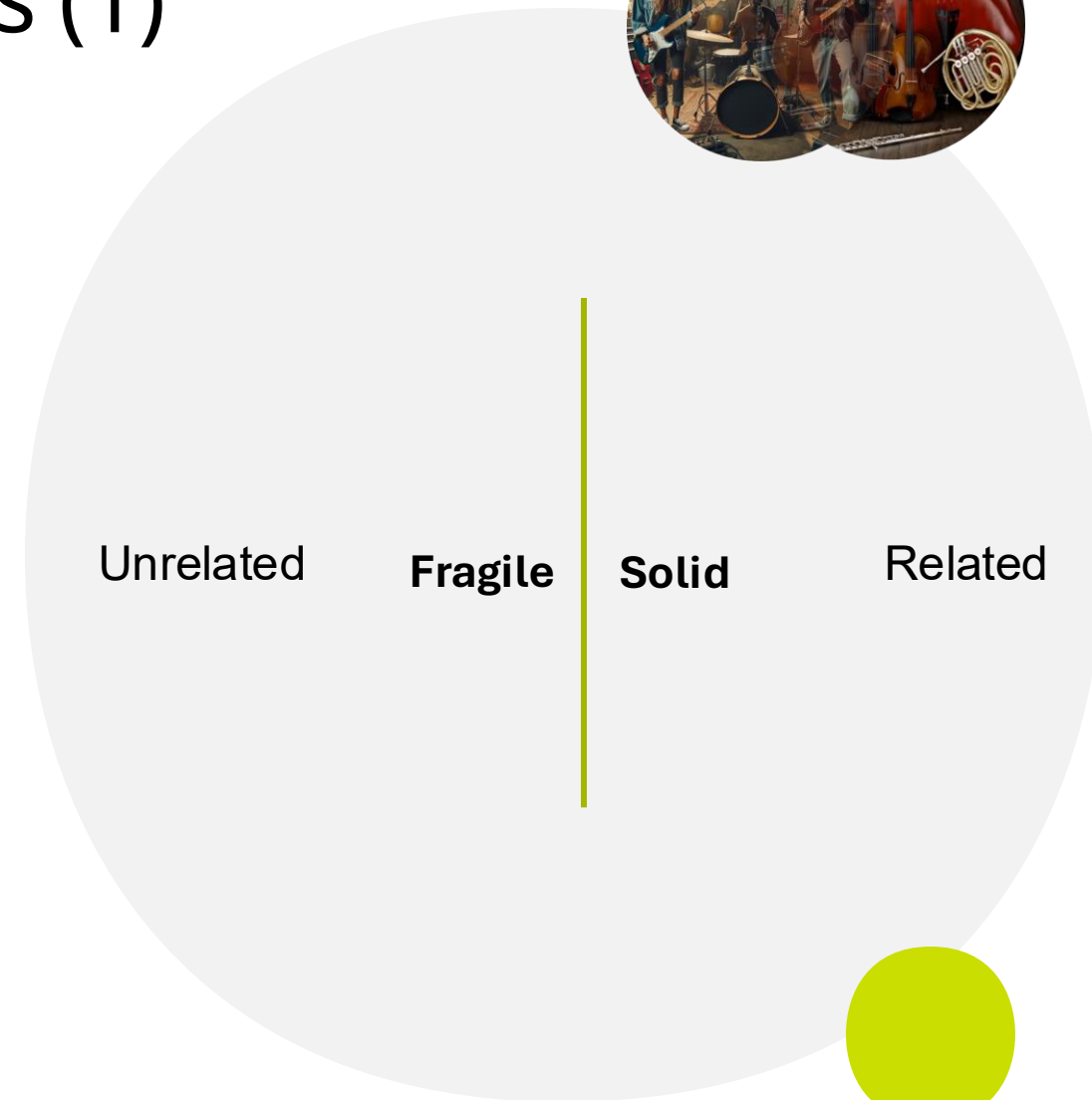
Ecosystem	Field	Relatedness
Italy	Optics	60%
Egypt	Optics	14%
Italy	Coffee	74%
Egypt	Coffee	26%

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

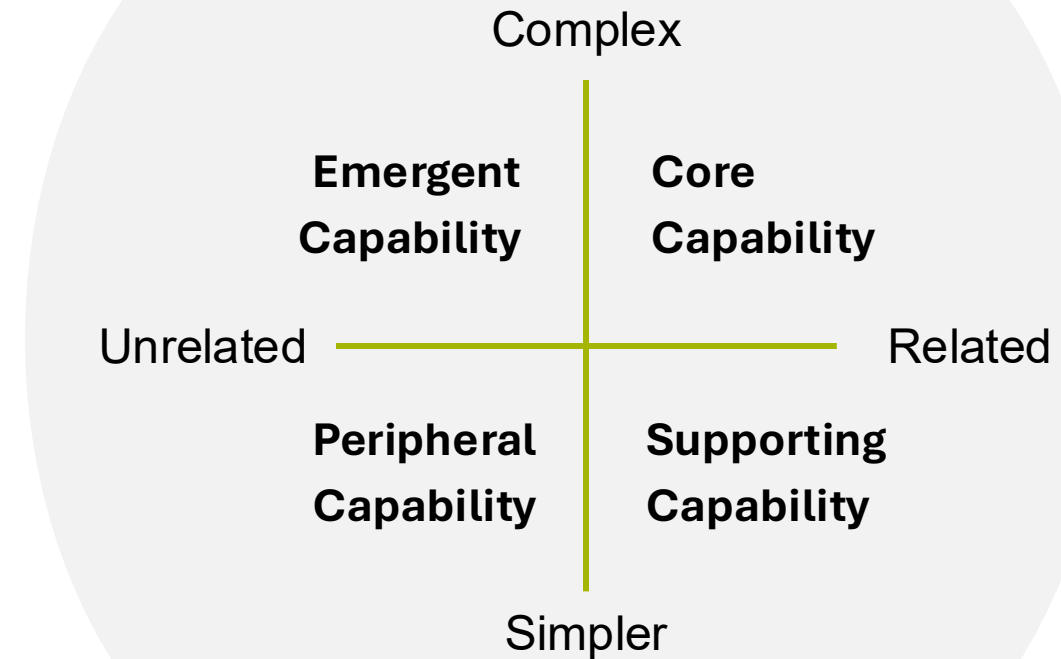
- **Solid capabilities.** Current capabilities that are surrounded by complementary skills. Ecosystems tend to keep them.
- **Fragile capabilities.** Current capabilities that are not surrounded by complementary skills. **73% of lost capabilities are fragile.**



Interpreting the main indicators (1)

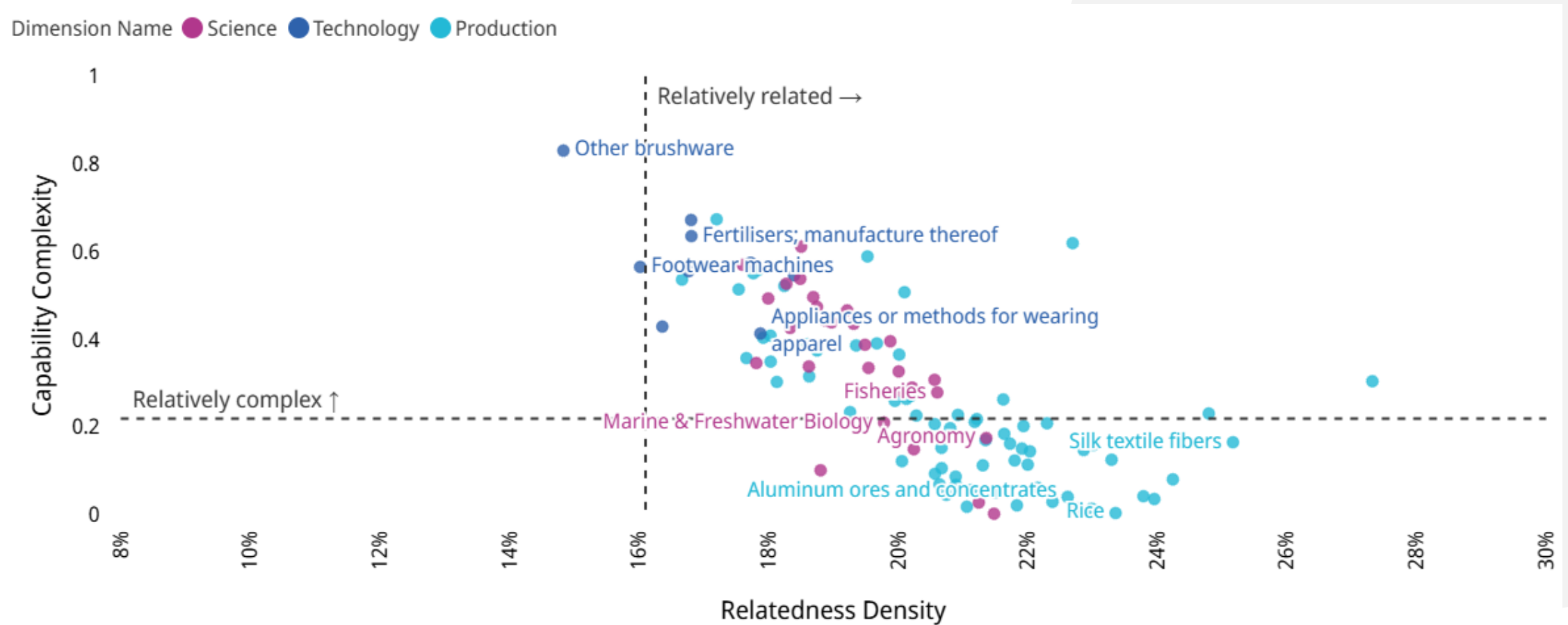
For ecosystem current capabilities

- **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.

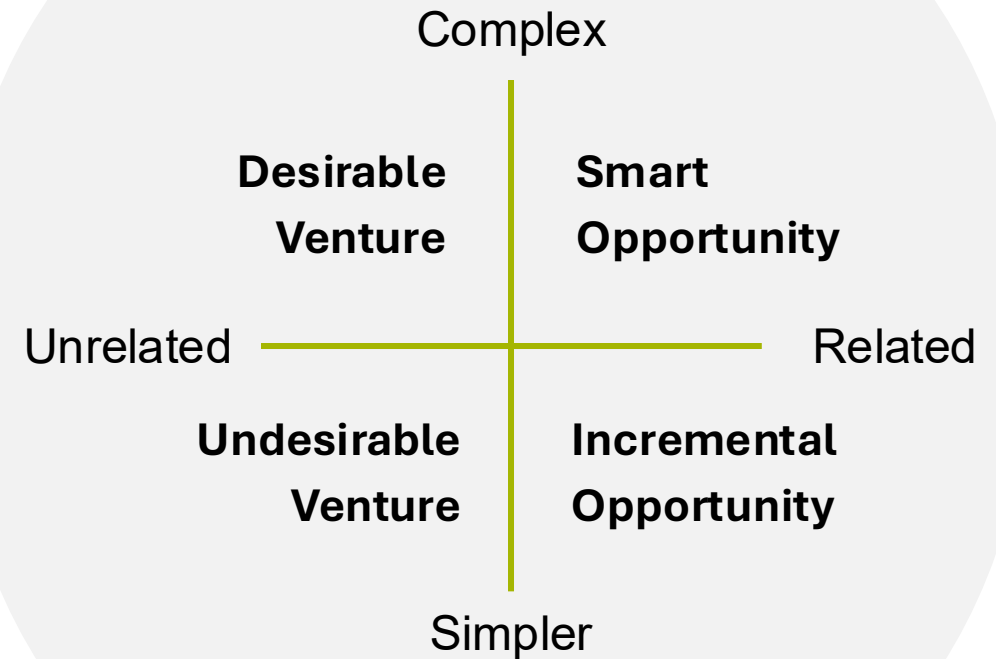


Unrelated **Ventures** **Lower-risk** Related

Interpreting the main indicators (2)

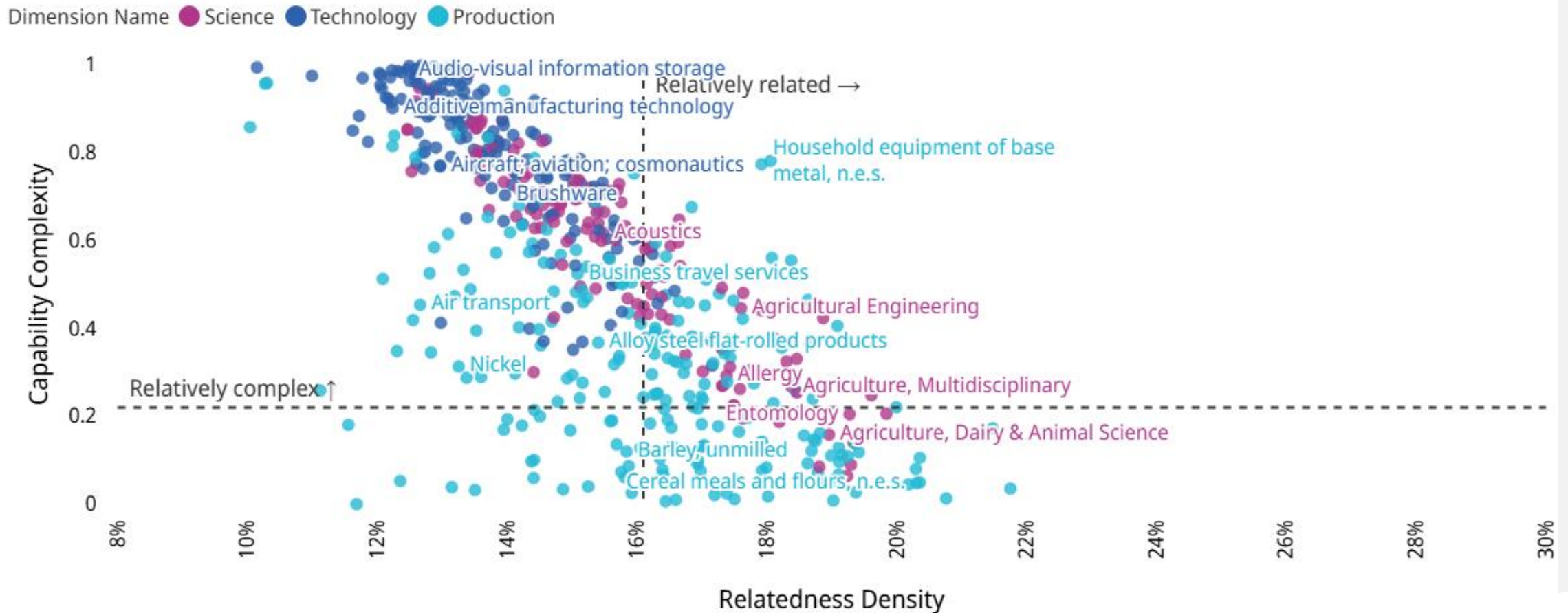
For ecosystem unattained capabilities

- **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.



Assessing the opportunities of an ecosystem

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



Find more ecosystems in this interactive story: <https://www.wipo.int/web/economics/w/blogs/unveiling-the-untapped-potential-of-innovation-ecosystems>

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	+ 0% exports
Egypt	Coffee	+ 760% exports

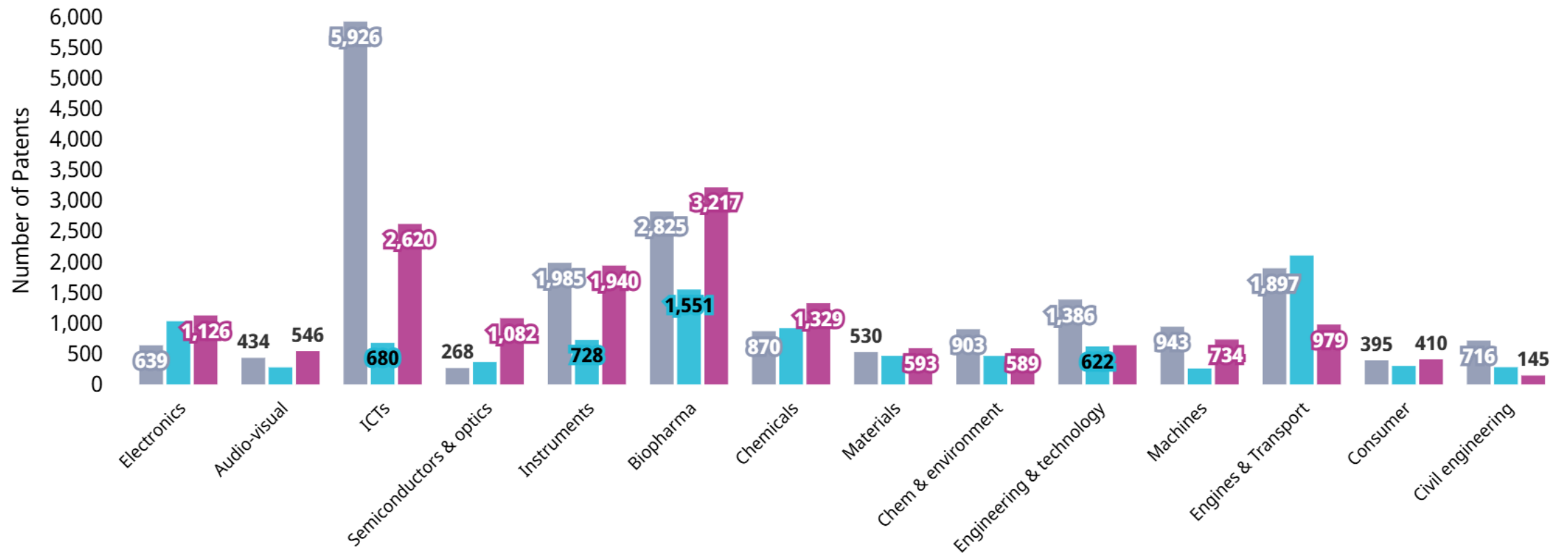
Italian scientific and productive capabilities could generate an extra 140% extra optical patents in the ecosystem...

The tapped and untapped technological potential

Average yearly technological outputs by domain, with their corresponding potentials

Country Sweden ▼

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



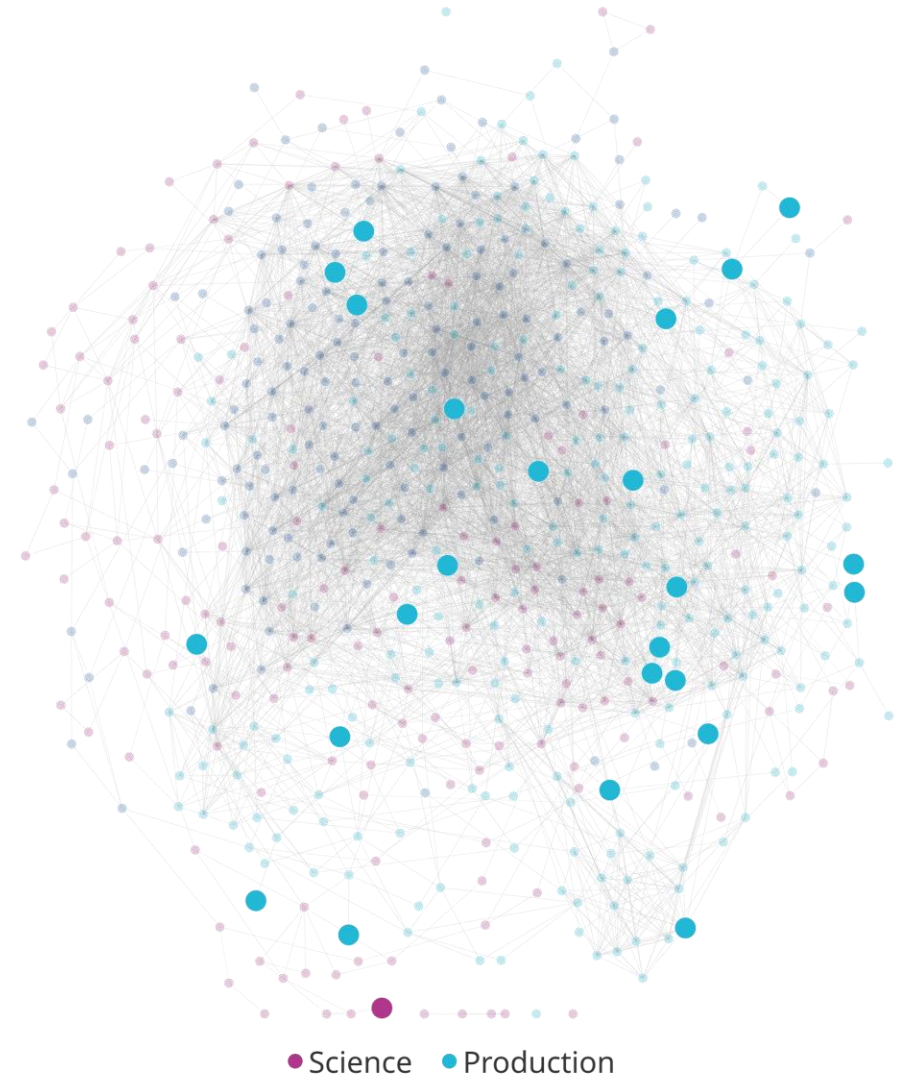
Source: [WIPR 2024](#)

Interpreting Innovation Capability Indicators

What can you learn from an innovation ecosystem profile?

Let's see together some other charts that can be found in a capability profile.

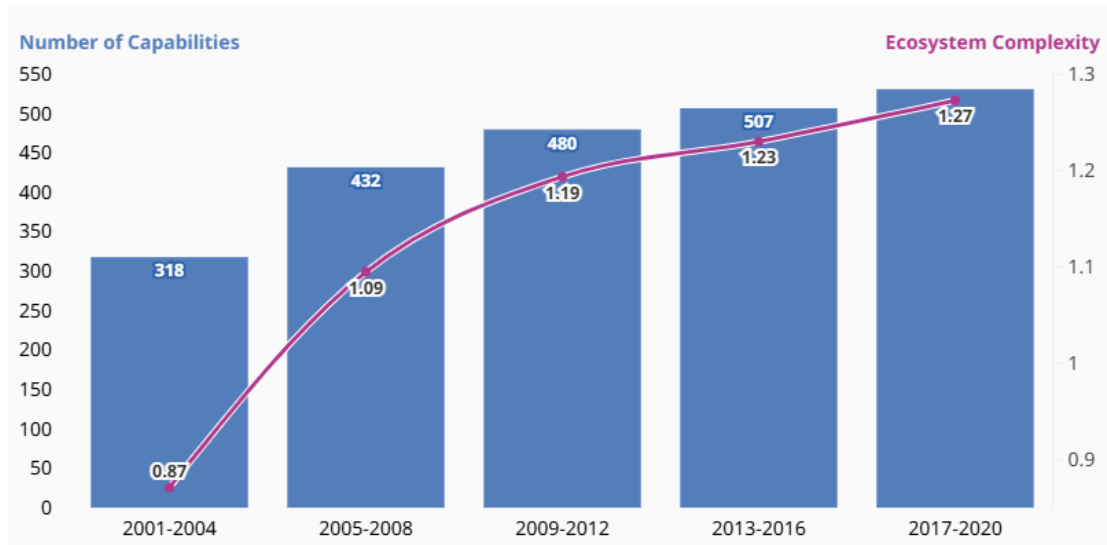
- Evolution of capability complexity
- Evolution of capability optimization
- Evolution of untapped potential



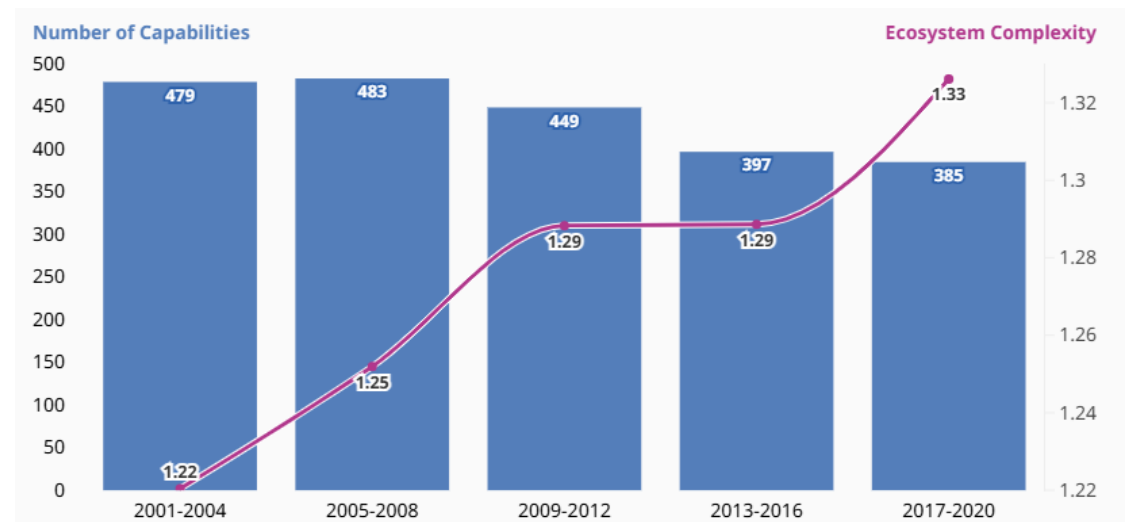
Unfolding the capability path (1)

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

China



United Kingdom

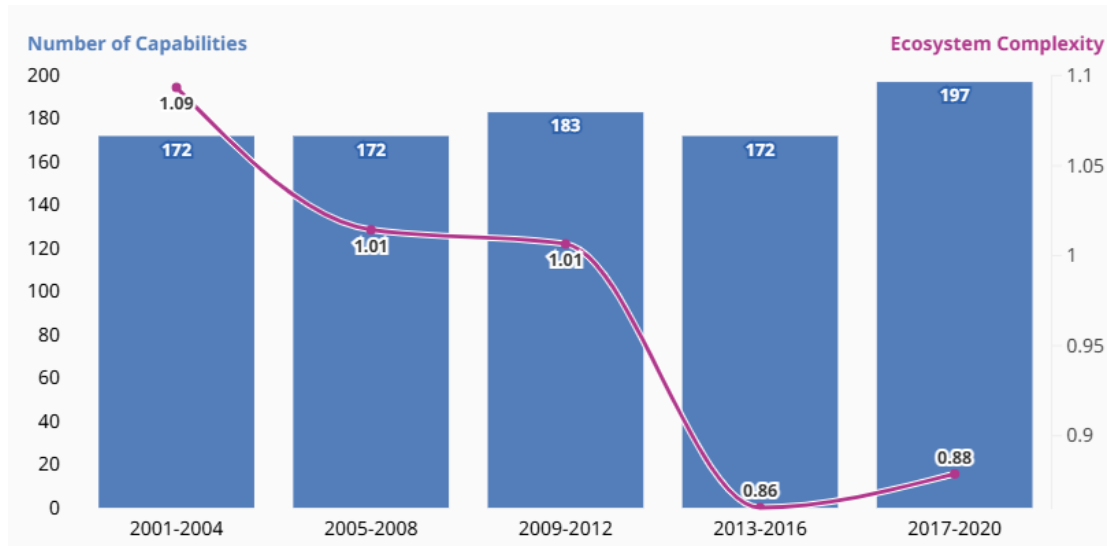


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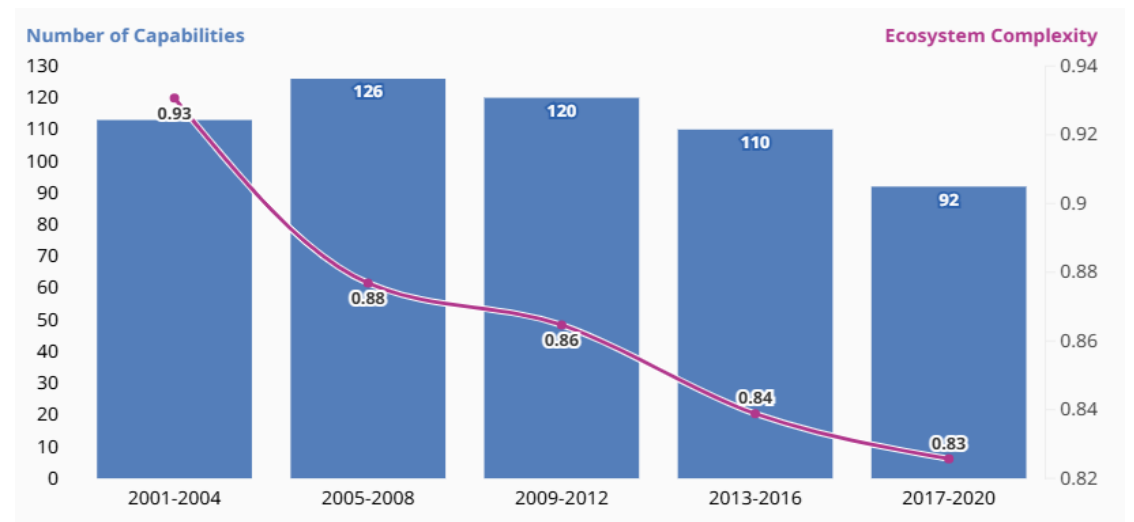
Unfolding the capability path (2)

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

Russia



Slovenia

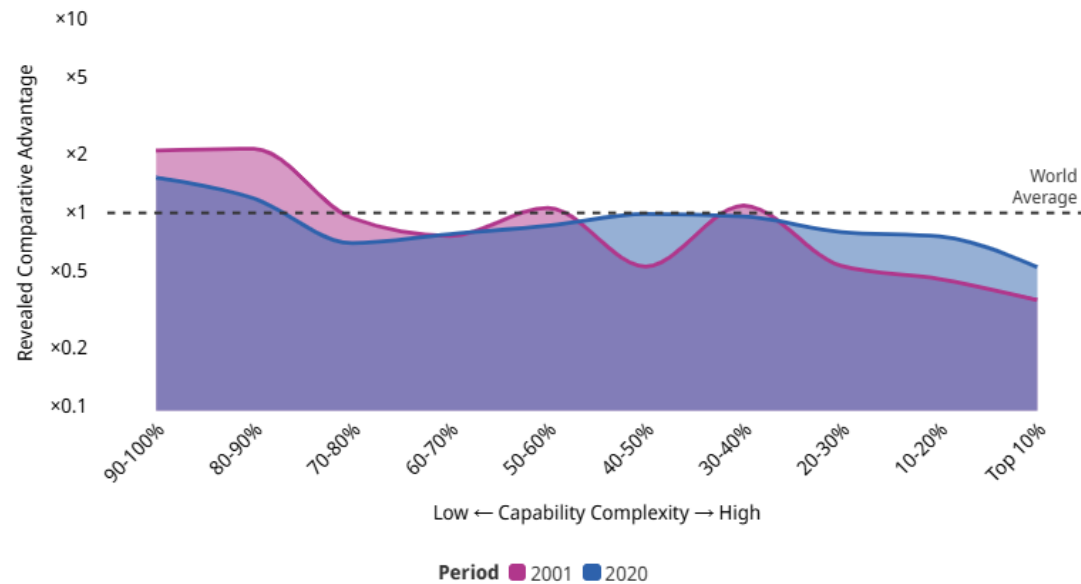


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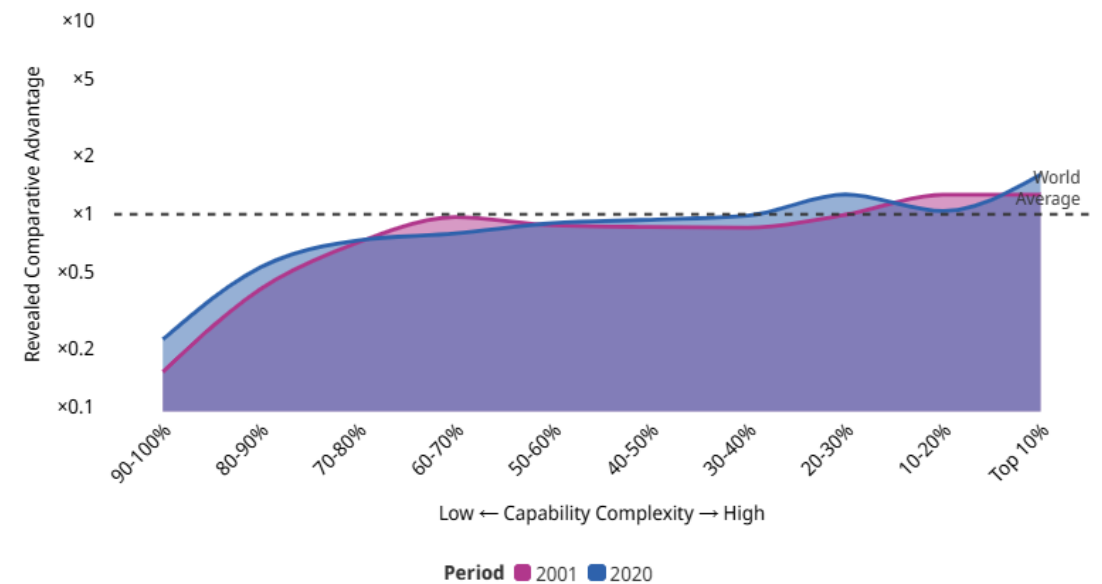
Optimizing innovation (1)

*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

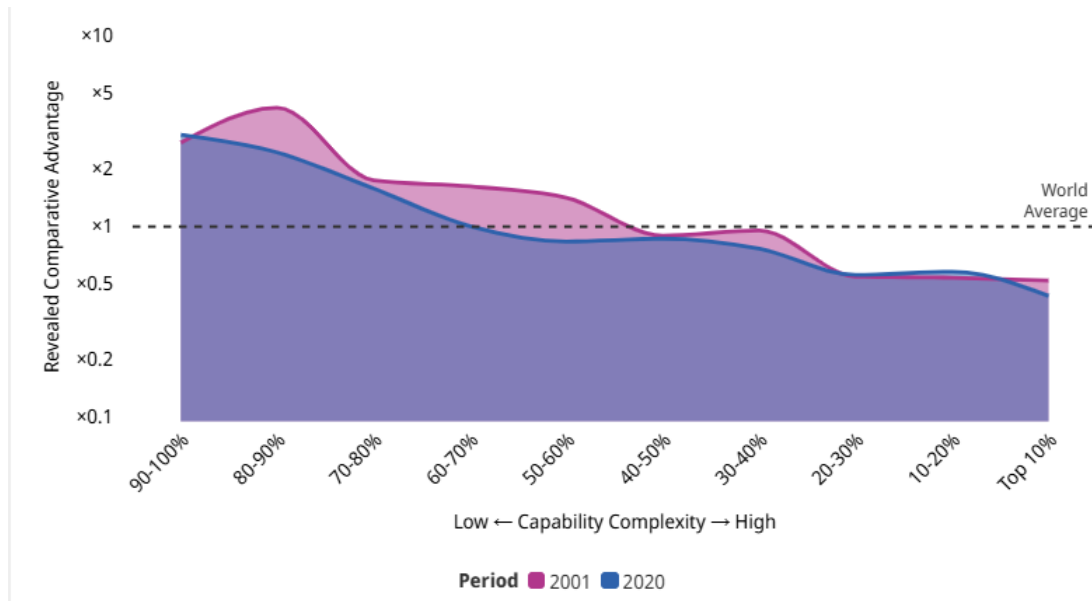


Find more ecosystems in this interactive story: <https://www.wipo.int/web/economics/w/blogs/optimizing-innovation-leveraging-complex-capabilities>

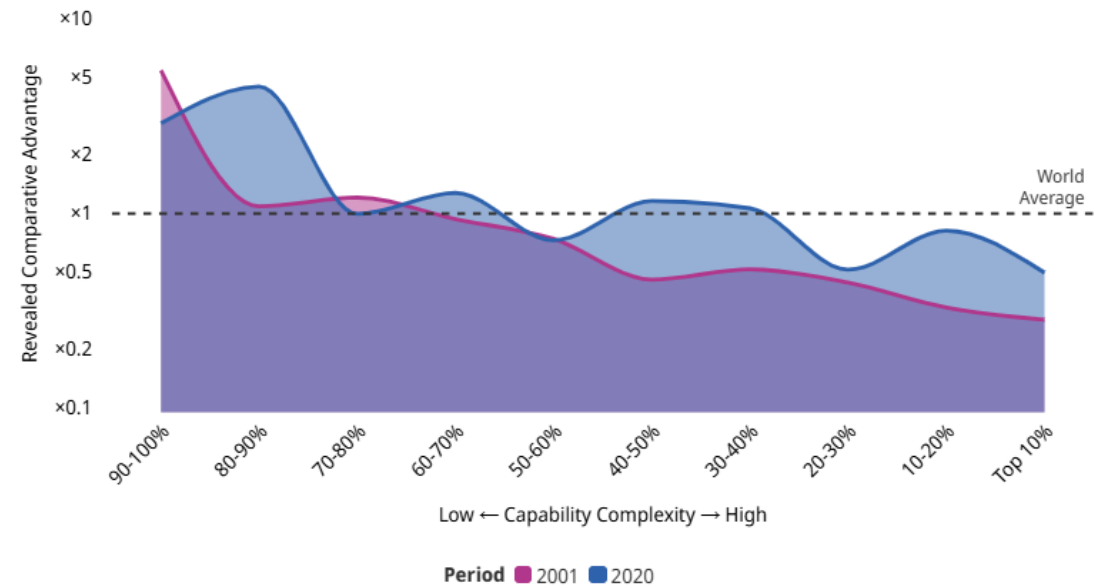
Optimizing innovation (2)

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.

Argentina



Morocco

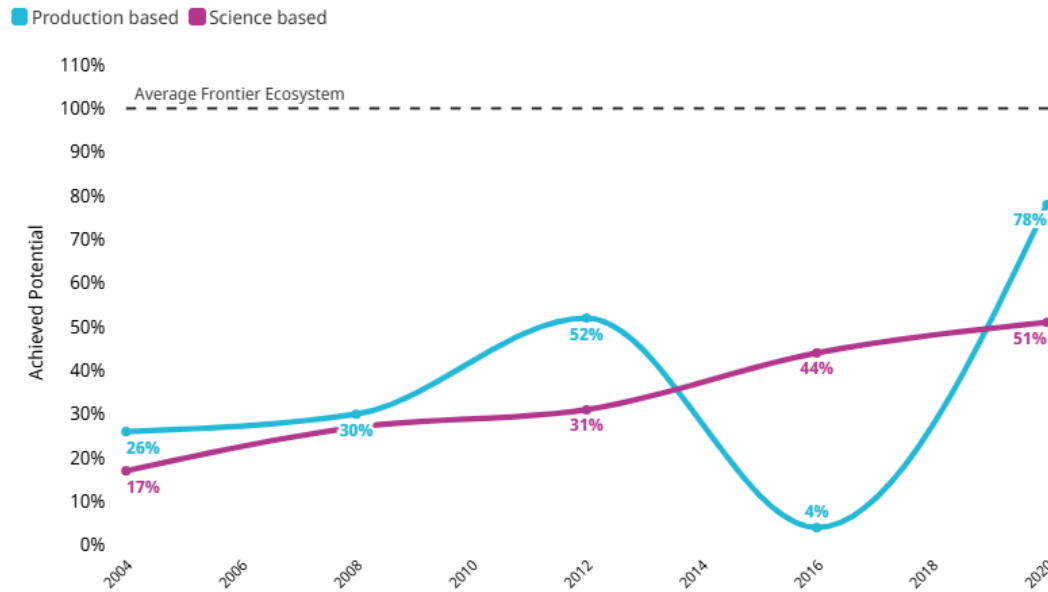


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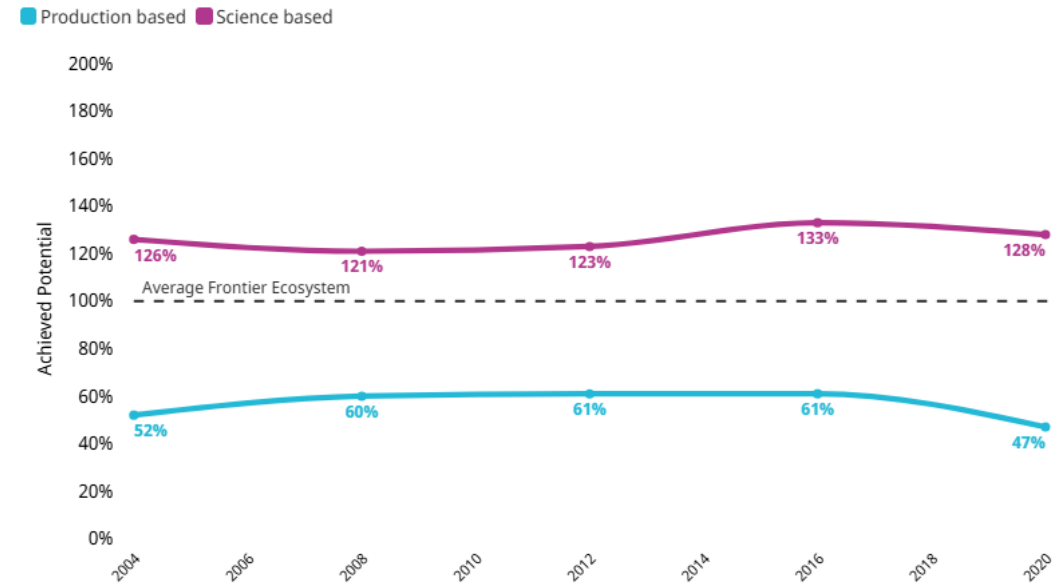
Tapping potential (1)

Science and Production can shed light into untapped Technological Potential

Chile



Netherlands

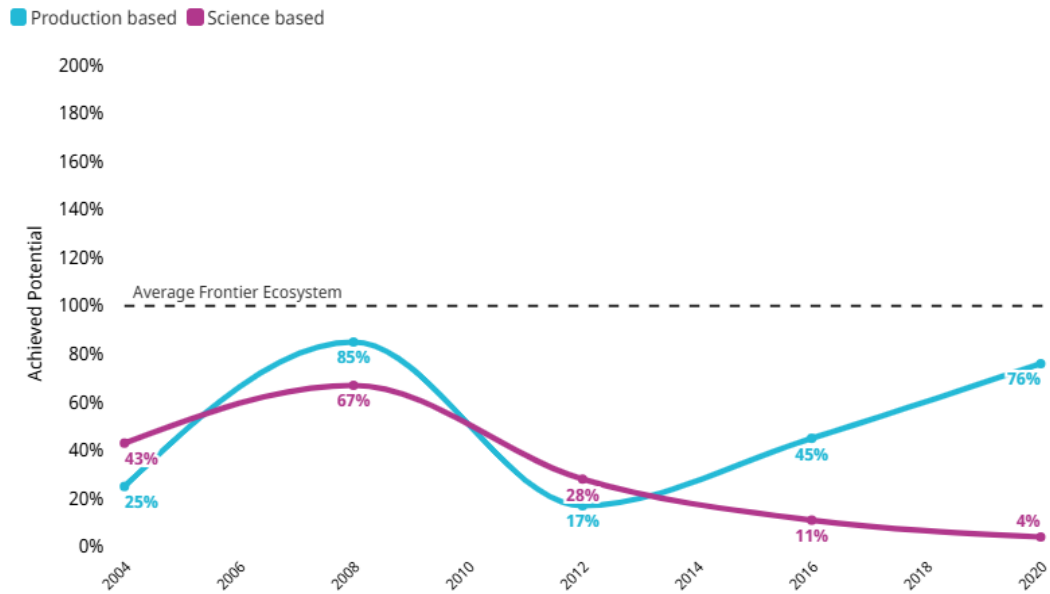


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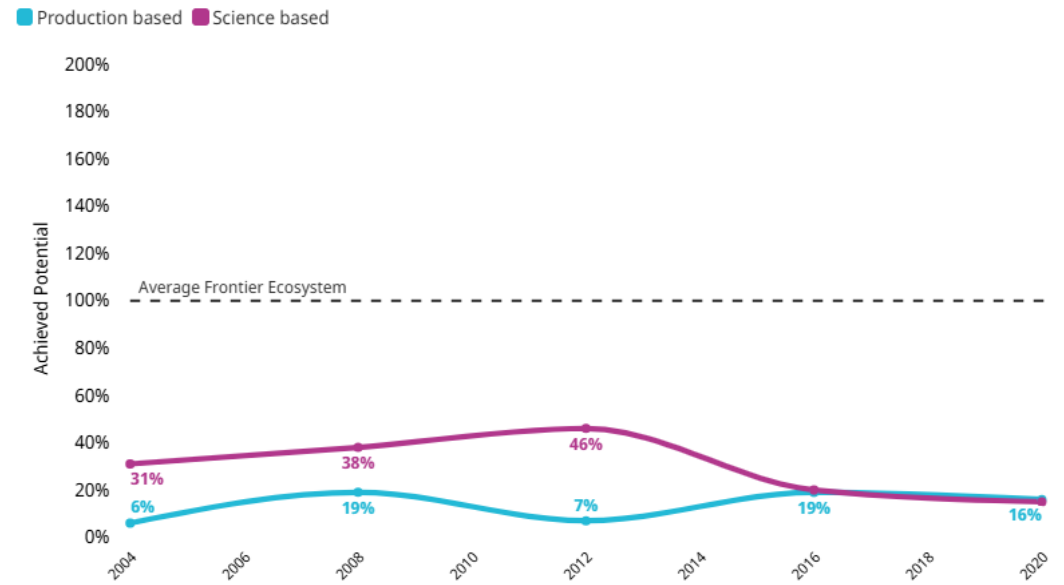
Tapping potential (2)

Science and Production can shed light into untapped Technological Potential

Pakistan



Qatar



Find more ecosystems in this interactive story: <https://www.wipo.int/web/economics/w/blogs/tracking-the-progress-of-innovation-ecosystems>

Key takeaways?





0 response submitted

How does the relatedness indicators help make innovation policy decisions?

Scan the QR or use link to join



<https://forms.office.com/e/KnhzWwN5Zn>

 Copy link

It points to fields that are achievable at lower risk.

It suggests which capabilities are isolated from complementary know-how.

All of the above.

Treemap

Bar



1 of 5



Show correct answer

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



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- 1: Why map Innovation Capabilities?
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Data sources

*Any dataset that has outputs related to innovation, divided by **location** and **field** of knowledge.*

Typical dimensions of **international** capabilities:

- **Trade**, using exports from UN COMTRADE.
- **Science**, using scientific publications from OpenAlex, Web of Science, Scopus...
- **Technologies**, using international patent families from PATSTAT, USPTO...
- **Entrepreneurship**, using trademarks from the Global Brands Database.

Other explored dimensions:

- **Workforce, Designs...**

Source: WIPR 2024

Data processing

From input data to mapping innovation capabilities

**Input data from different periods,
activities and places**

Period	Location	Field	Outputs
2022	L1	F1	10 patents
2022	L1	F2	15 patents
2022	L1	F3	5 patents
2022	L2	F1	5 patents
2022	L2	F2	3 patents
2022	L2	F3	7 patents
...

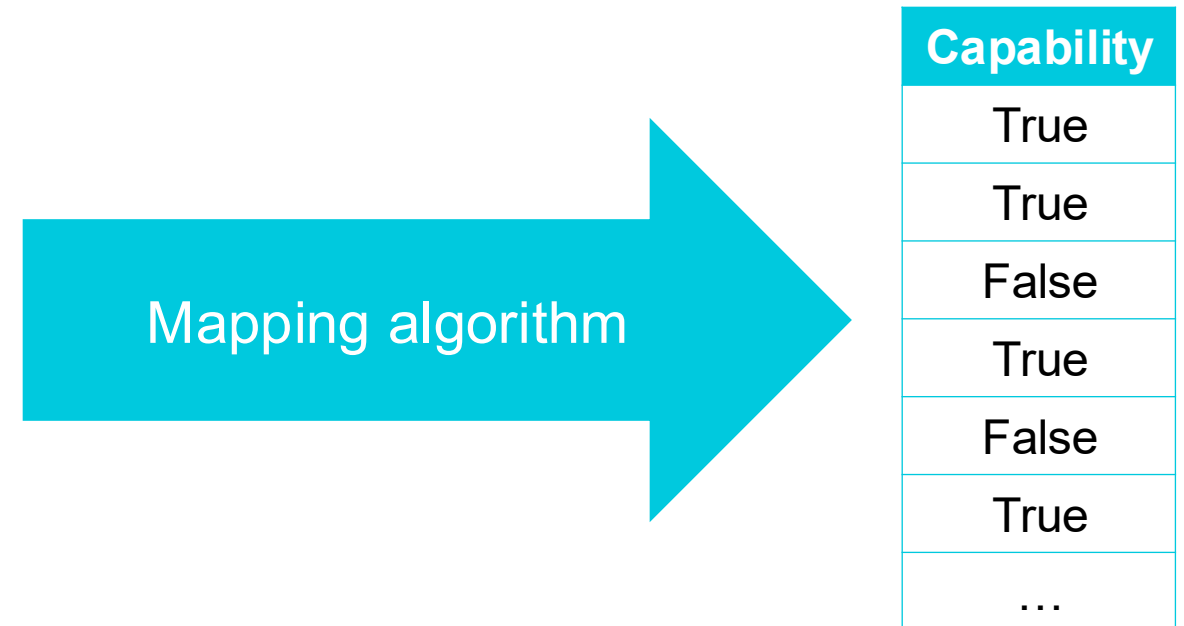
Data processing

From input data to mapping innovation capabilities

Input data from different periods, activities and places

Period	Location	Field	Outputs
2022	L1	F1	10
2022	L1	F2	15
2022	L1	F3	5
2022	L2	F1	5
2022	L2	F2	3
2022	L2	F3	7
...

Capability assignment based on criteria that captures expertise*



Data processing of innovation outputs

Combining innovation capability sources

Period	Location	Dimension	Field	Outputs	Capability
2022	L1	D1	F1	9	True
2022	L1	D1	F2	16	True
2022	L1	D1	F3	5	False
2022	L2	D1	F1	5	True
...
2022	L1	D2	F1	502	True
2022	L1	D2	F2	1088	True
...
2022	L1	D3	F1	0	True
2022	L1	D3	F2	73	True
...

Publicly available toolboxes

Python:

- ecomplexity 0.5.3



R:

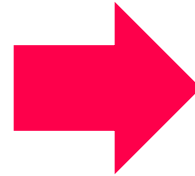
- EconGeo 2.0



Building proximity indicators

Publicly available libraries help create smart diversification indicators from capabilities...

Period	Location	Field	Capability
2022	L1	D1 - F1	True
2022	L1	D1 - F2	True
2022	L1	D1 - F3	False
2022	L2	D1 - F1	True
2022	L2	D1 - F2	False
2022	L2	D1 - F3	True
...



Period	Location A	Location B	Proximity
2022	L1	L2	0.22
2022	L1	L3	0.47
2022	L1	L4	0.38

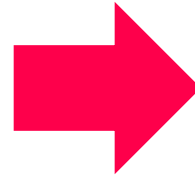


Period	Field A	Field B	Proximity
2022	D1 - F1	D1 - F2	0.52
2022	D1 - F1	D1 - F3	0.14
2022	D1 - F1	D2 - F1	0.03

Building complexity indicators

Publicly available libraries help create smart diversification indicators from capabilities...

Period	Location	Field	Capability
2022	L1	D1 - F1	True
2022	L1	D1 - F2	True
2022	L1	D1 - F3	False
2022	L2	D1 - F1	True
2022	L2	D1 - F2	False
2022	L2	D1 - F3	True
...



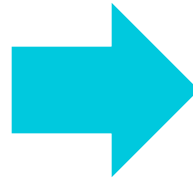
Period	Location	Diversity	Complexity
2022	L1	6	0.6
2022	L2	12	1.7
2022	L3	11	1.3

Period	Field	Ubiquity	Complexity
2022	D1 - F1	3	1.9
2022	D1 - F2	9	1
2022	D1 - F3	14	0.2

Building relatedness indicators

Publicly available libraries help create smart diversification indicators from capabilities...

Period	Location	Field	Capability
2022	L1	D1 - F1	True
2022	L1	D1 - F2	True
2022	L1	D1 - F3	False
2022	L2	D1 - F1	True
2022	L2	D1 - F2	False
2022	L2	D1 - F3	True
...



Relatedness	Complexity Gain
0.33	0.41
0.64	- 0.22
0.17	- 0.54
0.80	0.25
0.51	0.28
0.66	- 0.02
...	...

Outline of this training

- 1: Why map Innovation Capabilities?
- 2: How can Innovation Capabilities inform policy?
- 3: How to build innovation capability indicators
- **4: Applications**



Innovation Capabilities Outlook 2026

WIPO's methodology for mapping innovation capabilities, analyzing hundreds of millions of datapoints from **patents, trademarks, scientific publications, and exports** to reveal how economies and regions can leverage their existing strengths for economic growth.

Policymakers and business leaders can see a complete innovation landscape of **+190 economies, +2'500 fields in 25 years** and uncover:

- What capabilities exist and which are the most rewarding ones.
- Which economies are managing their capabilities effectively.
- How capabilities connect to find where threats and opportunities lie.



Mapping the global innovation landscape

WIPO Department of Economics and Harvard Kennedy School joint methodology

- 2,508 innovation capabilities across *science, technology, entrepreneurship, and production.*
- 193 economies.
- 25 years of historical data.



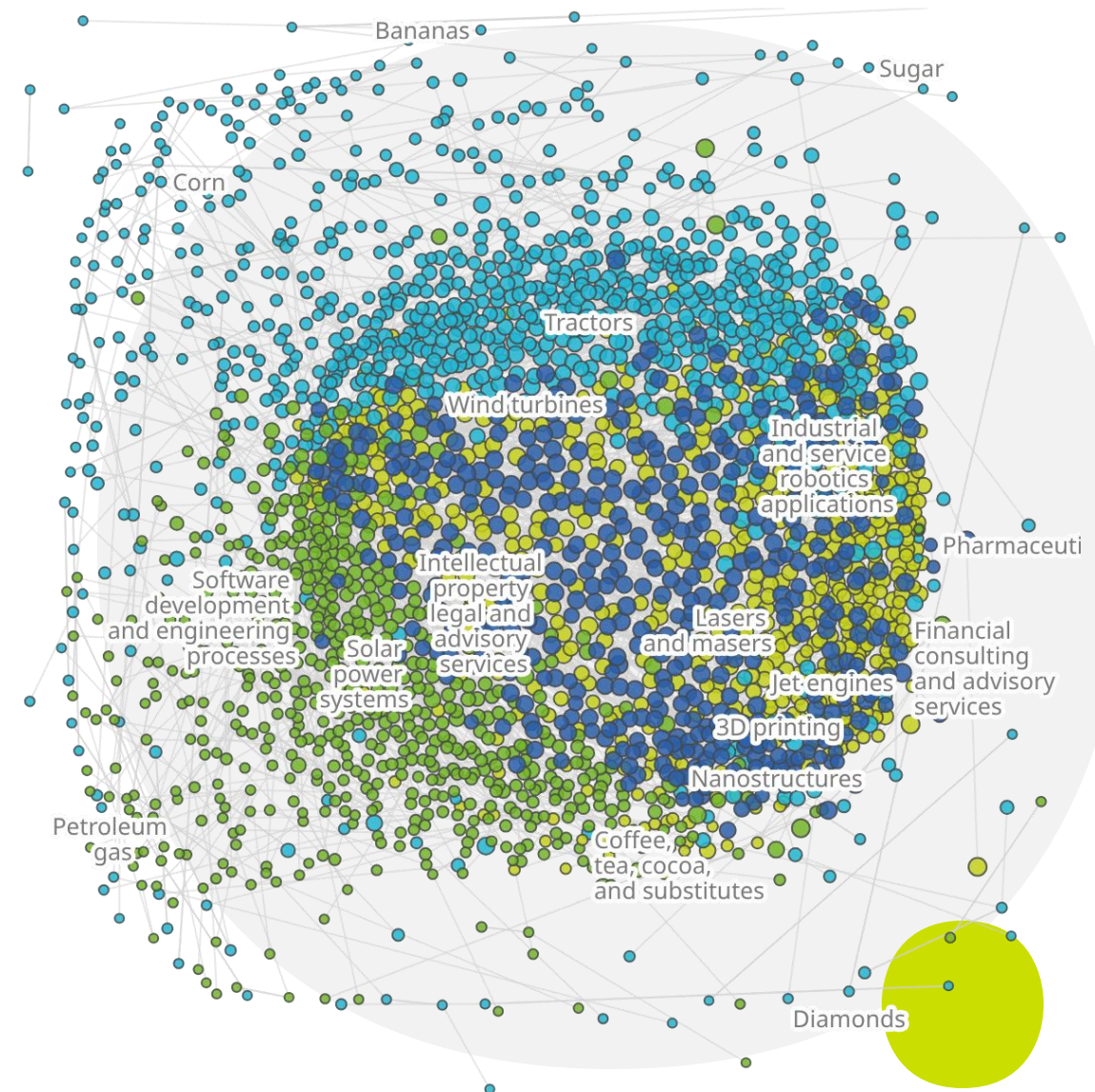
Source: Innovation Capabilities Outlook 2026

Mapping the global innovation landscape

WIPO Department of Economics and Harvard Kennedy School joint methodology

- Billions of data points from international sources of innovation.
- Trillions of connections between fields, ecosystems and periods...

Transformed into indicators for actionable insights for ecosystems and industries.



Source: Innovation Capabilities Outlook 2026

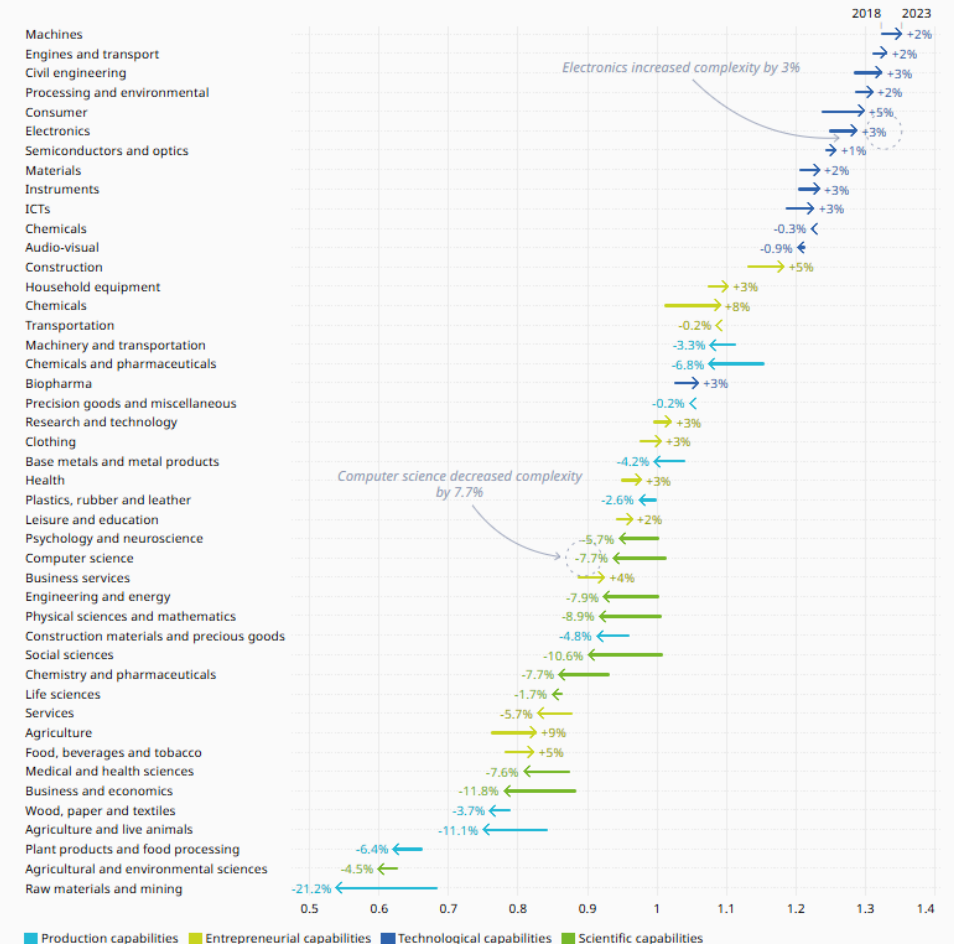
Key takeaways from ICO 2026:

1. Technologies are the most difficult capabilities to master and are becoming increasingly complex.

- Over the past five years, **technological complexity has accelerated** beyond other fields, creating a widening gap in scientific, entrepreneurial and production capabilities.
- **Scientific and production domain complexity has decreased**, making these capabilities less dependent on related knowledge for their domain. Although these skills are still relatively rare globally, they have become more accessible as standalone competencies.

Technological capabilities remain the most complex set of skills, and are breaking away from other fields

Figure 2.7 Average complexity of innovation capabilities, by domain, 2018 vs 2023

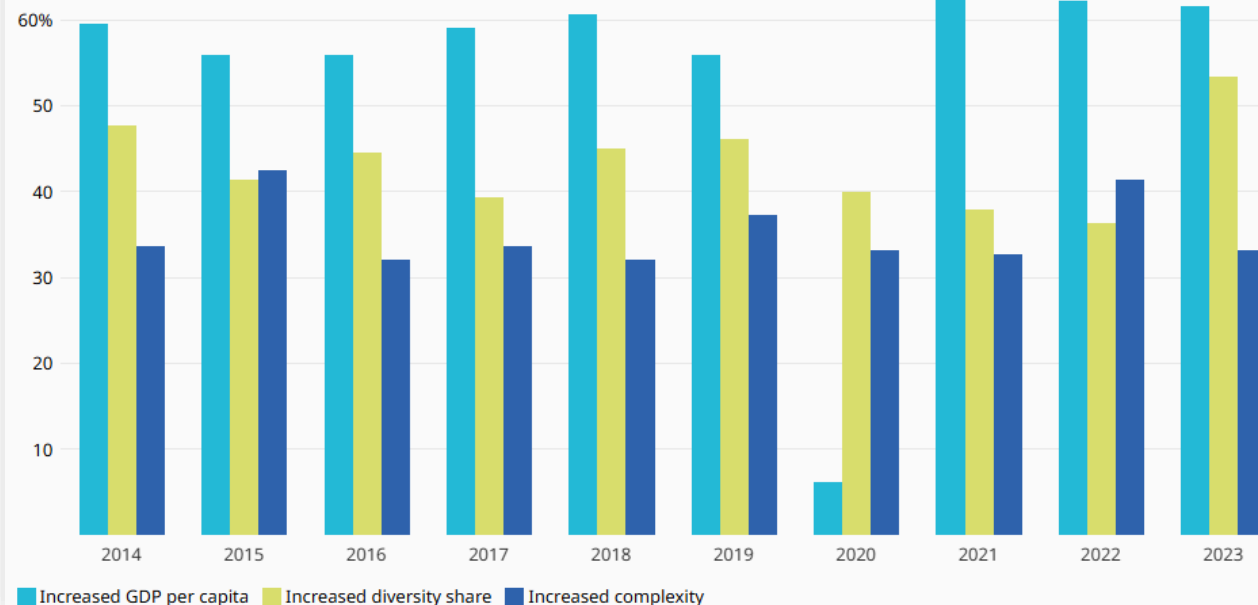


Key takeaways from ICO 2026:

2. **Building innovation capabilities is significantly more complicated than achieving economic growth**
 - Only a third of economies improve their capabilities each year.

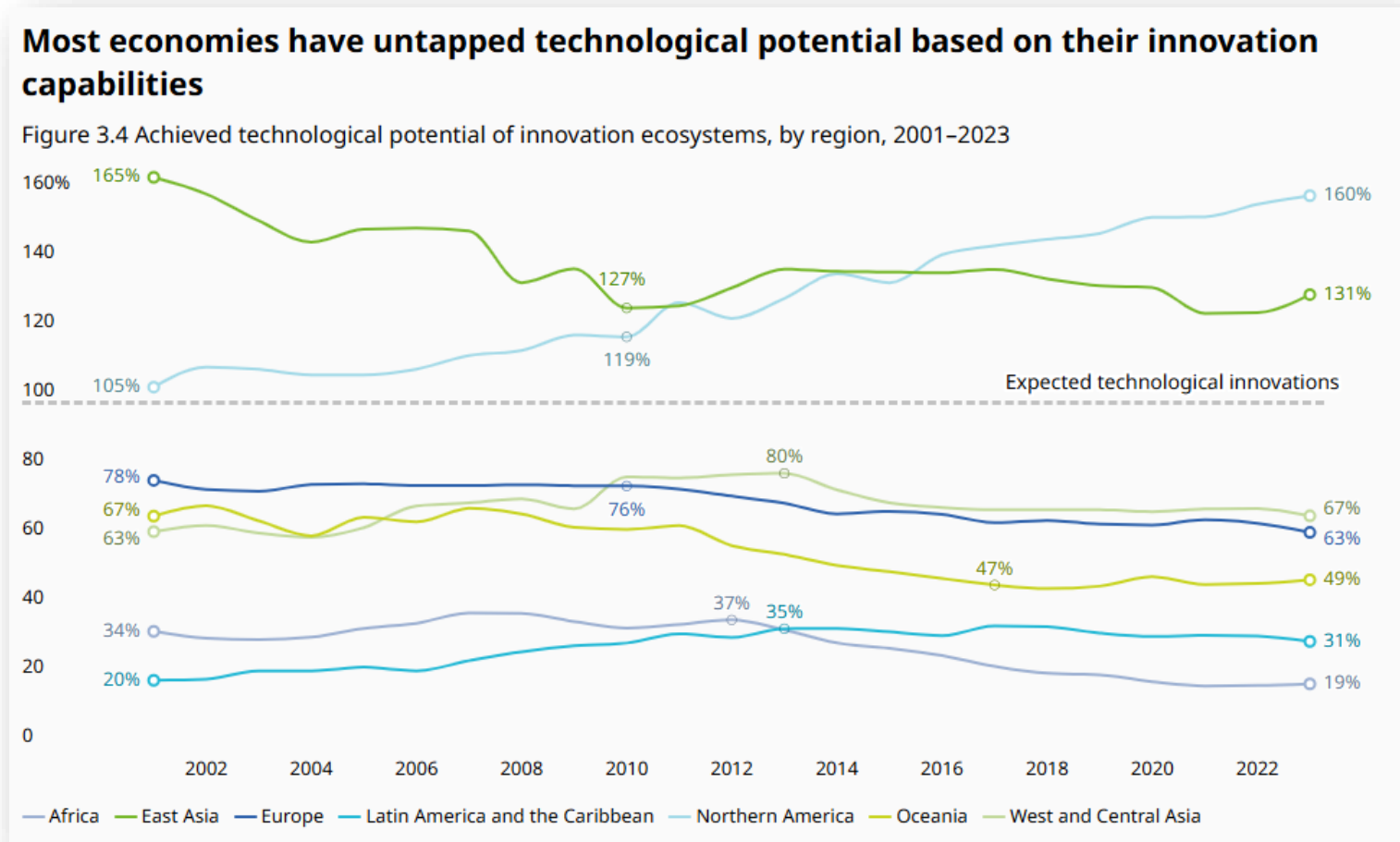
Most economies get wealthier every year but struggle to simultaneously increase their international innovation output, upgrade and diversify capabilities

Figure 2.5 Share of economies with economic growth, diversity growth, and complexity growth, 2014-2023



Key takeaways from ICO 2026:

3. The world has an untapped potential of +300K additional patents.



Key findings from the Innovation Capabilities Outlook 2026:

Other findings:

- Mature innovation systems demonstrate capabilities in the 4 dimensions mapped in the study
- Economies well-positioned to master complex skills are often also in the best positions to enter fast-growing fields.
- Diversified economies are more likely to make strategic leaps into new capabilities.
- AI (science and technology) capabilities are among the 20 fastest growing in the last 5 years.

Available now:

- Innovation Capabilities Datasets 2026

Coming soon:

- Industry and Economy Profiles.

Source: Innovation Capabilities Outlook 2026




Thank you!

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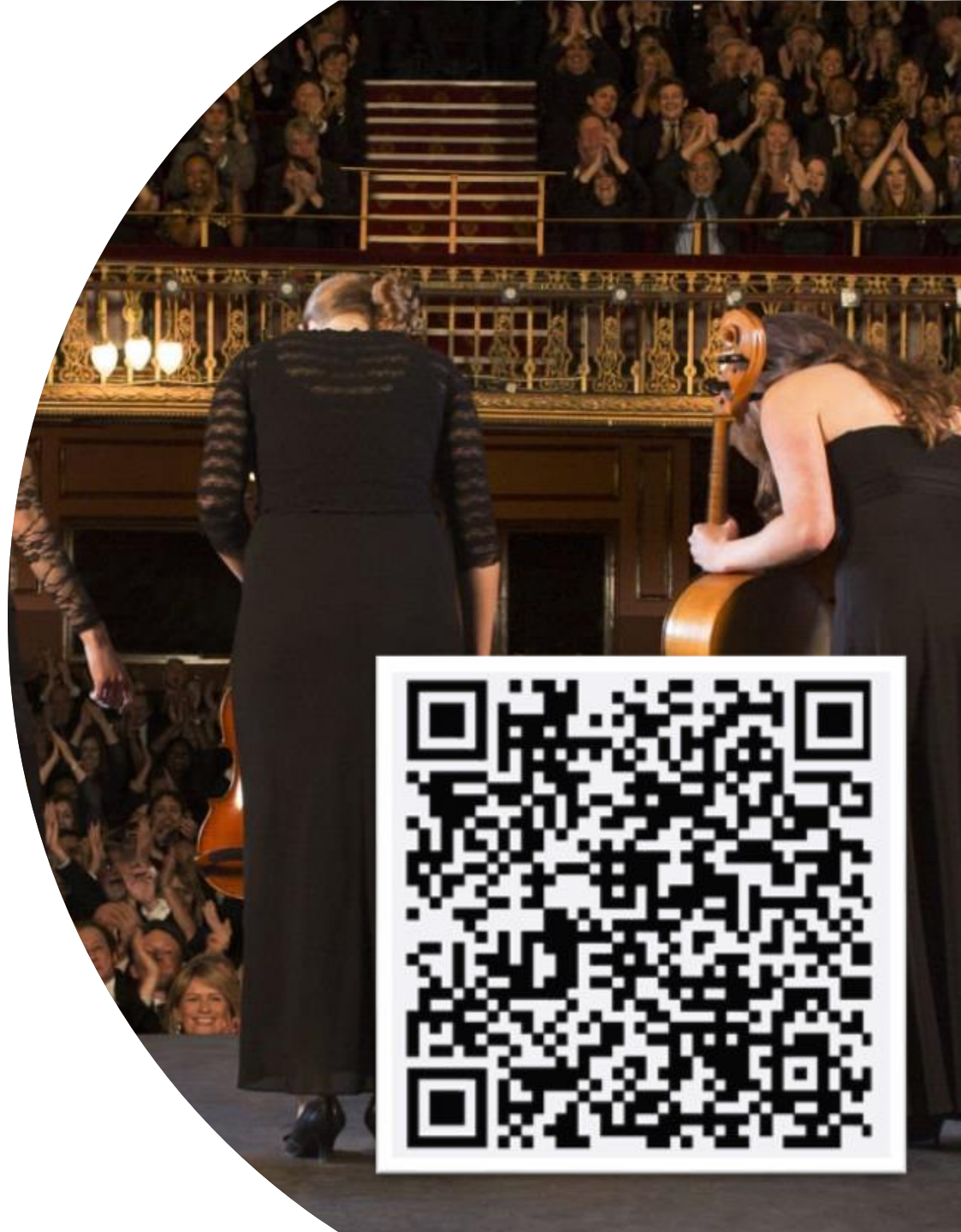


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Advanced materials

- *World IP Report 2024: [Making Innovation Policies Work for Development](#)*
- *[Innovation Capabilities Outlook 2026](#)*
- *Working Paper 2024: [Can we map Innovation Capabilities?](#)*
- *Working Paper 2026: [The Technological Potential of Innovation Ecosystems](#)*
- *List of [web stories](#) on Innovation Capabilities*
- *List of [relevant papers](#) on Innovation Capabilities*
- *List of [Python libraries](#) on Innovation Capabilities*



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