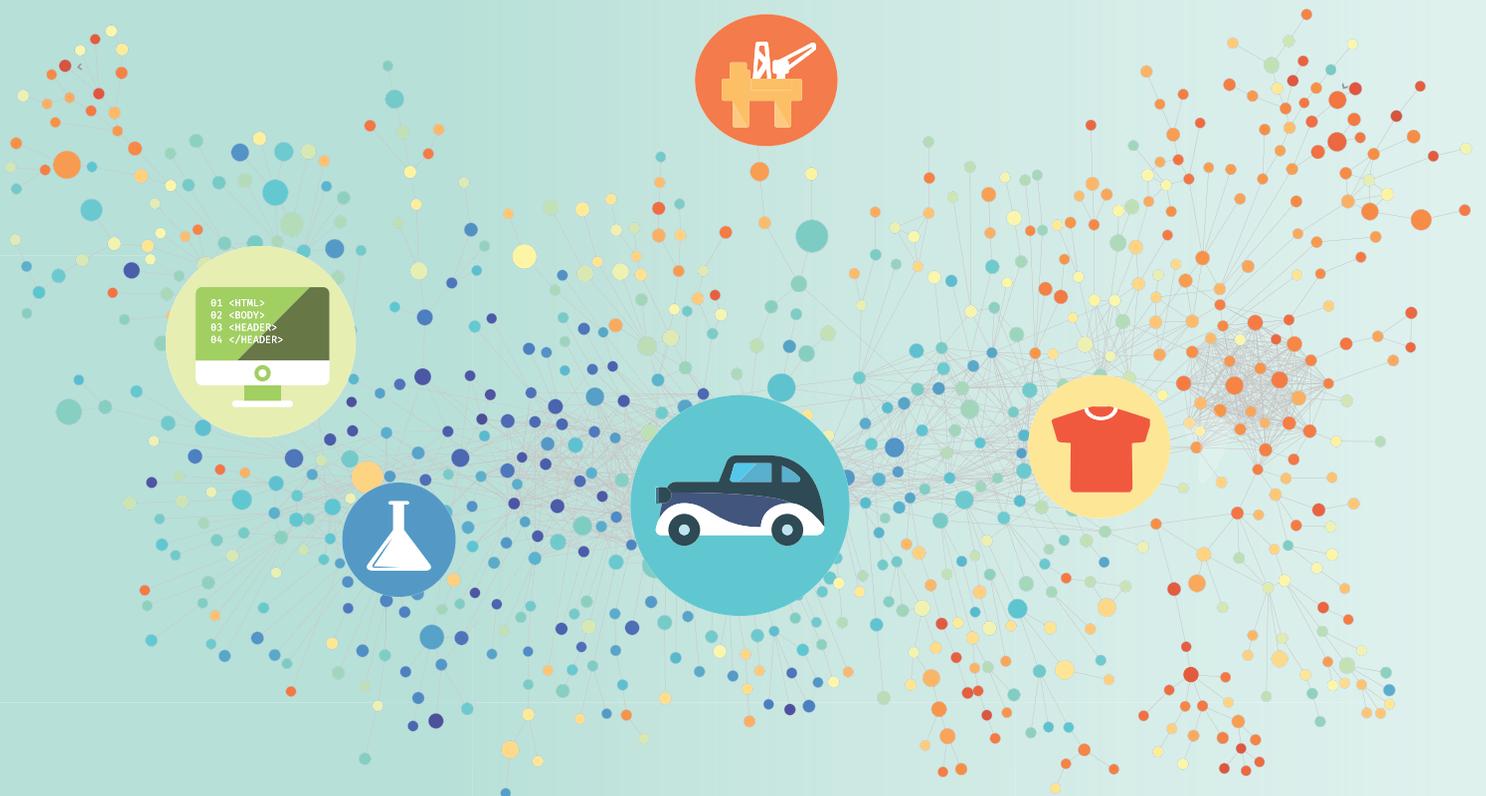# Fraunhofer
IMW

DIVERSIFICATION OF KNOWLEDGE

DR. DOMINIK HARTMANN

RESEARCH SPACE

TECHNOLOGY SPACE

PRODUCT SPACE

What we do

We help policy- and decision-makers to reveal the strengths and challenges of their innovation systems and to identify promising opportunities for scientific, technological and economic diversification.

### Imagine strategic decision problems

- I am the manager of a company and want to identify promising new innovation partners and business opportunities.
- I am a director of a research institution and want to boost the scientific competitiveness and diversify the publication portfolio of my institution, but I do not know which scientific areas I could and should pursue.
- I am an economic policy maker and want to know which skills and strategic industrial sectors I should promote with targeted educational or innovation policies.

How can we solve these problems?

Smart diversification is key to any strategic solution of these problems. Analyzing the diversification pattern of productive structures, job positions, innovation networks and research portfolios can provide a rich set of information to design successful strategies to boost the economic success of a country, region, company or university, etc.

Our scientific methods

New approaches from networks science, innovation economics, economic geography and management show that interactive learning and economic diversification are key determinants for the success of universities, companies and countries (e.g. Hidalgo et al., Science, 2007; Hidalgo and Hartmann, OECD Insights, 2016; Guevara et al., Scientometrics 2016). We combine the results of these cutting-edge research methods with in-depth qualitative studies on the innovation systems of countries and with the vast experience of the Fraunhofer Society in applied research technology to design tailor-made policy recommendations for countries, regions, universities and large companies on how to successfully diversify their knowledge portfolio. Subsequently, our four areas of expertise -1. Knowledge Portfolios and Diversification Opportunities.
2. International Innovation Networks,
3. Economic Diversification, and 4. Policy Recommendations— are summarized.
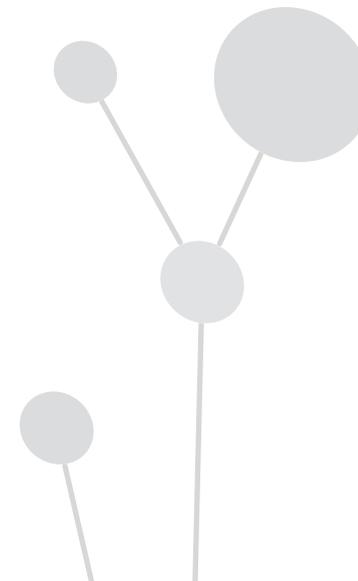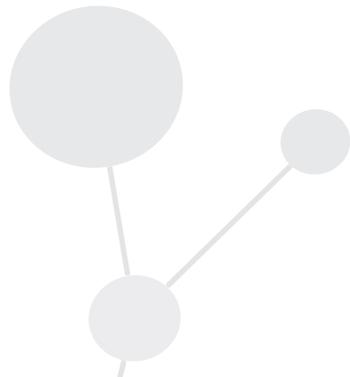
RESEARCH SPACE

Figure 1
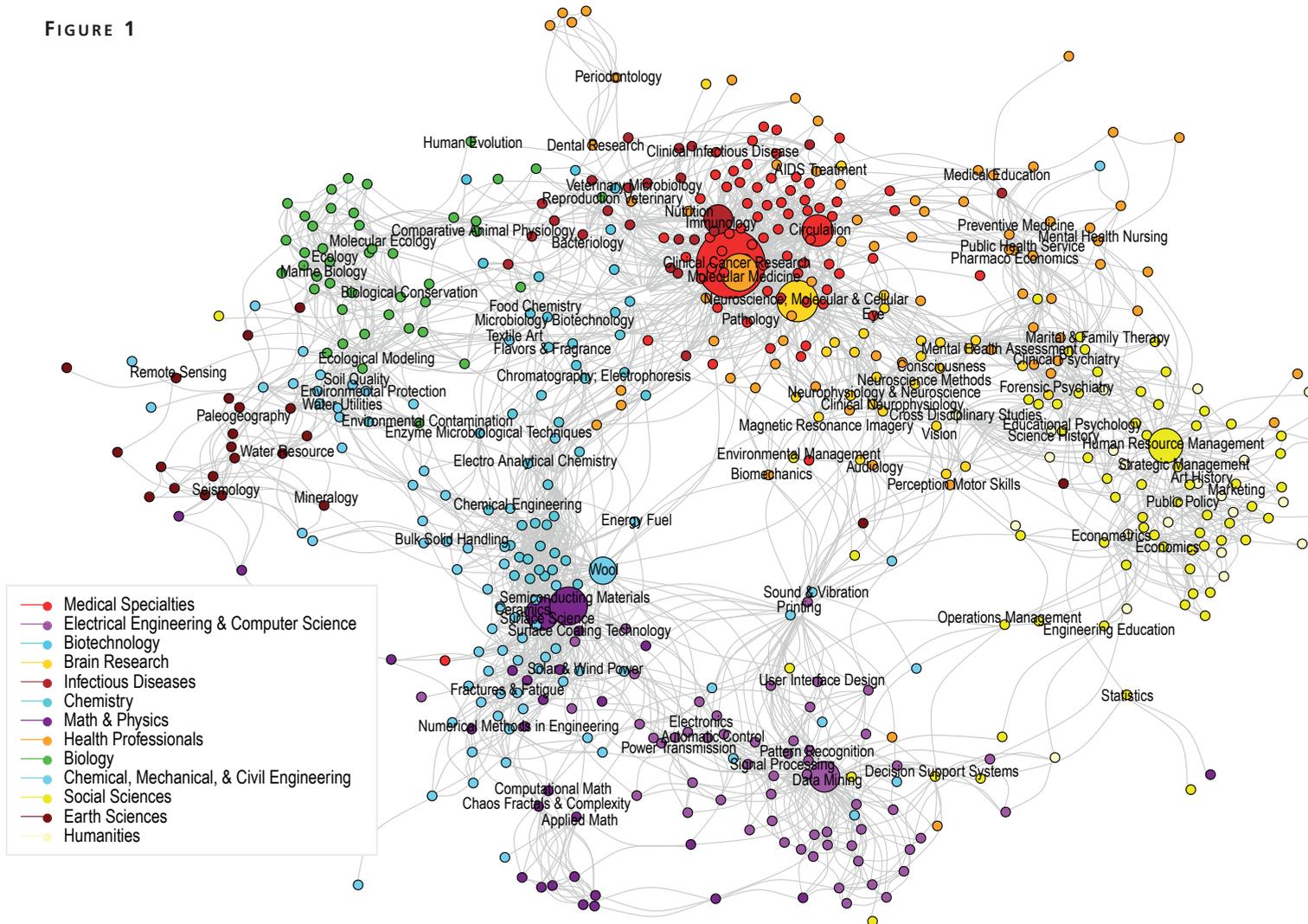
**Source: Guevara et al., Scientometrics, 2016**

1. Using the global research space

Using the global research space to reveal the comparative advantages, disadvantages and opportunities of universities and countries to diversify their knowledge portfolio The research space *Figure 1* (left) is a significantly better predictor of the evolution of the research output of individuals and universities than existing maps of science (Guevara et al., 2016). We can use these maps and underlying methods from machine learning to identify and compare the knowledge areas in which individuals, universities and countries are most likely to diversify successfully, based on their previous knowledge portfolio.

FIGURE 2
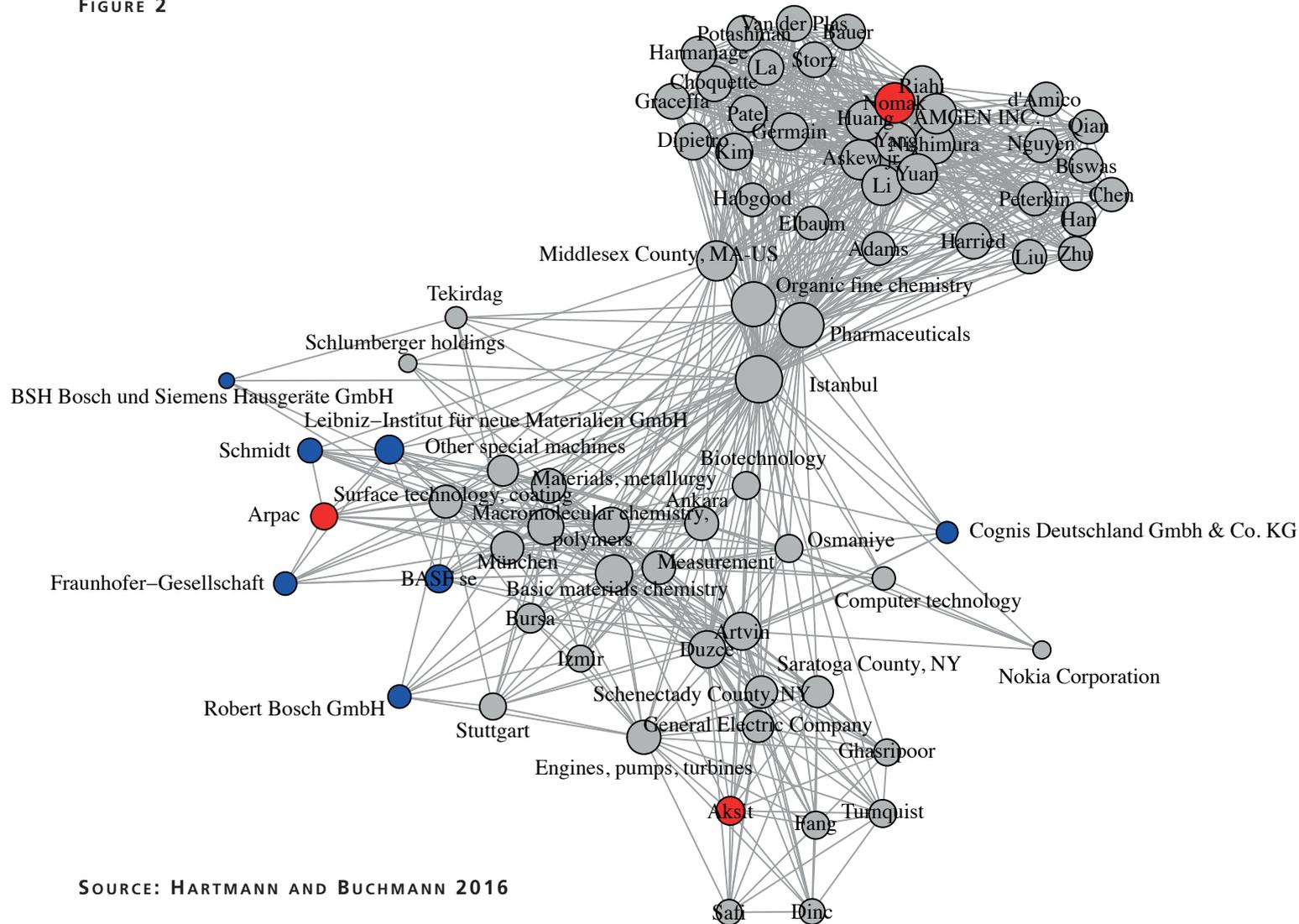
2. IDENTIFYING KEY PLAYERS WITHIN INTERNATIONAL KNOWLEDGE AND TECHNOLOGY TRANSFER

We can use different data sources, such as publications, patents, international projects or semi-structured interviews to identify the bridge builders between countries, regionas, companies and research institutions. For instance, *Figure 2* shows that several German and US technology companies are key players within the Turkish patent portfolio.
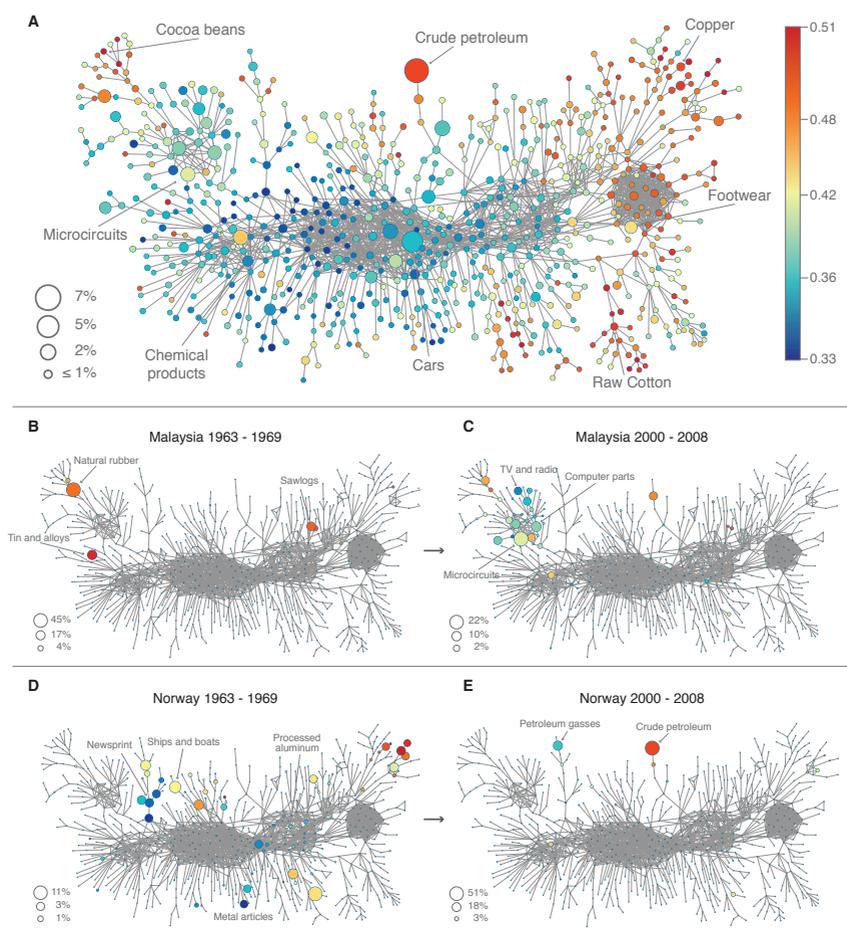
We complement the empirical studies with qualitative policy recommendations to promote economic win-win situations via intercultural boundary spanners and knowledge exchange.

SOURCE: HARTMANN AND BUCHMANN 2016

PRODUCT SPACE

FIGURE 3

A

Cocoa beans · Crude petroleum · Copper · Footwear · Microcircuits · Chemical products · Cars · Raw Cotton

7% · 5% · 2% · ≤ 1%

0.51 · 0.48 · 0.42 · 0.36 · 0.33

B — Malaysia 1963 - 1969
Natural rubber · Sawlogs · Tin and alloys · 45% · 17% · 4%

C — Malaysia 2000 - 2008
TV and radio · Computer parts · Microcircuits · 22% · 10% · 2%

D — Norway 1963 - 1969
Newsprint · Ships and boats · Processed aluminum · Metal articles · 11% · 3% · 1%

E — Norway 2000 - 2008
Petroleum gasses · Crude petroleum · 51% · 18% · 3%

SOURCE: HARTMANN ET AL. 2017

3. STRATEGIES FOR ECONOMIC DIVERSIFICATION

Cutting edge-research from network science and economic complexity shows that the productive structures of countries determine their future level of economic development and income inequality (Hidalgo et al., Science, 20007; Hartmann et al., 2016, OECD Insights). This new research allows for an understanding of the systemic connections between different economic sectors and the institutions that are necessary for becoming competitive in different types of products and industries. *Figure 3* shows to which extent 775 different industrial products share competences and to which extent these products are related to high (=red) and low (=blue) levels of income inequality.

We use these methods to reveal country's opportunities for smart, sustainable and inclusive growth. *Figure 4* (next page) compares the productive structure of A.
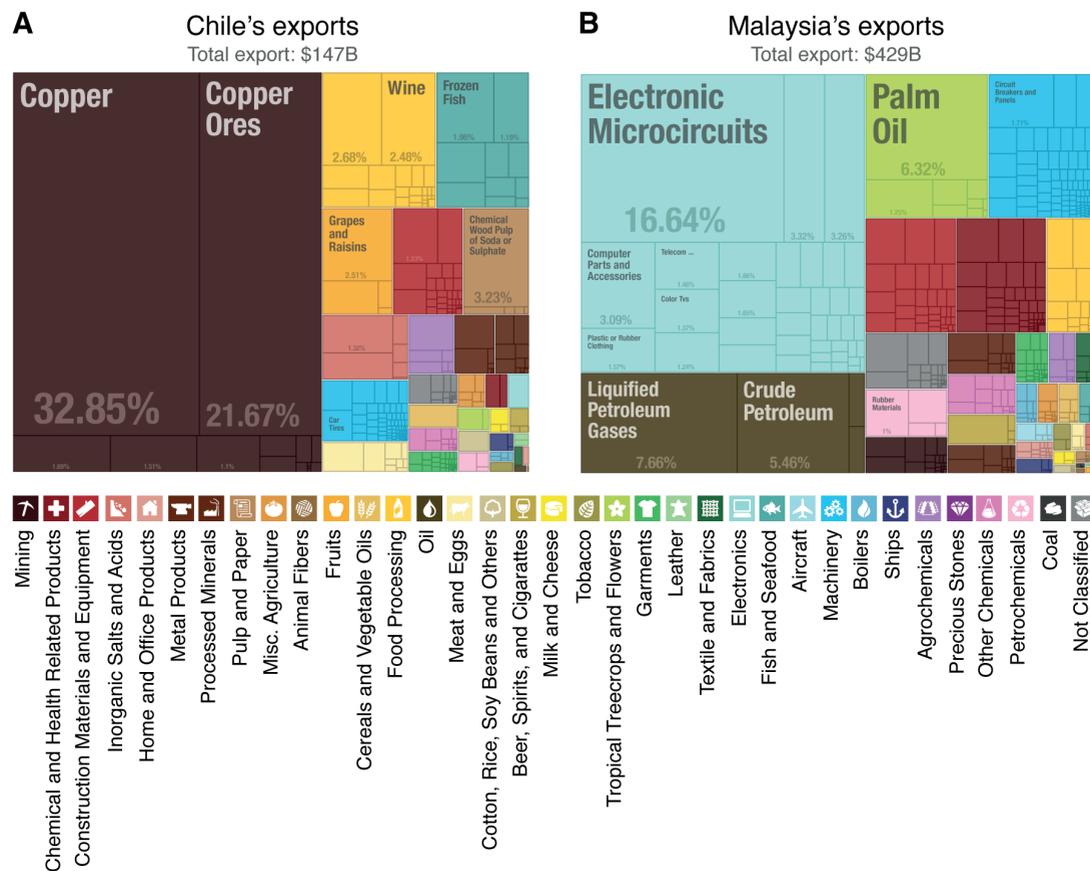
Chile and Malaysia. It becomes obvious that Chile's lack of economic diversification and dependence on copper constrains its possibilities for inclusive growth. Conversely, Malaysia and several other East Asian economies have successfully managed to combine industrial and social policies to diversify their economies and have the ability to continue building up new capabilities to further diversify their productive structure.

Figure 3. The product space and income inequality. (A) In this visualization of the product, space nodes are colored according to a product's PGI as measured between 1995-2008. Node sizes are proportional to world trade between 2000 and 2008. The networks are based on a proximity matrix representing 775SITC-4 product classes exported between 1963-2008. The link strength (proximity) is based on the conditional probability that the products are co-exported.
Source: Hartmann et al., 2015

FIGURE 4

A Chile's exports
Total export: $147B

B Malaysia's exports
Total export: $429B

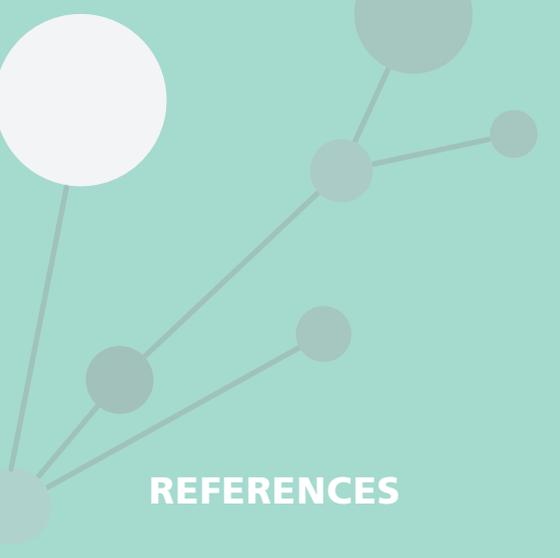Source: Hartmann et al., 2017; atlas.media.mit.edu

4. Qualitative analysis and policy recommendations

A smart combination of science, industrial, and social policies is necessary to achieve economic prosperity and reduce income inequality. Our methods allow us to identify opportunities for the scientific and industrial diversification of regions and countries while taking their unique productive structures and capabilities into account. This is crucial to designing education and scientific policies that match the economic growth opportunities.

To understand the practical challenges and opportunities we also reveal key players and structural holes in the regional, national and international innovation networks. To reveal potentially new growth paths and policy strategies we use scenario building workshops with experts.

In this way we can provide tailor-made, data driven and practical policy recommendations on how to strategically combine education, science and economic diversification policies.

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DOMINIK HARTMANN

Dr. Dominik Hartmann has been working as a scientific assistant at Fraunhofer Center for International Management and Knowledge Economy IMW since October, 2016. Previously, he conducted research as an EU Marie Curie Fellow at the Massachusetts In-stitute of Technology's (MIT) and University of Hohenheim's media labs from 2014-2016. In his work, Dr. Hartmann analyzes interdisciplinary networks in the global research landscape as well as the link between economic complexity and sustainable development in more than 120 countries. He holds a Bachelor of Business Administra-tion from the University of Augsburg, a master's degree in International Development from the University of Complutense de Madrid and a PhD in Innovation Economics from the University of Hohenheim. His interest in cultural diversity, interdisciplinary research and global development has brought him to leading research and development institutions in countries such as the United Kingdom, the Netherlands, Peru, Brazil, Chile and Turkey. His scientific work has been internationally disseminated via academic journals and publications such as Routledge, Scientometrics, World Development, Integration & Trade and Routledge book series.

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