NATIONAL RESEARCH UNIVERSITY HIGHER SCHOOL OF ECONOMICS

INSTITUTE FOR STATISTICAL STUDIES AND ECONOMICS OF KNOWLEDGE

Science and Technology Foresight: Response to New Agenda

Alexander Sokolov

HSE ISSEK, UNESCO Chair on Future Studies

2024-2025 CSTD Intersessional panel

Technology Foresight and Technology Assessment for Sustainable Development

UNCTAD, Geneva, 22 October 2024

We want to know more about future S&T

Why is it important?

- New opportunities for innovation
- Competitiveness
- Strategic planning
- Better understanding of social and economic impacts
- Curiosity

Why is it that difficult?

- Accelerating technological development
- Interconnectedness of technologies
- Growing complexity
- Serendipity, unexpected ideas, wild cards
- Lack of data vs Too much data
- **Linear thinking**

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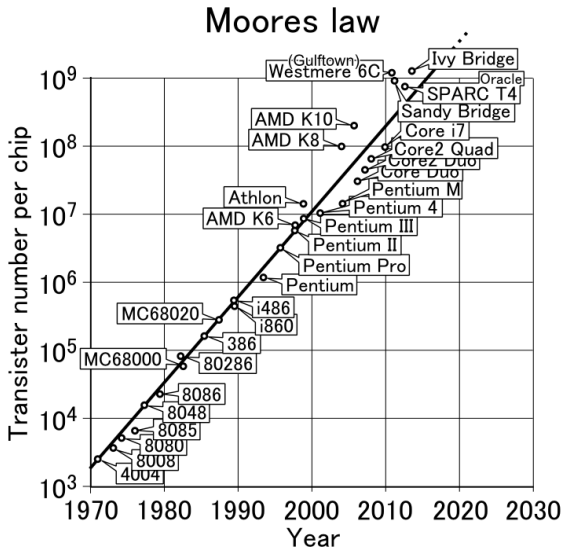
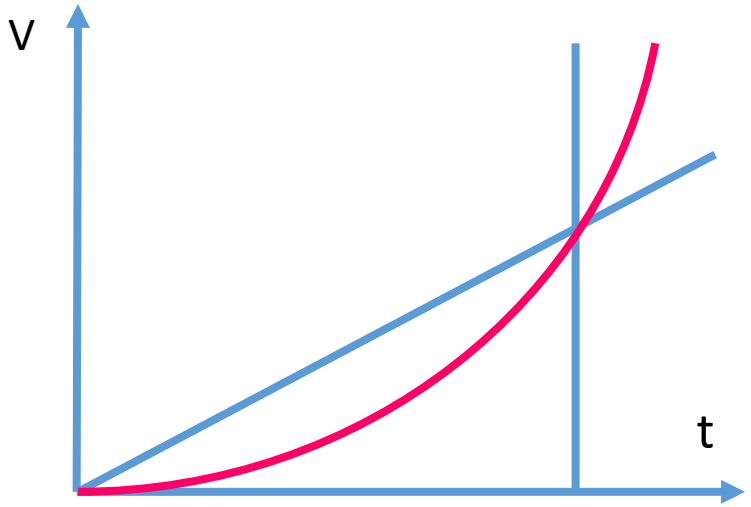
Linear thinking

Moore's law



Amara's Law



People tend to overestimate the effect of technologies in the short-run and to underestimate in the long-run

Roy Amara, futurist

Metcalfe's Law

A network's impact is the square of the number of nodes in the network

$V \sim N^2$

Bob Metcalfe, creator of the Ethernet

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Foresight : Definition and Basic Principles

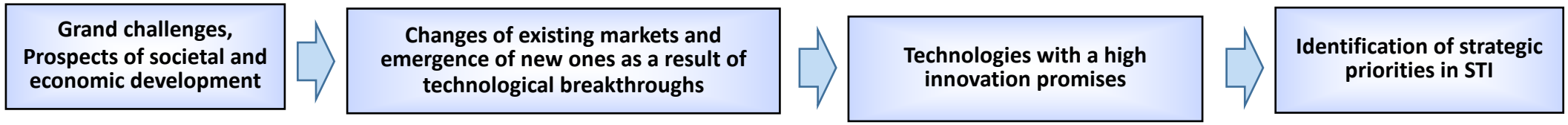
Definition

The process involved in **systematically** attempting to look into the **longer-term future** of science, technology, the economy and society with the aim of **identifying the areas of strategic research and the emerging generic technologies** likely to yield the **greatest economic and social benefit**

Ben Martin

Basic principles

- Identify possible versions of the future
- Reach a consensus among stakeholders and experts about preferable target option of the future
- Together develop a set of consecutive measures for achieving the selected option of the future



Grand challenges

The most complex, widespread and intractable problems that require solutions by many actors, including governments and international organisations

Megatrends

large-scale social, economic, political, environmental or technological changes that are slow to form but which, once they have taken root, exercise a profound and lasting influence on many if not most human activities, processes and perceptions

OECD STI Outlook, 2016

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Foresight for Policy Making under Deep Uncertainty

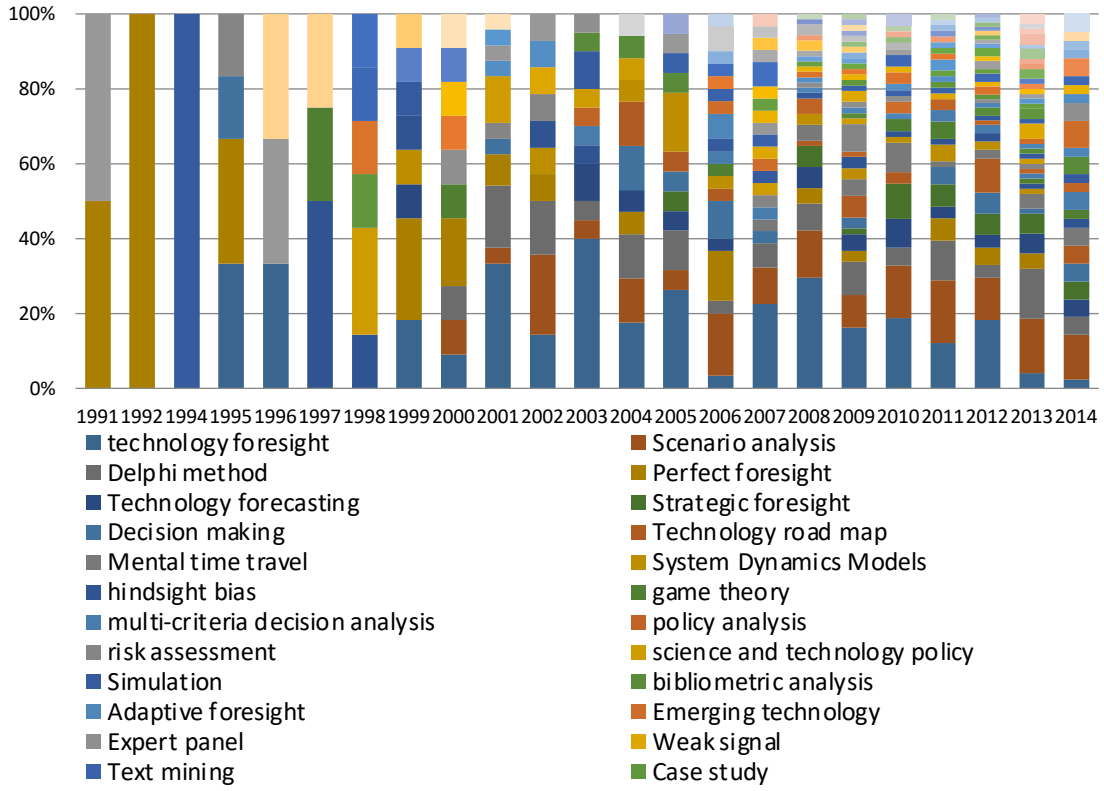
Increasing uncertainty requires methods working under condition of high turbulence and abrupt change of trends

Problems	**High uncertainty**	**Lack of data vs Too much data**		**Increasing complexity of processes and systems**	**Unpreparedness to shocks**	**Inter-disciplinarity**	**Polarity of opinions**	**Emerging short-term problems**
Methods	Scenarios	Expert studies	**Big data and AI**	Modeling	Wild cards	STEEPVL	Consensus forecasts	Situation analysis
Results	Range of possible futures	Exposure of tacit knowledge	Quick identification of emerging trends and weak signals	Understanding linkages between parts of the system	Unpredictable events with high impact	Wide spectrum of problems (economy, society, technologies, values etc.)	Shared forecast estimates	Operational decision-making

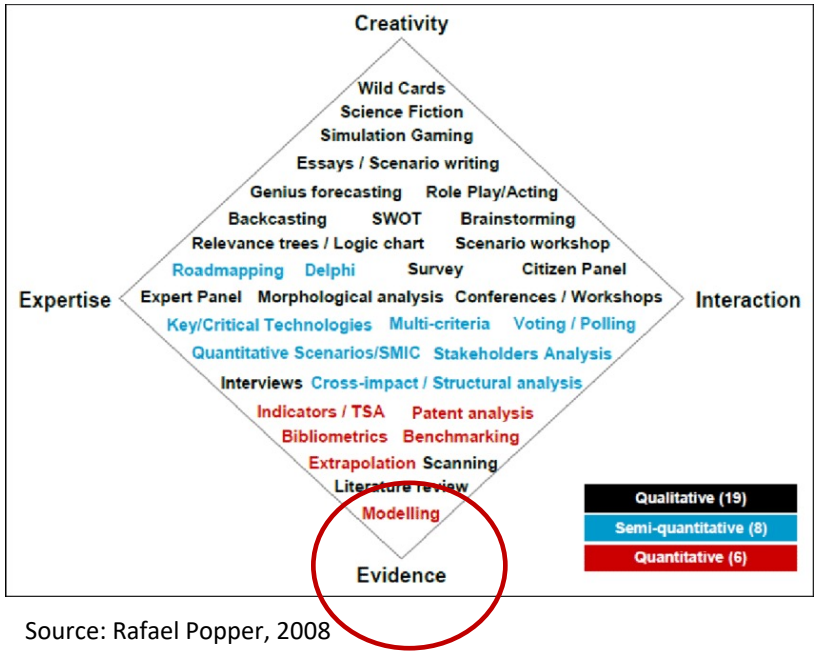
The Digital Transformation of Foresight

New Trends in Foresight Methods

Foresight methods



Source: Saritas, O., Burmaoglu, S. (2015) The evolution of the use of Foresight methods: a scientometric analysis of global FTA research output, *Scientometrics*, 105, 1, 497-508.



Source: Rafael Popper, 2008

	Cases	%
Literature review	477	54 %
Expert panels	440	50 %
Scenarios	372	42 %
Trend extrapolation/Megatrend analysis	223	25 %
Futures workshops	216	24 %
Brainstorming	169	19 %
Other methods	157	18 %
Interviews	154	17 %
Delphi	137	15 %
Questionnaire/Survey	133	15 %
Key technologies	133	15 %
Environmental scanning	124	14 %
Essays	109	12 %
SWOT analysis	101	11 %
Technology roadmapping	72	8 %
Modelling and simulation	67	8 %
Backcasting	47	5 %
Stakeholder mapping	46	5 %
Cross-impact/Structural analysis (e.g. MICMAC)	36	4 %
Bibliometical analysis	22	2 %
Morphological analysis	21	2 %
Citizens panels	19	2 %
Relevance trees	17	2 %
Multi-criteria analysis	11	1 %
Gaming	6	1 %

Source - European Foresight Monitoring Network, 2009

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iFORA – AI Powered analytical system for technology foresight

iFora
Intelligent Foresight Analytics

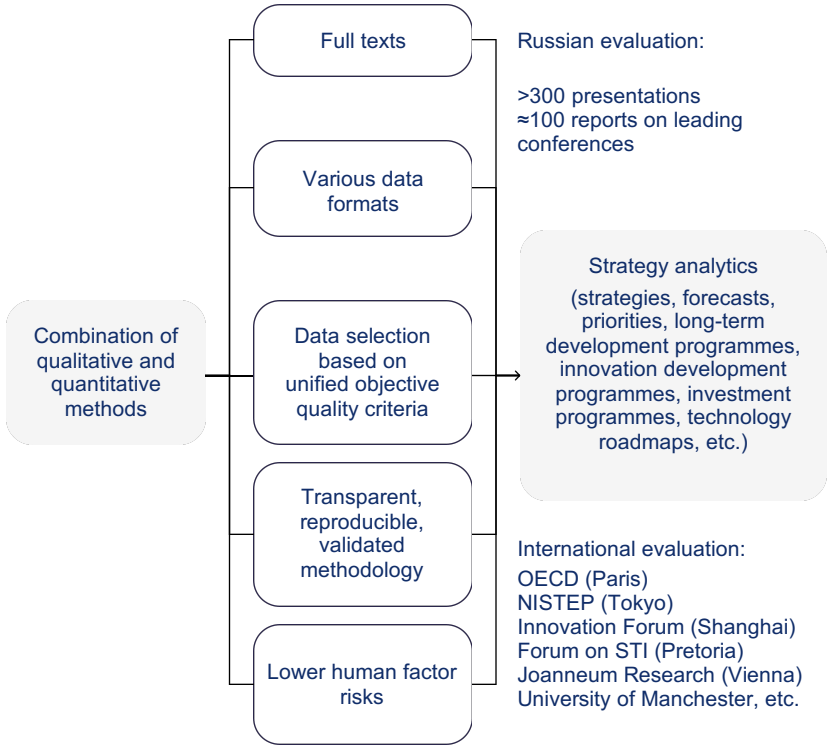
>800m
documents

+30k
documents daily

Languages

- Russian
- Roman
- English
- Cyrillic
- Chinese

>354m	Scientific publications
>122m	Patents
>55m	Popular science media
>28m	Market analytics and professional media
>4m	Research projects / grants international and national programmes / foundations
>3.5m	Public procurement data
>3.5m	Clinical research
>3.5m	Social networks
>2m	Vacancies
>1m	Documents of international organisations, consulting companies
>300k	R&D reports
>100k	Scientific conferences
>5k	Educational programmes
	Other text documents



iFORA™ mentioned in *Nature* as an effective support tool for decision-making (Nature, 2020, Vol. 583)

iFORA™ featured by OECD as an example of successful initiative in science digitalisation (OECD Science, Technology and Innovation Outlook 2018)

HSE supoercomputer cHARISMa received a Priority 2020 reward in advanced technology implementation. Peak performance as of 2023: 2 petaflops.

UN trade & development

≈CSTD issues paper , 2024

≈40 Special iFORA Issues (operational analytics)

>100 projects under contracts with largest companies, including global

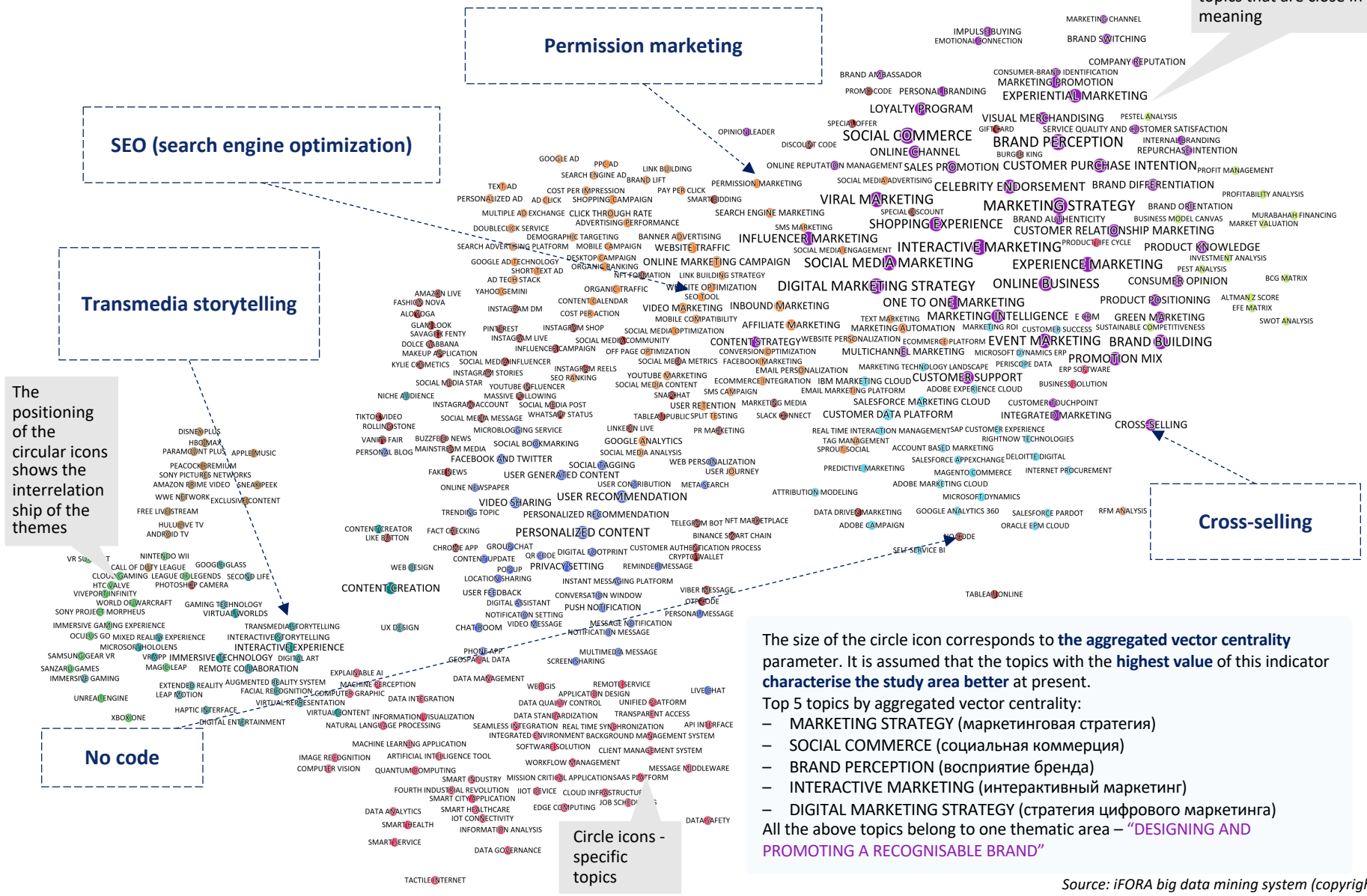
✓ UNLOCKS ADVANTAGES OF AUTOMATED ANALYTICS

iFORA is based on a modular approach

AND COMBINES SPECIALIZED MODULES FOR SPECIFIC TASKS

Trends	Technology development analysis	Technology independence assessment	Market assessment	Forecasts	Risk assessment	Legal environment analysis	Regional analysis	Identification of competence networks and competences	Analysis and prediction of professional competences	Emerging NLP solutions / services
Trend fitting	Science and technology landscape mapping	Calculation of technology importance and dynamics in the country and globally	Qualitative market assessment	Consensus forecasting	Competitiveness analysis	Analysis of legal framework, standards	Identification of development barriers for regional business	Identification of enterprise' networks	Identification of promising professions related to emerging technologies	Automated summarisation of texts
Assessment of importance and dynamics of trends	Technology life cycle analysis	Identification of different selected technology development levels in the country and globally	Market maturity assessment	Building of timelines of the future	Reputation analysis	Priority identification	Analysis of reputation in media spaces	Identification of enterprise's specialisation	Identification of most promising competences	Profile document analysis based on NER models
Structural changes analysis	Technology sector impact analysis	Support measures selection	Procurement analysis	Selection of product development areas	Identification of strategy development directions and threats	Comparison of national and international agenda	Calculation of independent rankings	Analysis of educational programmes	Formation of project teams, experts selection	Development of interactive interfaces and data marts
Hype mapping	Technology readiness level determination	Identification of possible growth points	Building of technology and product portfolios	Identification of possible growth points	Risk systematisation and mapping	Analysis of gaps in legal framework	Identification of key trends to work "blank spots"	Expert landscape analysis	Juxtaposition of trends and demand on personnel competences	Development of customised machine learning models
Identification of emerging trends	...	...	...	...	Identification of media and advertising impact	...	...	Identification of professional community leaders	...	...
...					...			...		

Global agenda: thematic landscape



The size of the circle icon corresponds to **the aggregated vector centrality** parameter. It is assumed that the topics with the **highest value** of this indicator **characterise the study area better** at present.

Top 5 topics by aggregated vector centrality:

- MARKETING STRATEGY (маркетинговая стратегия)
- SOCIAL COMMERCE (социальная коммерция)
- BRAND PERCEPTION (восприятие бренда)
- INTERACTIVE MARKETING (интерактивный маркетинг)
- DIGITAL MARKETING STRATEGY (стратегия цифрового маркетинга)

All the above topics belong to one thematic area – "DESIGNING AND PROMOTING A RECOGNISABLE BRAND"

Trends (thematic areas)

- GAMIFICATION
- USE OF SOCIAL NETWORKS AND MEDIA IN MARKETING
- SMART TECHNOLOGIES
- IMPROVED CUSTOMER FOCUS
- BUSINESS PROCESS PLANNING AND ORGANISATION OF THE CORPORATE ENVIRONMENT
- IMMERSIVE TECHNOLOGIES
- FORMING A STRATEGY TO ATTRACT AND RETAIN CUSTOMERS
- DEVELOPMENT OF ONLINE MARKETING TOOLS
- DESIGNING AND PROMOTING A RECOGNISABLE BRAND
- DEVELOPMENT OF STREAMING SERVICES

– also relevant in the Russian agenda

– also relevant in the Chinese agenda

Source: iFORA big data mining system (copyright – HSE ISSEK)

Chinese agenda: thematic landscape

Colour groups of icons (clusters) - combination of topics that are close in meaning

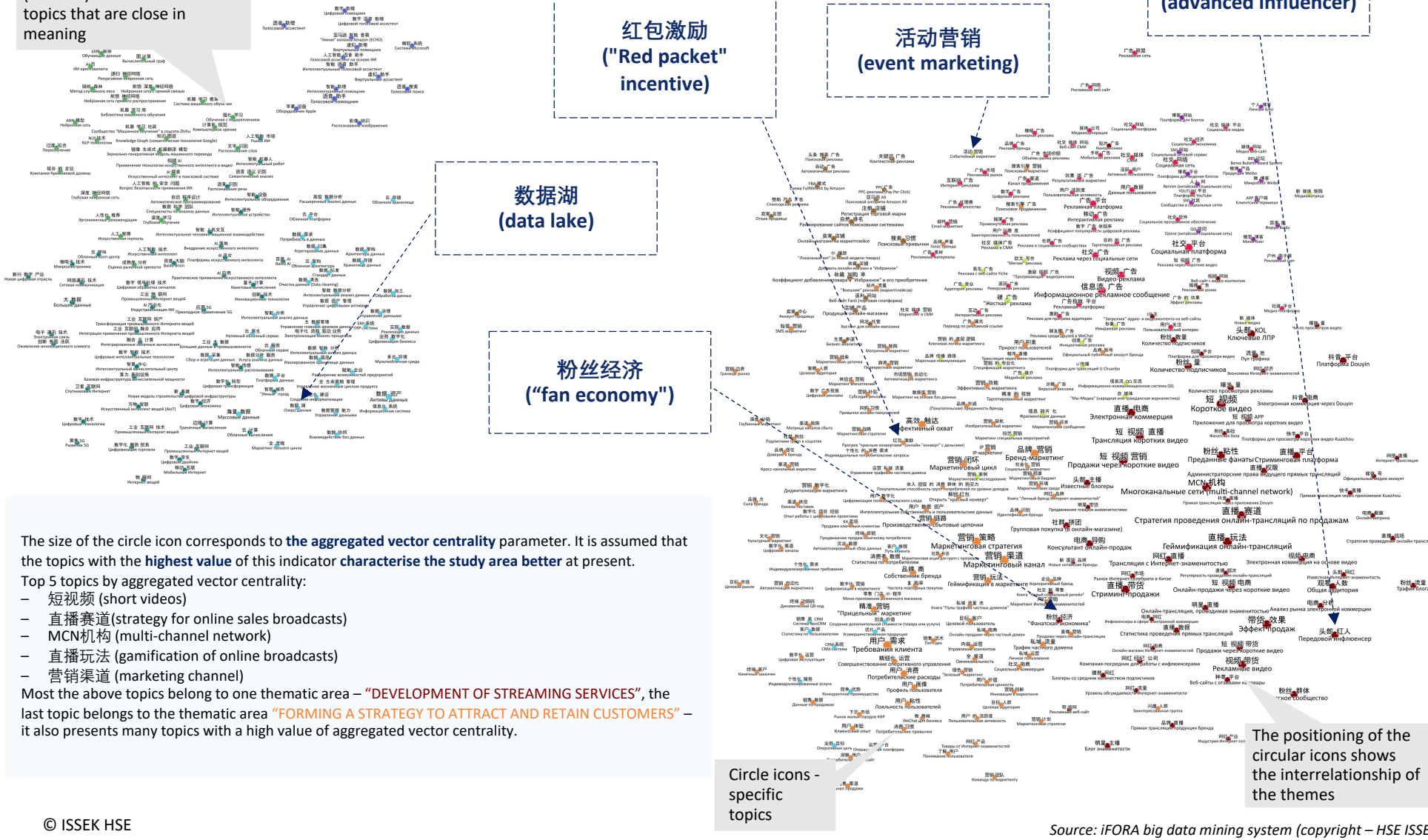
红包激励 ("Red packet" incentive)

活动营销 (event marketing)

头部红人 (advanced influencer)

数据湖 (data lake)

粉丝经济 ("fan economy")



The size of the circle icon corresponds to **the aggregated vector centrality** parameter. It is assumed that the topics with the **highest value** of this indicator **characterise the study area better** at present.

Top 5 topics by aggregated vector centrality:

- 短视频 (short videos)
- 直播赛道(strategy for online sales broadcasts)
- MCN机构 (multi-channel network)
- 直播玩法 (gamification of online broadcasts)
- 营销渠道 (marketing channel)

Most the above topics belong to one thematic area – "DEVELOPMENT OF STREAMING SERVICES", the last topic belongs to the thematic area "FORMING A STRATEGY TO ATTRACT AND RETAIN CUSTOMERS" – it also presents many topics with a high value of aggregated vector centrality.

Circle icons - specific topics

The positioning of the circular icons shows the interrelationship of the themes

Trends (thematic areas)

- APPLICATION OF AI AND THE INTERNET OF THINGS IN MARKETING
- DEVELOPMENT OF STREAMING SERVICES
- EXPANDING ONLINE ADVERTISING OPPORTUNITIES
- FORMING A STRATEGY TO ATTRACT AND RETAIN CUSTOMERS
- USE OF SOCIAL NETWORKS AND MEDIA IN MARKETING
- EXPANDING APPLICATIONS OF MACHINE LEARNING
- CLOUD TECHNOLOGIES
- VIRTUAL ASSISTANTS
- INCREASING THE EFFICIENCY OF BLOG MARKETING
- E-COMMERCE MARKET DEVELOPMENT

– also relevant in the global agenda

– also relevant in the Russian agenda

Source: iFORA big data mining system (copyright – HSE ISSEK)

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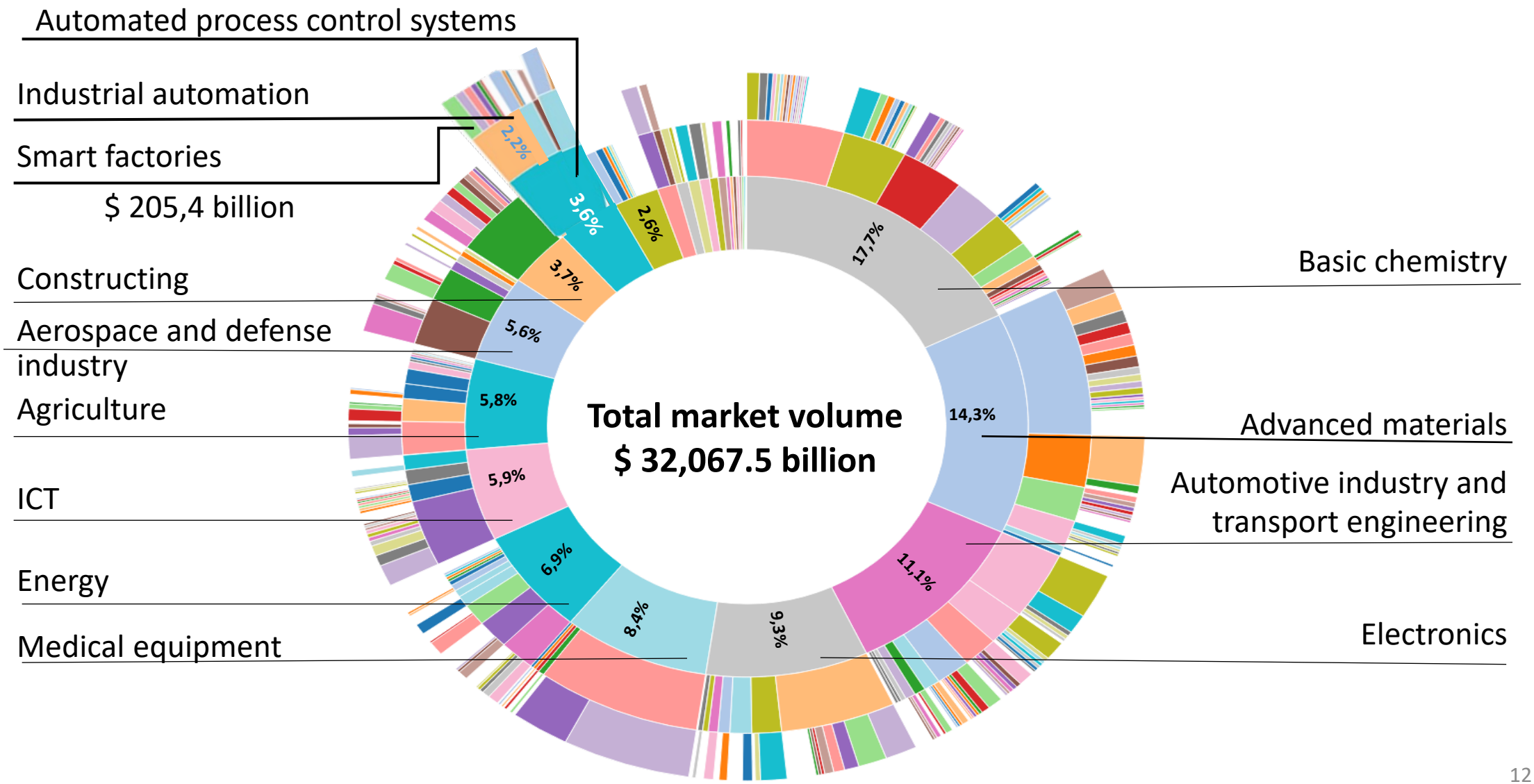
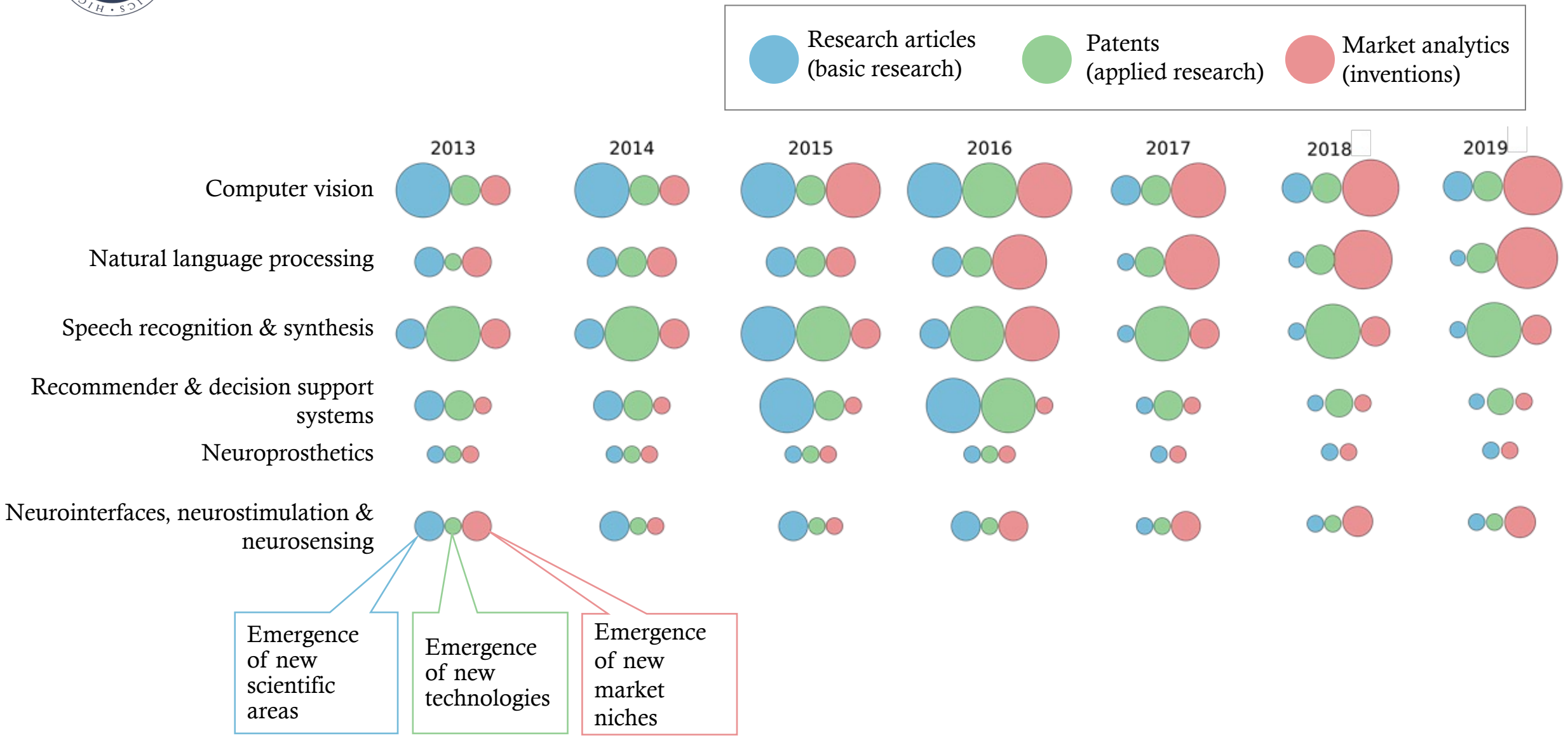
MARKET ANALYSIS

Data aggregation based on industrial market reviews



Source: intelligent FOResight Analytics System (HSE Institute for Statistical Studies and Economics of Knowledge, Moscow) based on international market reviews

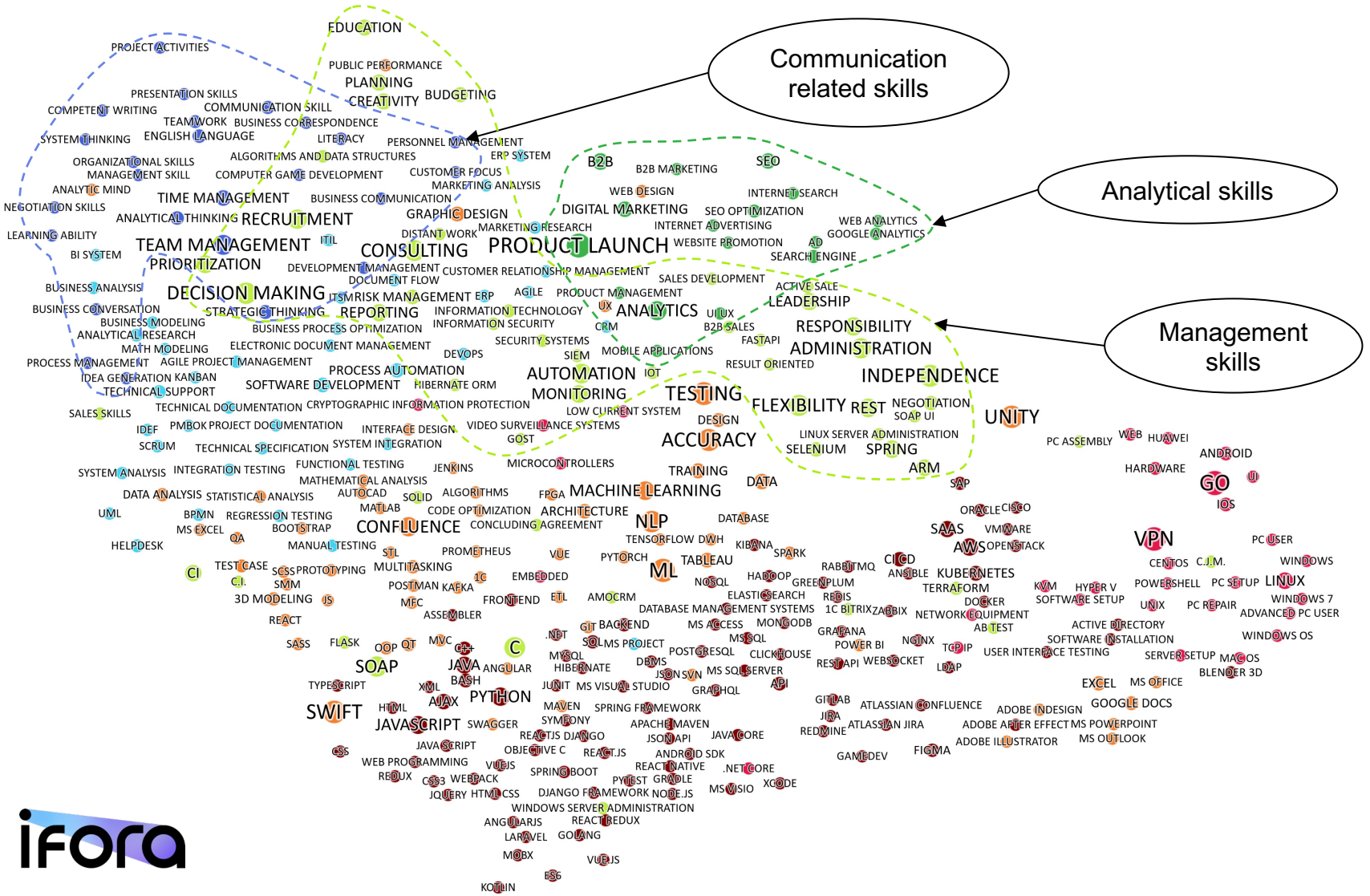
TECHNOLOGY LIFE CYCLE



Source: intelligent FOResight Analytics System (HSE Institute for Statistical Studies and Economics of Knowledge, Moscow) based on international data sources

IN-DEMAND SKILLS OF EMPLOYEES

CASE OF IT



Based on market analysis

Subject areas

- 1C BITRIX; AUTOMATION; INFORMATION SECURITY
- INTERFACE DESIGN; WEB DESIGN; REACT
- UNIX; POWERSHELL; .NET CORE
- ANALYTICS; WEB ANALYTICS; MOBILE APPLICATIONS
- BACKEND; .NET; POSTGRESQL
- SOFTWARE DEVELOPMENT; DEVOPS; BUSINESS MODELING
- PROCESS MANAGEMENT; COMPUTER GAME DEVELOPMENT; BUSINESS COMMUNICATION

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S&T Foresight for South Africa: Purpose

The project commissioned by the Department of Science and Innovation of South Africa and the National Advisory Council on Innovation

Purpose of the study:

Identification of priorities for new decadal STI plan with clearly defined targets that must be specific, measurable, actionable, realistic, relevant and time-bound

S&T Foresight for South Africa: Coverage

Areas for developing possible missions/priorities:

1. Circular economy/climate change
2. Health innovation
3. Education for the future and the future of society
4. High-tech industrialisation

Proposed priorities and expected socioeconomic impact:

1. Economic growth
2. Job creation
3. High quality health care services
4. High living standard
5. Access and supply of clean water
6. Affordable food
7. Carbon emission reduction
8. Low greenhouse gas emission
9. Export growth and competitiveness
10. Skills development
11. Renewable energy growth
12. Poverty alleviation

The Process

1 – Scoping to identify the areas to be covered

2 – Data Analytics: statistical, semantic and scientometric analysis of the selected areas to understand their development, trends and dynamics, and significance for South Africa

3 – Interpretation and priority setting to identify the priorities for South Africa towards 2030, and set necessary targets

4 – Strategizing: Provisional strategies are developed to achieve the priorities

5 – Policy recommendations and actions: Workshops with the participation of experts from South Africa and HSE to finalize policy recommendations and actions

6 – Reporting the outputs to include data and expert analyses with resultant policy and strategy recommendations

Statistical analysis: Case of Renewable Energy Growth

Renewable energy growth

- Access to electricity (% of population)
- Combustible renewables and waste (% of total energy)
- Electricity production from renewable sources, excluding hydroelectric (% of total)
- GDP per unit of energy use (PPP $ per kg of oil equivalent)
- Renewable electricity output (% of total electricity output)
- Renewable energy consumption (% of total final energy consumption)
- Normalized indicators values and composite index for the «Renewable energy growth» factor

Semantic Analysis: Sources (2010-2020)

Global

29,312,296 documents

www.nytimes.com
www.washingtontimes.com
www.express.co.uk
indianexpress.com
www.independent.co.uk
...

Highly relevant to South Africa

2,356,272 documents

www.aljazeera.com
www.africanbusinessmagazine.com
newafricanmagazine.com
africalaunchpad.com
radar.africa
www.esi-africa.com
…

Health innovation

Global

527,665 documents

www.fiercehealthcare.com
medicalxpress.com
medcitynews.com
www.healthcarefinancenews.com
www.healthcaredive.com
…

Highly relevant to South Africa

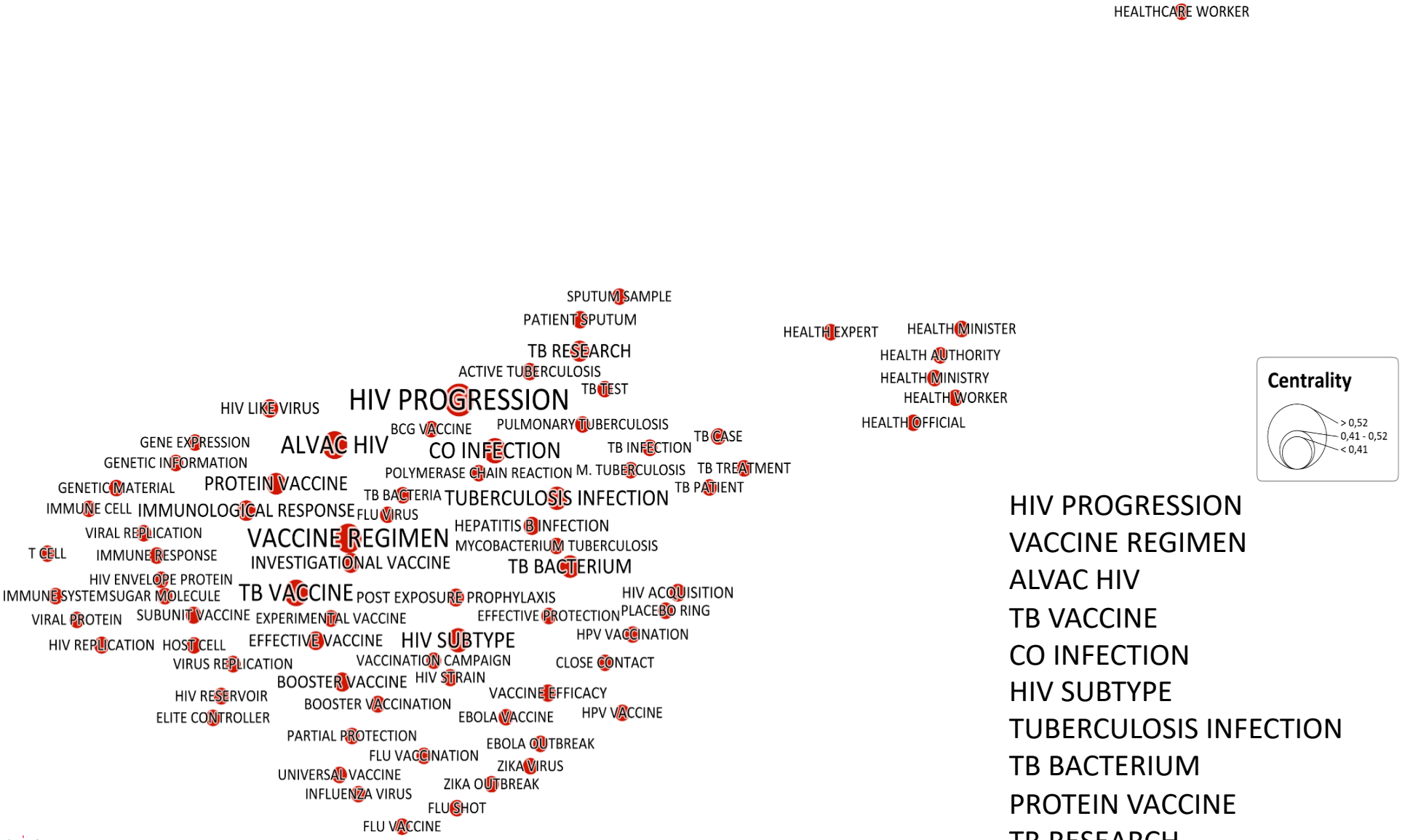
6,281 documents

Clusters Identification: Case of Health

CLUSTERS

1. AI, Machine Learning, Mobile applications → E-Health
2. Clinical trial, high risk, increase risk → Preventive medicine
3. Health care, patient care, health system → Unified healthcare system
4. Immune system, immune response, zika virus → Immune system & vaccination
5. Sexual violence, birth control, sexual activity → Reproductive health
6. Weight loss, physical activity, healthy lifestyle → Healthy lifestyle
7. Young people, global warming, rural area → External factors

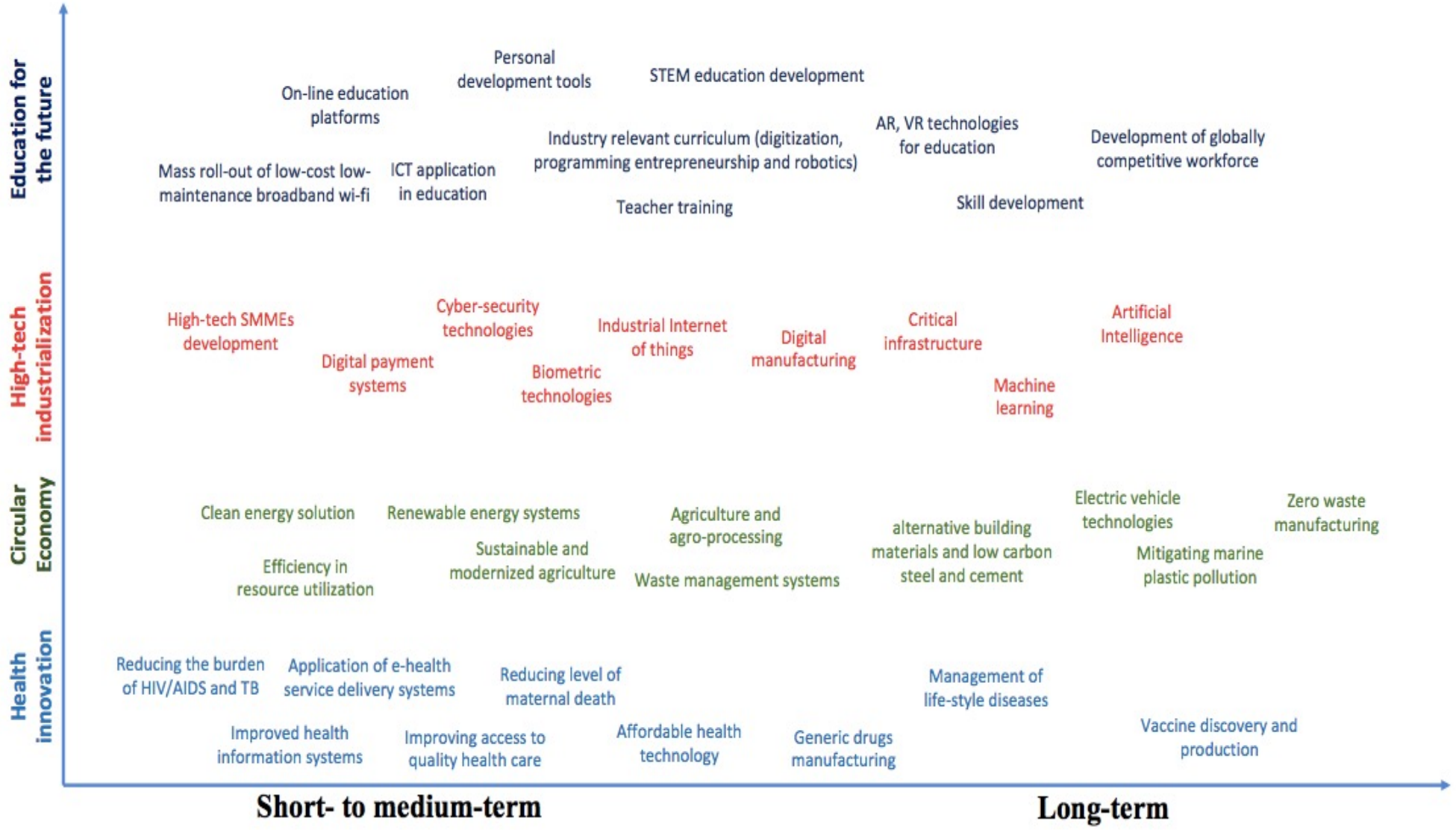
Immune System and Vaccination Cluster Map

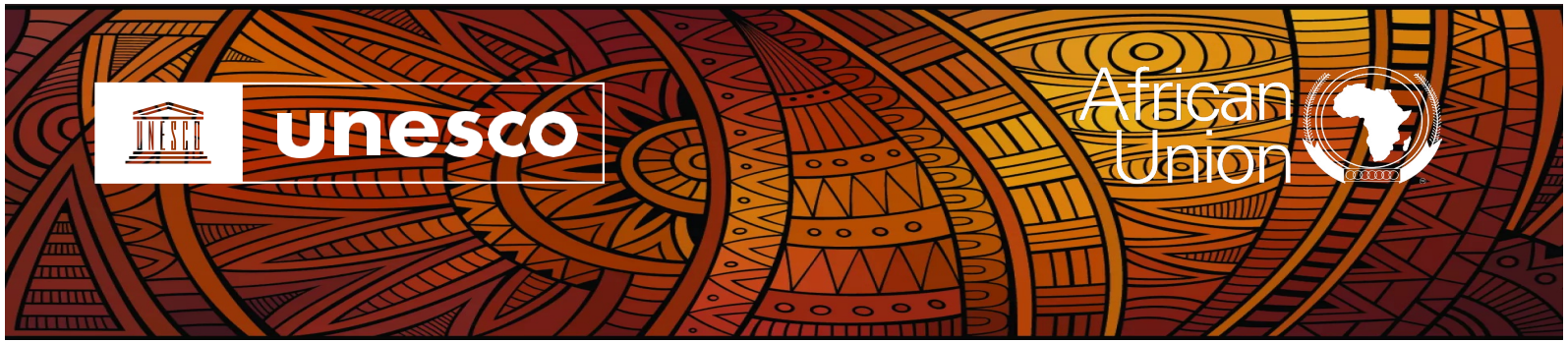


HIV PROGRESSION
VACCINE REGIMEN
ALVAC HIV
TB VACCINE
CO INFECTION
HIV SUBTYPE
TUBERCULOSIS INFECTION
TB BACTERIUM
PROTEIN VACCINE
TB RESEARCH

Source: Intelligent Big Data Analysis System iFORA

Strategic Roadmap for the Implementation of Policy Recommendations





UNESCO Chairs and Partners Forum "Transforming Knowledge for Africa's Future"

"Science, Technology and Innovation Foresight for African countries", 30 September 2024

Recommendations to promote STI Foresight in Africa

- Put S&T Foresight on the agenda of governments and international organisations
- Support educational and training programmes and practical trainings – both in African countries and in leading Foresight organisations worldwide
- Establish more futures labs and UNESCO chairs in African universities
- Support financially implementation of S&T Foresight studies in African countries

S&T Foresight in BRICS Countries

Centro de Gestão e Estudos Estratégicos, CGEE

HSE University

Technology Information Forecasting and Assessment Council, TIFAC

Chinese Academy of Science and Technology for Development, CASTED

National Advisory Council on Innovation, NACI

+

Dubai Future Foundation

Egypt Science and Technology Observatory

Prince Mohamed University

University of Isfahan
National Institute for Research Policy

Collaboration under the UNESCO UNITWIN Programme

unesco Chair

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S&T Foresight for BRICS: Collaboration Initiatives

- At the Symposium “BRICS Science, Technology and Innovation Policy and Foresight Exercises” (December 4-5, 2023), representatives of all BRICS countries noted the need to conduct joint foresight research in the field of scientific and technical cooperation

- At the Workshop on Technology Foresight in BRICS (Moscow, September 18, 2024), the participants proposed to establish an S&T Foresight Association for BRICS

28 – 29 October 2024

Special Workshop: Prospects of Science and Technology in BRICS Countries

Yuan Like, CASTED, China. Open Foresight: Application and Experience in China

Gautam Goswami, TIFAC, India. Climate Change Challenges – a S&T Foresight Analysis

Yulia Milshina, HSE University, Russia. Wild Cards: Technology-based Responses

Mlungisi Cele, NACI, South Africa. Deepen and Accelerate Knowledge and Innovation Led Inclusive and Sustainable Development

Fernando Rizzo, CGEE, Brazil. BRICS Strategic Collaboration on Priority Themes

Mohamed Ramadan, STI Observatory, Egypt. Exploring Future Pathways for Strengthening STI Collaboration between Egypt and BRICS

Reza Hafezi, National Research Institute for Science Policy, Iran. S&T Foresight Programs in Iran: History, Opportunities and Lessons

Sergei Revin, Cosmonaut, Russia. Artificial Illumination from Space for BRICS Countries

Recommendations to promote STI Foresight in developing countries

POLICY

- Put S&T Foresight on the agenda of governments and international organisations

INSTITUTIONAL MEASURES

- Establish more futures labs / UNESCO chairs in developing countries (e.g. at leading universities)

CAPACITY BUILDING

- Support educational and training programmes and practical trainings – both in African countries and in leading Foresight organisations worldwide
- Training of trainers in S&T Foresight

FINANCIAL ASSISTANCE

- Support financially implementation of S&T Foresight studies in African countries
- Support research and students mobility in Foresight

Thank you!

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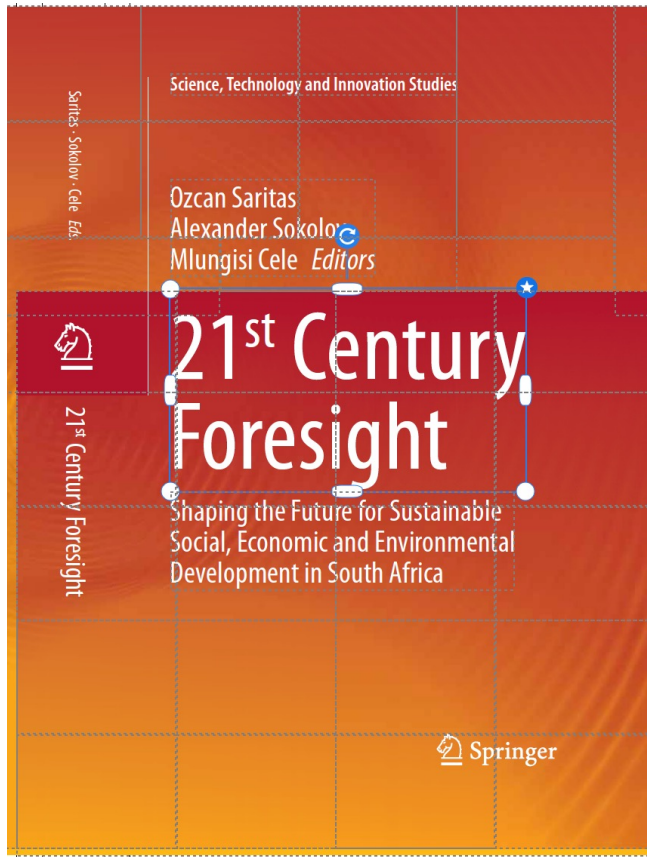
http://issek.hse.ru

https://foresight-journal.hse.ru

https://unescofutures.hse.ru/



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