Philosophical reflections on societal impact of research

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Impact

Lively academic debate about research
need for knowledge and data rather than opinions

- How can research quality be assessed?
- What are good funding framework conditions for research?
- By whom and how is the best research found and financed?
- Is some research "finer"/"better" than other research?
- Which research should be given higher or lower priority, and who decides?
- Can both basic research and applied research be good research?
- What is free research, and is there "unfree" research?

Knowledge of effects is necessary

Obtained using metrics, indicators, data, methods and analyses

Method for identification of impact of research:

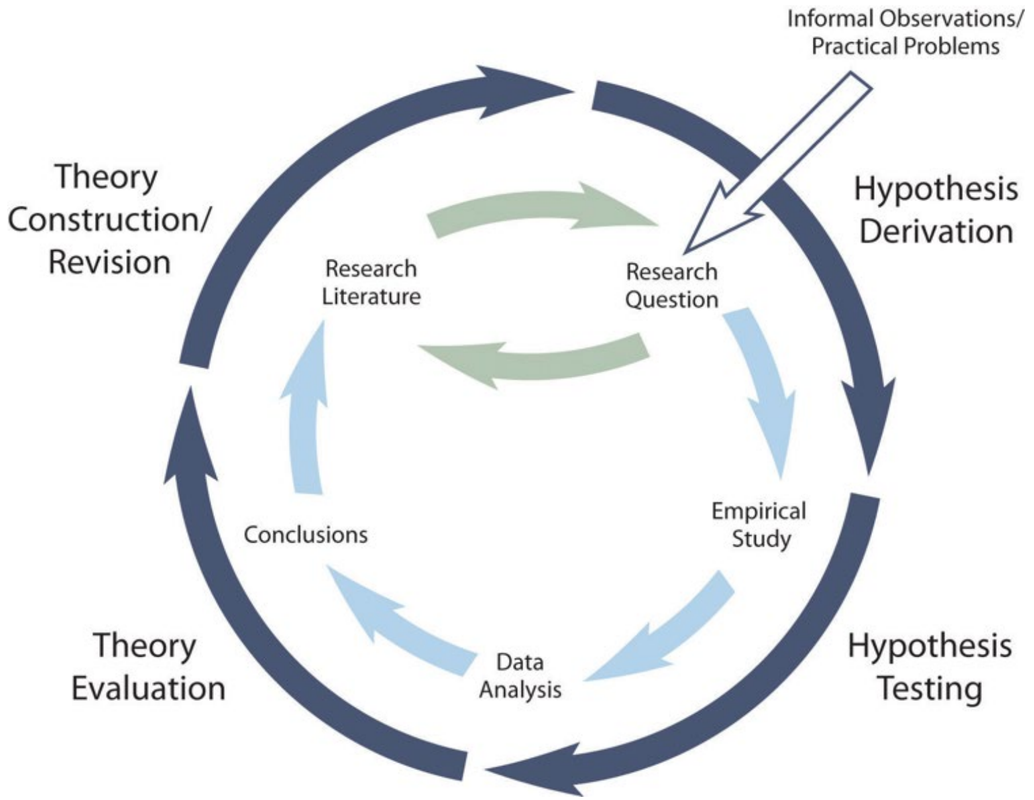
Science-of-science – the study of scientific research itself!

1. **Investigation of the technology, engineering, and management aspects** of research to optimize and innovate the research process and manage and increase the impact of research.

2. **Identifying and analyzing research trends, patterns, and dynamics** within scientific research, which may include studying the researchers, publications, and impact of the research.

3. **Evaluating research impact** and effectiveness of scientific research, incl. funding models, and how it influences further research, science and society.

4. **Understanding scientific research itself**: Investigating the methodologies, principles, and processes utilized in scientific investigations.



Judgments and Evidence

novo nordisk **fonden**

What does science want?

Create evidence and judgment of predictive validity, not be in the power of opinions, prejustices or attitudes.

- **Immediate judgment**
  of a phenomenon (*prejudice, opinion, attitude*).
- **Indirect preliminary judgment**
  hypothesis *regarding the phenomenon* based on case or experience (*reasoned hypothesis*).
- **Evidence judgments**
  reasoned assessment based on empirical assessment of experiences with a phenomenon (*reasoned opinion*).
- **Predicative evidence**
  empirical assessment of the phenomenon and the linguistic formulation of the phenomenon, so that the linguistic expressions are as good as possible (*explanation to be understood*).
- **Predictive judgment**
  calculating the probability of a future judgments of a phenomenon. Rely on large datasets of experiences and probabilistic calculations. (*Take predictive/known evidence to generate judgment of a new phenomenon*) evidence of predictive validity.

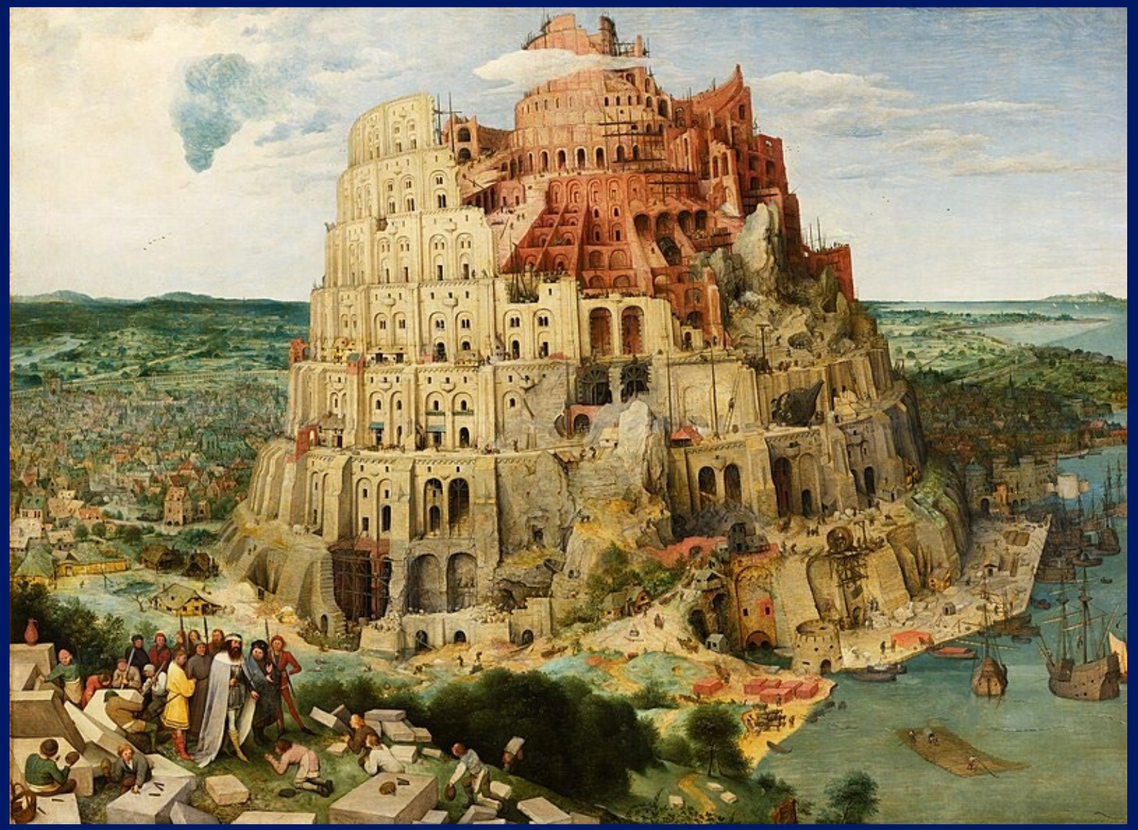
Primordial man is driven by curiosity about knowledge
("the tree of knowledge")

Since Adam and Eve, man from generation to generation has been driven by **curiosity about knowledge as part of evolution** in order to survive, live longer, improve his living conditions, as well as gain knowledge about **good and evil, freedom, independence, choice, responsibility and politics**.

"The Fall (knowledge)" has had major **individual, organizational, scientific and societal** consequences.

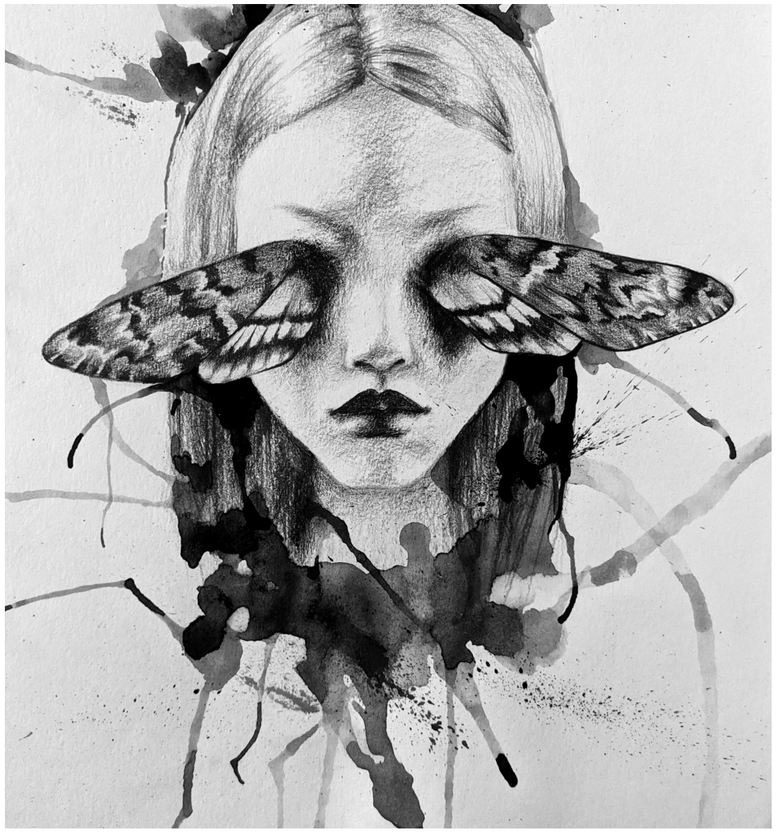
The Tower of Babel

In terms of research and knowledge, **the Tower of Babel** symbolizes the challenges and barriers that researchers encounter in their work, such as language barriers, economics, cultural differences, and different scientific paradigms, as well as the danger of striving for knowledge without ethical and moral considerations.



What is good art?
Subjective/different perspectives

What is scientific or societal
impact?



What is
a butterfly?

What is
a box?

Subjective perspectives, shaped by individual biases, thoughts, and backgrounds, are personal interpretations not grounded in objective truth or fact.

Individuals, cultures and society have different perspectives: The view, on what scientific or societal impact of research is, depends on the perspective of those who analyze and interpret the impact.

Societal effects depend on different perspectives on the purpose of the research

Philosophical
wisdom, existence and objective truth

Sociological
understanding social patterns, institutions, and cultural norms and their influence on human behavior

Psychological
need for purpose, control, freedom and understanding our surroundings

Humanistic
the individual's free will, creativity and striving for self-realization

Natural science
expanding the existing understanding of the world as a progressive foundation for development and application of knowledge

Biological
evolutionary advantage to adapt to the environment

Medical
focus on health, happiness and well-being

Economic
promoting growth, innovation, welfare and competitiveness

Political
essential for decision-making and democracy

Theoretical reflections regarding impact

Theoretical reflections concerning the repercussions of research can be dissected into a framework of **five categories**:

1. **Purpose/objective**
2. **Nature of results**
3. **Temporal perspective**
4. **Consequential spectrum**
5. **Anticipated outcomes**

Each provides a perspective through which the impacts of research within and beyond the scientific community can be evaluated and interpreted.

Theory of impact assessment

1. Purpose/objective

- **Intended**: Effects align with the initial goals and objectives set forth by the research.
- **Unintended**: Results diverge from intentions, adding benefits or unintended effects.

2. Nature of results

- **Tangible**: Concrete and explicit results that can be directly observed and quantified.
- **Intangible**: Abstract results, such as theoretical advancements or shifts in understanding, which may not be physically measurable but hold significant value in science or society.

3. Temporal perspectives

- **Short-Term**: Immediate or near-future outcomes directly attributed to the research.
- **Long-Term**: Extended impacts that unfold over a protracted period post-research.

4. Consequential spectrum

- **Positive**: Beneficial outcomes/advancements, enhancing knowledge or societal conditions.
- **Negative**: Detrimental effects potentially hindering progress or causing setbacks.

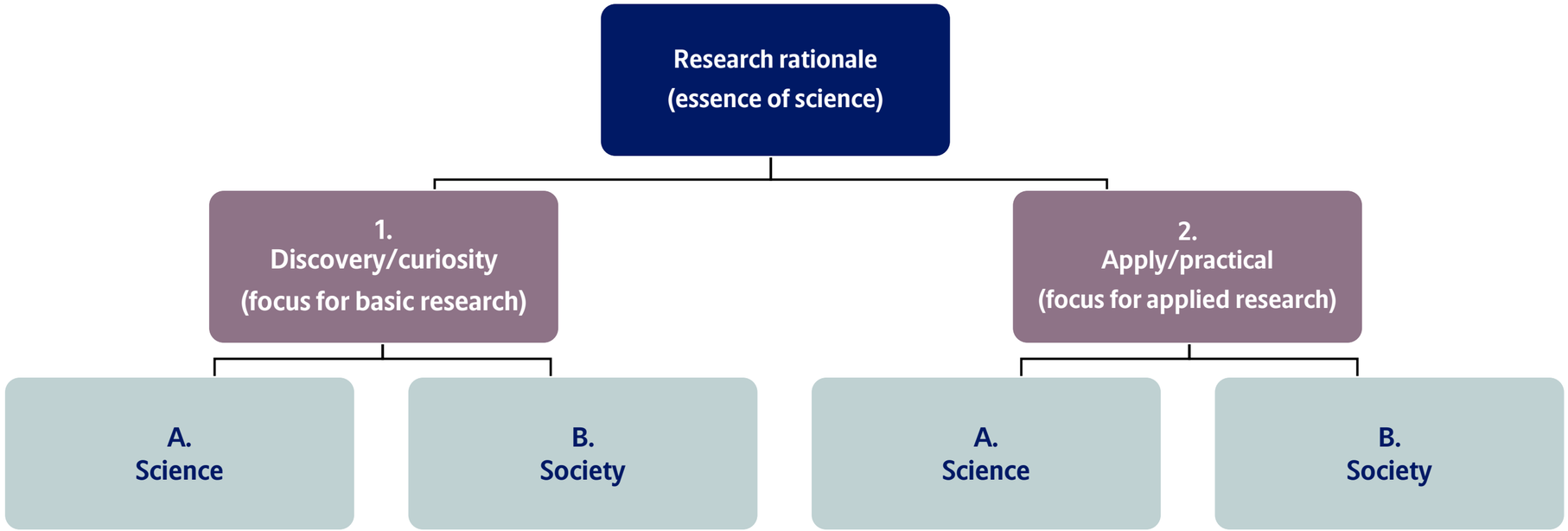
5. Anticipated outcomes

- **Expected**: Predicted or hypothesized effects based on research parameters and objectives.
- **Unexpected**: Results that were not initially predicted but emerged during or post-research.

How are the effects of research documented and measured?

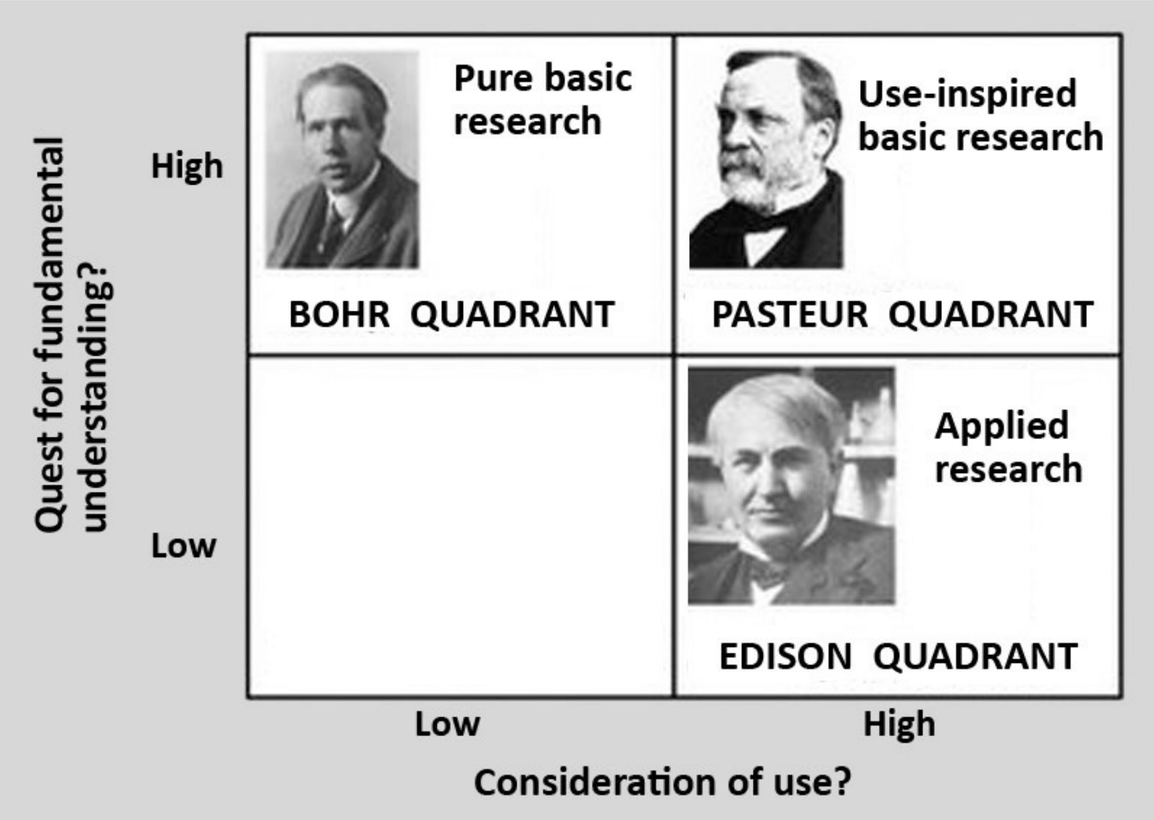
Why?

Where?



„Das Ganze ist das Falsche“

Pasteur’s Quadrant



Pasteur’s Quadrant captures that science can be driven by curiosity (“basic research”), practical applications (“applied research”) and research activities that cover both angles as “use inspired basic research”.

Who are affected by intervention?

Individium

E.g. individual researchers, students, children, etc.

Examples of effects

- Research career
- Researcher collaborations
- Research output (journal articles, databases, methods, inventions, etc.)
- Engagement activities

Organisation/Institution

E.g. universities, companies, research institutions, etc.

Examples of effects

- Research teams and research community
- Institutional collaborations
- Research output (journal articles, databases, methods, interventions)
- Education and outreach activities
- Infrastructure development

Societal sector

E.g. research environment, public health, social, energy, agriculture, environment, etc.

Examples of effects

- Scientific production, progress and breakthrough
- Technology and methodology development
- Innovations and discoveries
- Products and services
- Paradigm shifts in functioning of a sector

Society/Wider society

E.g. development of populations, countries, democracy, etc.

Examples of effects

- Reach to people in humanitarian, social, health, economic, environmental and other societal settings
- Political, economic, social and environmental changes in society (employment, climate, social conditions, etc.)

Scientific impact

Sectoral and societal impact

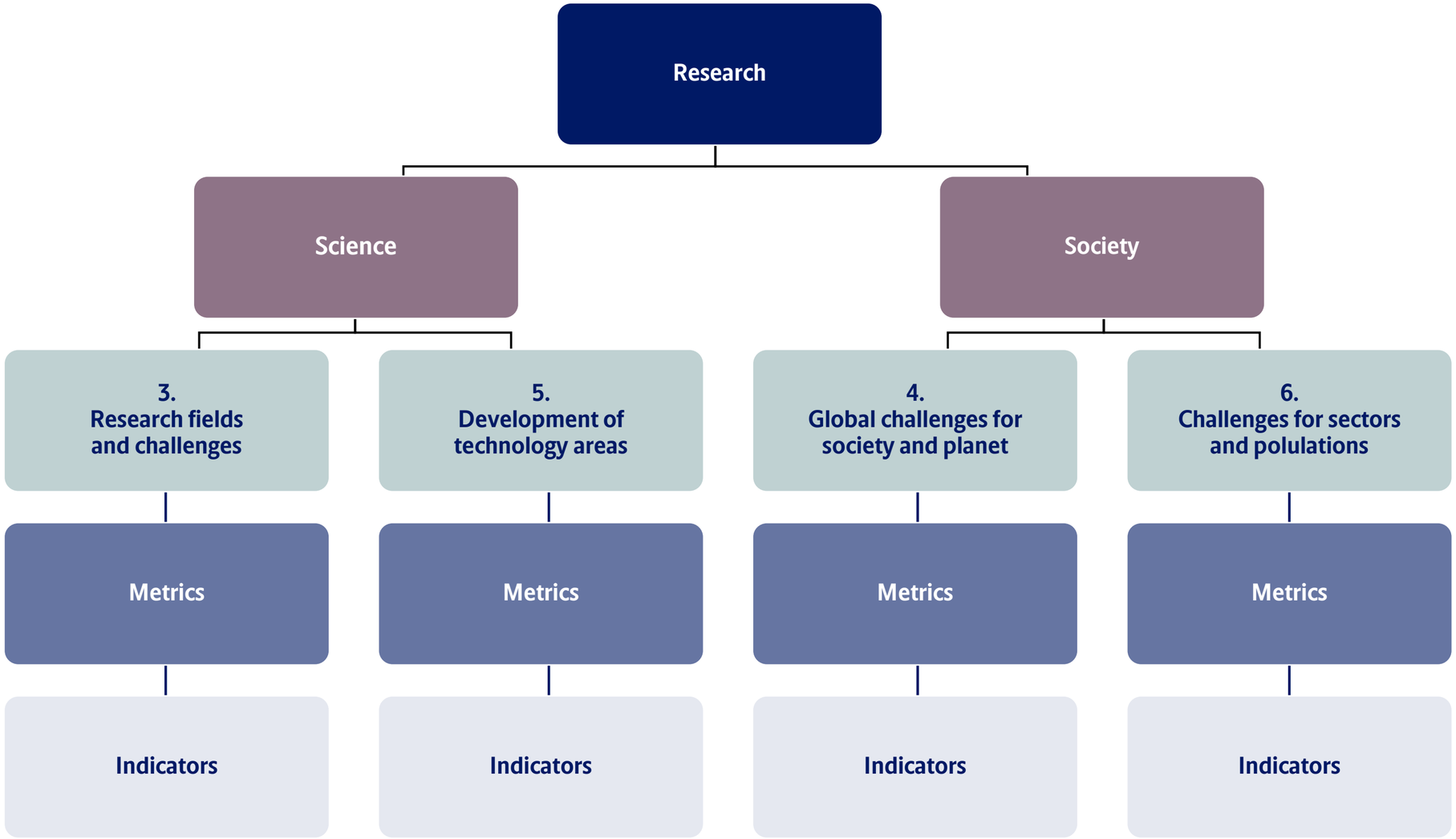
Wider societal impact

How are the effects of research documented and measured?

Where?

What?

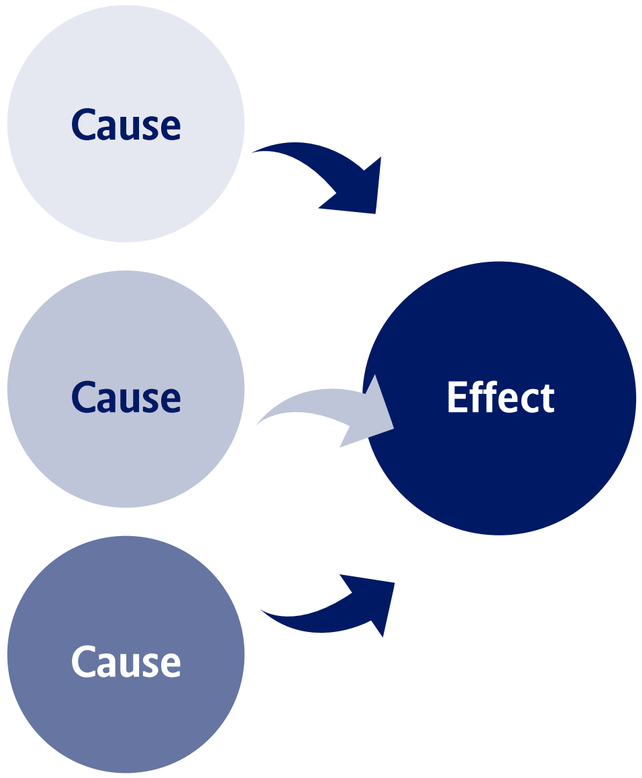
How?



Metric & indicator - definition

Metric
("what it is")
is a quantifiable measure - typically a numerical standard for measurement - used, for example, to monitor and evaluate the status of a certain development and can be measured directly.

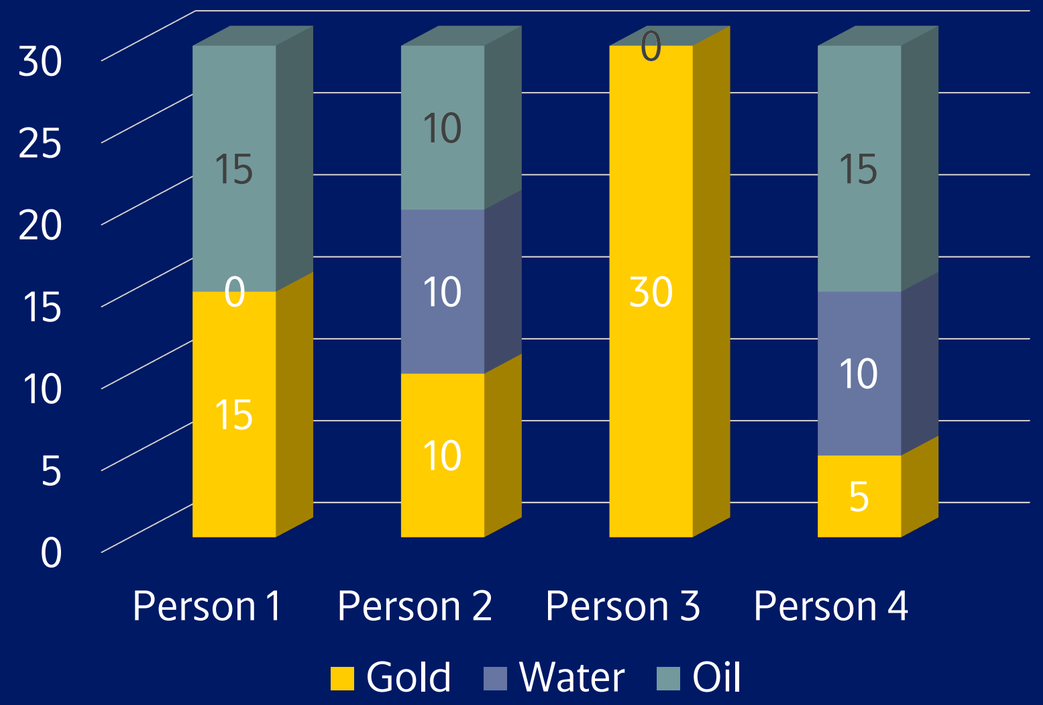
Indicators
("how it gets meaning")
provide insight into a state or condition that can represent an abstract or qualitative concept or a quantitative relationship. Is a signal that reveals information about something specific. Typically used to understand trends, patterns or performance and to understand and interpret data.



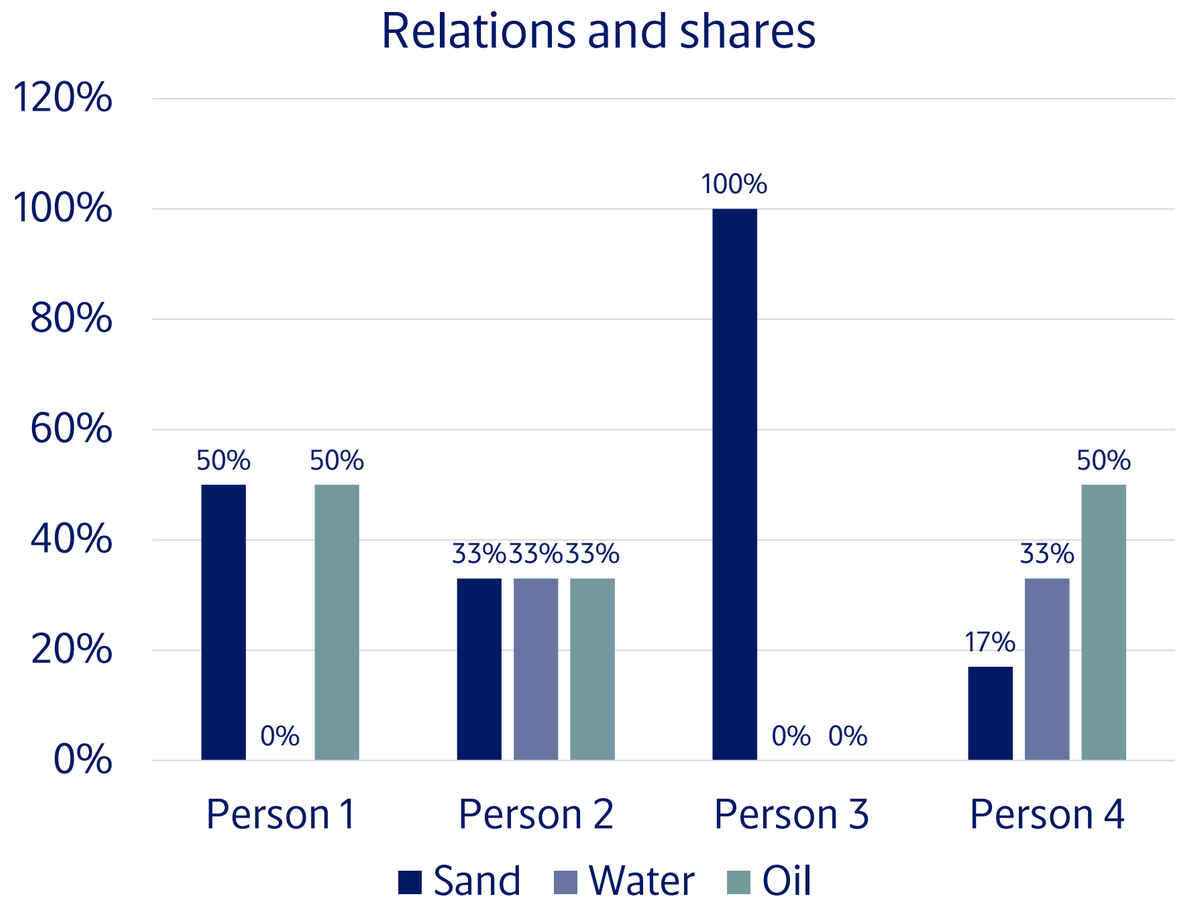
Metrics – ”how it is”!

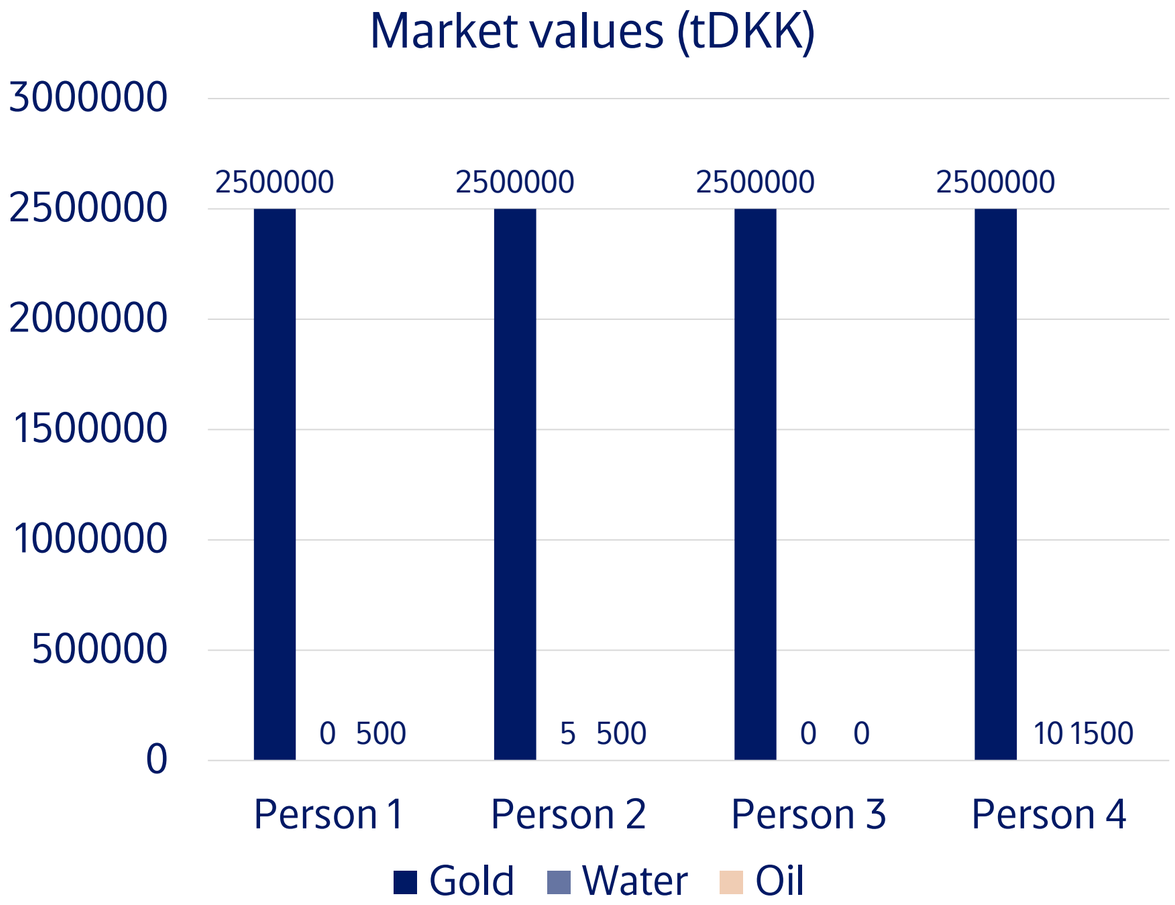
Descriptive Statistics involves summarizing and organizing the data so it can be easily understood. Descriptive statistics describe the main features of a dataset in a quantitative manner.

Content of my backpack (30 kilos)



Indicators – quantitative relations
(Analytics: ”what it means”)





Indicators – qualitative relations
(Inferential statistics: ”what it means”)

Days of survival :

Person 1 and 3

- **3 days**
  with 5 kilo gold, with or without oil, but no water

Person 2

- **15 days**
  with 5 kilo gold and 5 liter water, but no oil

Person 4

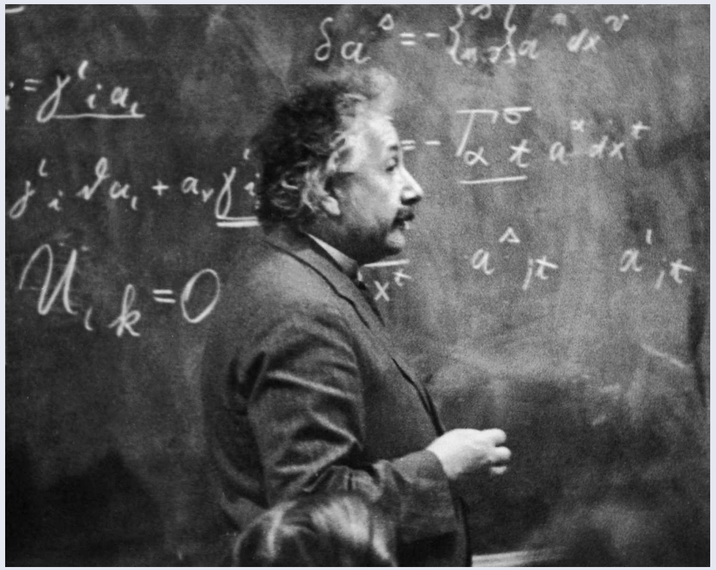
- **27 days**
  with 5 kilo gold, 10 liter water and 10 liter oil

Inferential Statistics involve using data from a sample to infer or deduce properties about a population, including making predictions or inferences about a population based on observations from a subset of that population.

Survival in the desert
with gold, water and oil in the backpack

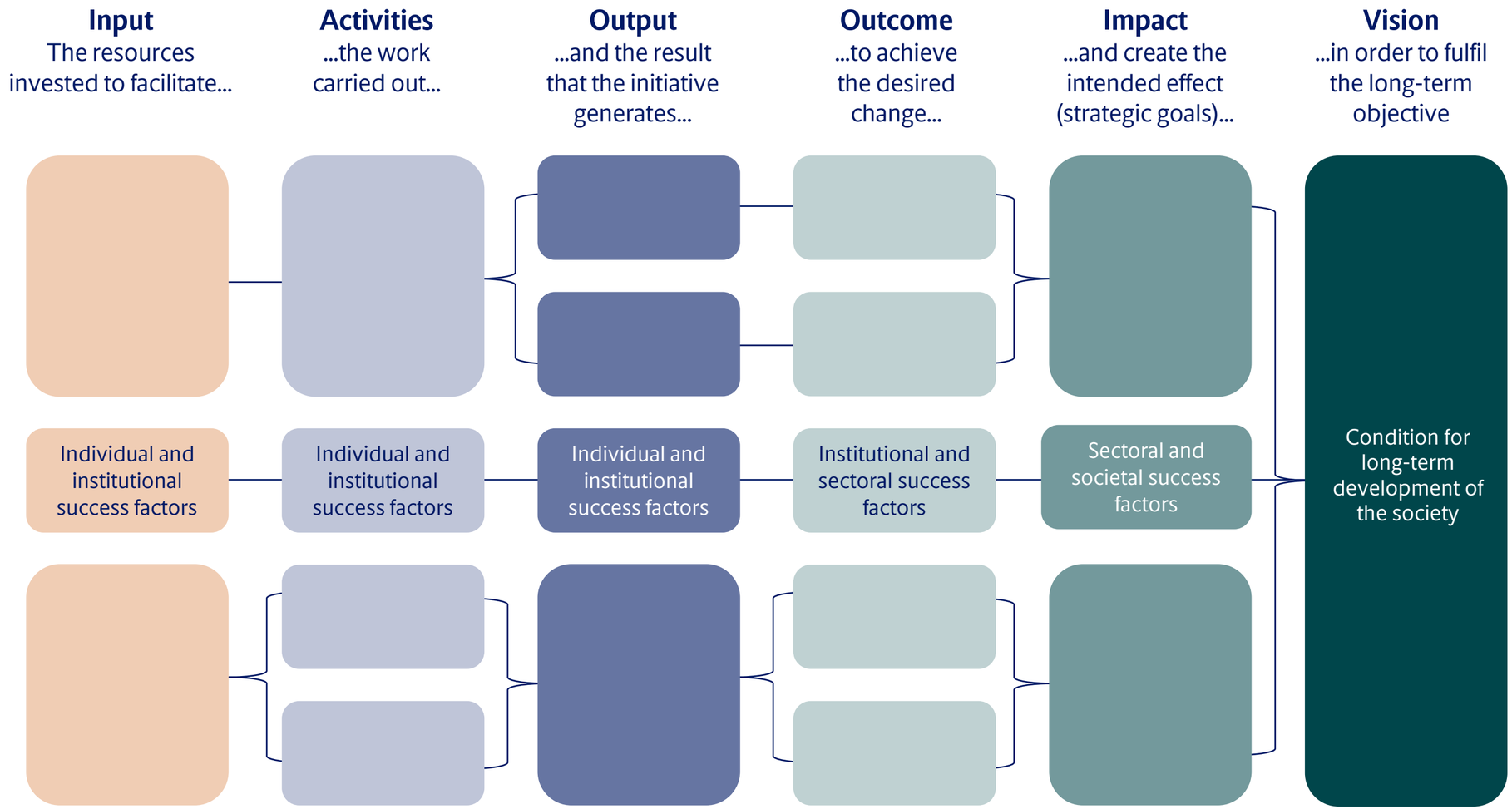
Tidsperspektiv for initiativ

Vision	→	Fremtiden
Effekter	→	Længere tid efter ophør
Strategiske mål	→	Ved ophør og lige efter
Resultater	→	Undervejs frem til ophør
Aktiviteter	→	Fra starten
Formål	→	Før igangsættelse



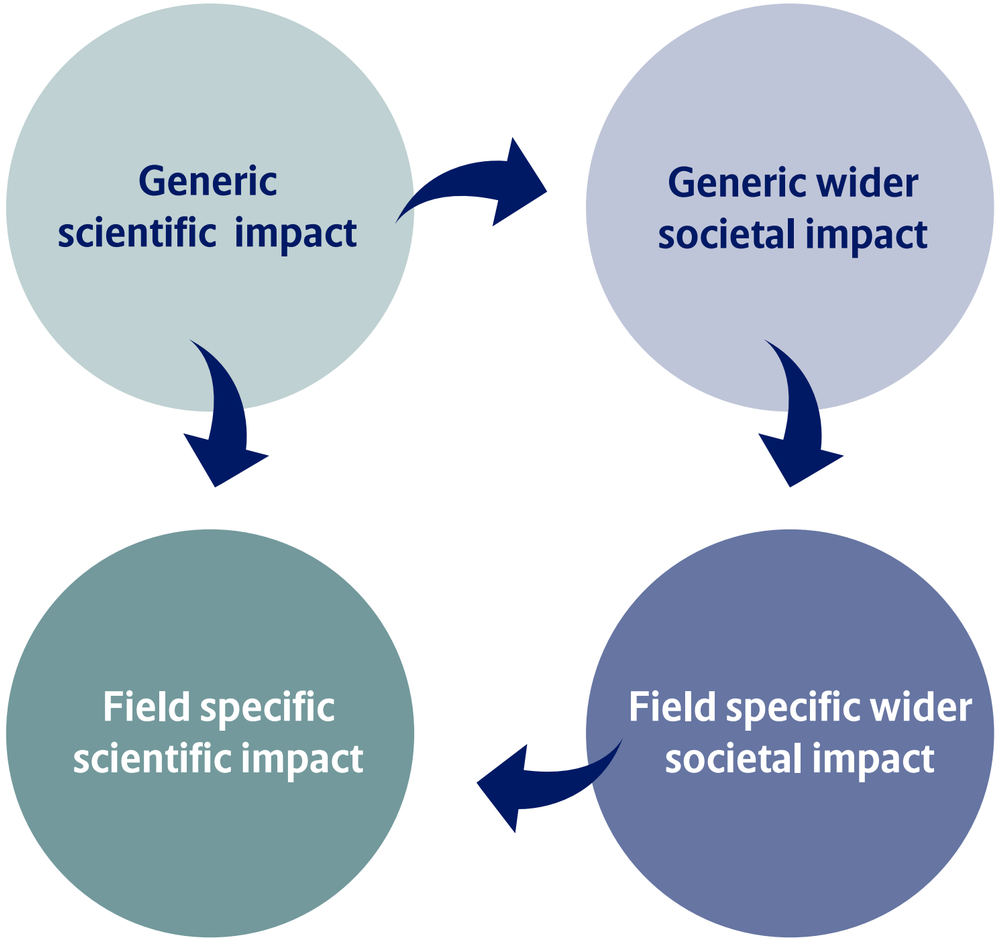
Relativity:
The effects of research are relative and depends on the time of observation. The effects might change and disappear in the course of time. The concept that effects are relative challenges our intuitive understanding, which often assumes an absolute, universal effect independent of time.

The Logic Model
(from individual and institutional to sectoral and societal change)



Generiske versus specifikke Metrics og Indicators

- Research investments.
- Research output (publications, methods, databases, models).
- Citations and Journal Impact Factor.
- Collaborations, partnerships and networks.
- Invention disclosures and IP.
- New technologies.
- Talents, careers, research infrastructure.



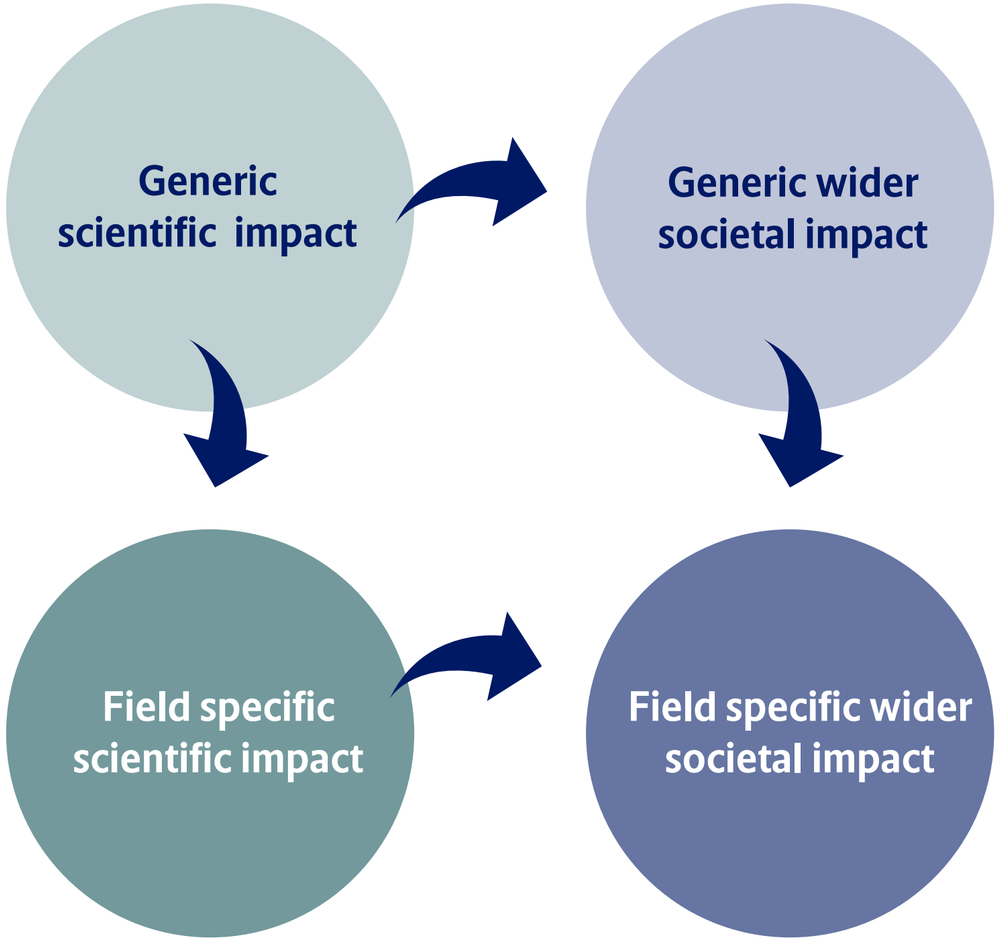
- Innovation investments.
- Translation, adaption and implementation into practice.
- Policy impact and governance.
- Public engagement, awareness and outreach.
- Capacity building and education.
- ESG and CSR (sustainability).

- Clinical or field trials.
- New drugs, medical technolgies. and therapeutic interventions.
- Quantum computer technologies.
- Carbon capture technologies.
- Improved products and services. (e.g. soil health and food).

- Patient outcomes (disease prevalence or incidence).
- Life expactancy or quality -adjusted life years.
- Water, polution and biodiversity.
- Green gass emmisions.
- Sustainable agriculture practice.
- Economic benefits.

Example:
the impact of Ørsted's discovery of electromagnetismus

- **Basic research**
  Hans Christian Ørsted (1820) discovered that electric current can generate a magnetic field. Ampère (1827) formulated a combined theory of electricity and magnetism. Faraday (1831) describes electro-magnetic induction.



- **Development of codes**
  (such as Morse code).
- **International Cooperation** between countries and scientists worldwide to create global telegraph networks.
- **Benefits of the telegraph** for a more effective trade and military, and for faster contacts between people.
- **Development of electric lightening** and to modern electronics and power systems.
- **Economy:** suppor the development of businesses, trade and financial systems.

- **Invention of the telegraph** (1830s) the understanding how electric current can flow through wires.
- **Research (1840s-1890s)** in conductive materials that can effectively conduct electric current.

- **The invention** of electrical communication technology (telegraph, telefax, telephone).
- **Development** of insulating materials that can effectively be used to insulate electrical wires and minimize signal loss.
- **Developments** of voltaic cells and the **invention** of the battery.

Example of a sterilized logic model for a research grant with success factors and KPIs

Input	Activities	Outputs	Outcomes	Impact	Vision
The **resources** invested to facilitate..	..the **work** carried out..	..and the **results** that the initiative generates..	..to achieve the **desired outcomes**..	..and create the **intended effect**..	..in order to **fulfil the long-term objective**
Resources • Grant and payouts • Planned number of PhD students	**Basic and translational research initiated** • Team members • Projects initated • Collaborations	**Research findings disseminated through publications in high impact journals** • Articles and ranking • International co-authors • Industry co-authors	**New knowledge used in society** • Interventions • Products • Citation impact • Patents • Clinical guidelines citing research • IP	**Paradigm shifts as a result of scientific discoveries** • Of technologies and procedures find use • Of clinical trials	**Vision: Long-term objective** The long-term goal is to create a new generation of effective and safe X therapies built on an international collaborative of excellence in research
	Develop a new educational framework for training in translational research • Experts involved	**Research-based education, and training in translational research** • Of courses • PhDs taught at courses or activity	**Graduated PhD's find relevant jobs in academia and industry** • Of PhDs that find job within relevant sceientific fileds • PhDs work explicitly with development of therapies	**Researchers that create solutions from basic and applied research** • Outplacement of graduated PhDs in labs within the field • Employment in sector-relevant private research	

Scientific discoveries with significant long-term and wider societal impact

Discovery of Electricity (18th-19th centuries)
The work of many scientists, including Hans Christian Ørsted, Benjamin Franklin and Michael Faraday, led to the discovery and understanding of electricity. This has resulted in countless applications, from electric lighting to modern electronics and power systems.

Discovery of X-rays (1895)
Wilhelm Conrad Röntgen's discovery of X-rays revolutionized medical imaging, enabling non-invasive visualization of internal structures and aiding in medical diagnoses.

Development of Quantum Mechanics (early 20th century)
The development of quantum mechanics led to the development of many technologies we use today, including lasers, semiconductors, and MRI scanners.

Development of Insulin Therapy for Diabetes (1920s)
The discovery of insulin and its therapeutic use transformed the treatment of diabetes, greatly improving the quality of life for more than 150 million of individuals every year living with the disease.

Discovery of Penicillin (1928)
Alexander Fleming's accidental discovery of penicillin revolutionized medicine, leading to the development of antibiotics that have saved 100 millions of lives worldwide.

Development of Vaccines
The discovery and development of vaccines for diseases like smallpox, polio, measles, influenza, and COVID-19 have had a transformative impact on public health for the whole humanity, significantly reducing morbidity and mortality.

Discovery of the Polio Vaccine (1955)
Jonas Salk's development of the polio vaccine virtually eradicated polio that had caused paralysis in thousands of children.

Internet and World Wide Web (1960s-1990s)
Tim Berners-Lee's development of the World Wide Web made the internet accessible to the general public, revolutionizing the way we communicate, access information, and conduct business. It has significantly transformed aspects of society.

Development of the Microprocessor (1971)
The invention of the microprocessor by Intel paved the way for the development of personal computers and other digital devices.

„Das Ganze ist das Falsche“

Importance of assessing societal impact

Informed decision-making

- Can help to make informed decisions about funding research.
- Can inform the direction of future research.

Demonstrating value

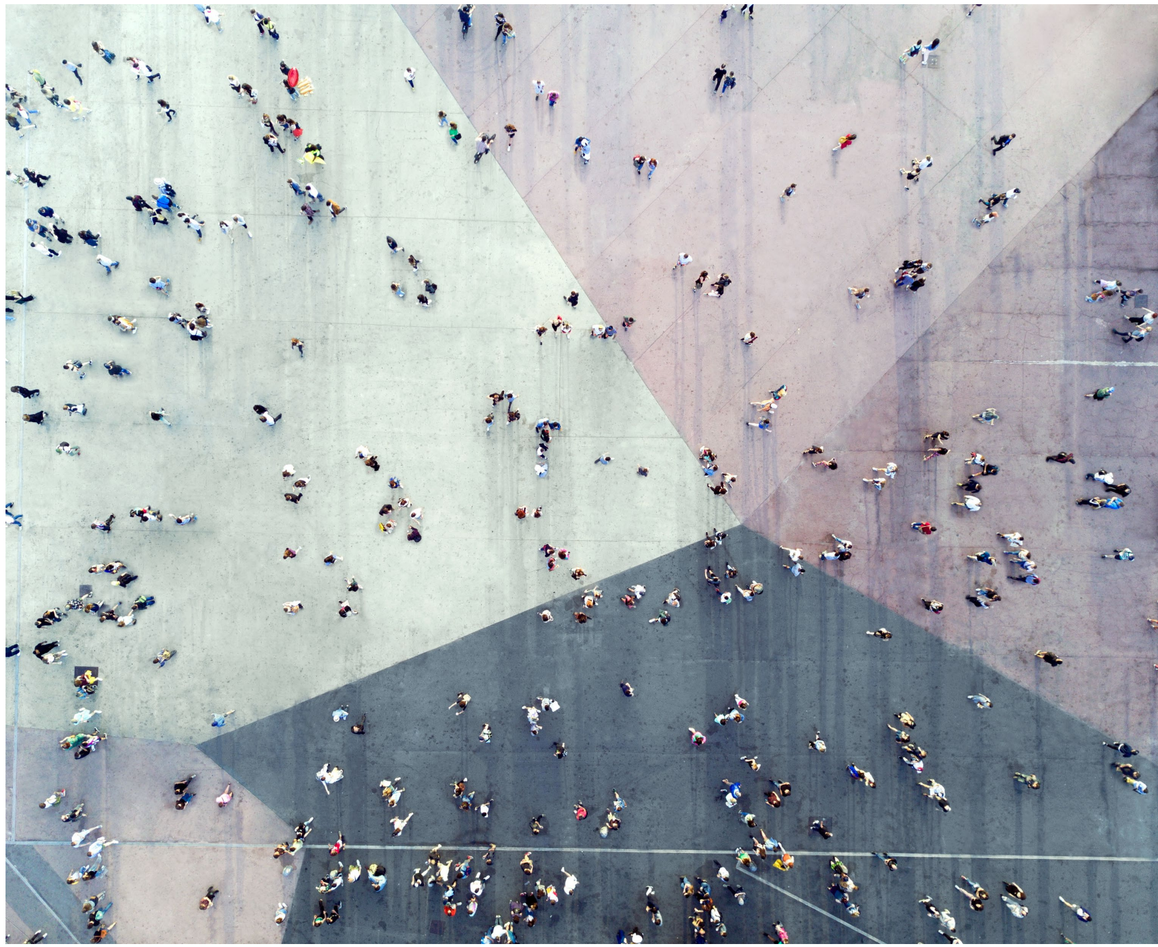
- Can highlight the scientific and societal importance of research, supporting investment in research.

Facilitating positive change, quality and relevance

- Can enhance the quality and societal relevance by encouraging researchers to consider the broader implications of their work.
- Can facilitate positive change by applying research findings to address societal challenges.

Accountability and transparency

- Can ensures accountability to funders, researchers, and the wider society.
- Can provide transparency regarding the utilization of resources and the outcomes achieved.



Challenges in assessing societal impact

Difficult to establish objective assessment

- Impacts are multifaceted and manifest in various forms.
- Stakeholders perceive and value impacts differently (high risk of subjectivity).

Bias, unknown effects and blind spots

- Assessments can be influenced by the biases of evaluators, data, or norms.
- Some impacts may only become apparent after a significant period or remain unrecognized or unattributed to specific research.
- Unintended or unanticipated impact might be overlooked.

Insufficient data and knowledge

- Comprehensive data on all potential impacts might not be available or measurable.
- Complex societal systems makes it difficult to trace impacts directly to research.

Methodological limitations

- Over-reliance on quantitative metrics or underappreciation of qualitative effects.
- Different methods might yield different results.

Cartesian doubt

The idea of systematically doubting everything you know or think you know, to use only what is undoubtedly certain as the basis for knowledge.

Limitation of measuring impact and conclusion

Measuring the additionalities of the societal impact is complex due to limitations such as

- The temporal dynamics, where impacts evolve and may not be permanent
- The substitution and succession of knowledge, which can overshadow original discoveries; and
- The interconnectedness of research outcomes, making attribution challenging.

The multidimensionality of economic, social, and cultural effects and the qualitative-quantitative dichotomy complicate measurement

- Establishing causality and specific attribution amidst collective research efforts
- Navigating policy and regulatory influences
- Addressing ethical and equity considerations
- Managing global and local disparities in impact
- Accounting for unintended consequences also pose significant challenges

Conclusion

A comprehensive understanding of research impact necessitates a multidimensional and context-specific approach, considering the evolving nature of additionalities in societal impact.

Innovation: Phone vs Humanitariants		
1980		LogFrame
1990		LogFrame
2000		LogFrame
2010		LogFrame
2020		LogFrame

Thank you
for your attention

Thomas Alslev Christensen
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