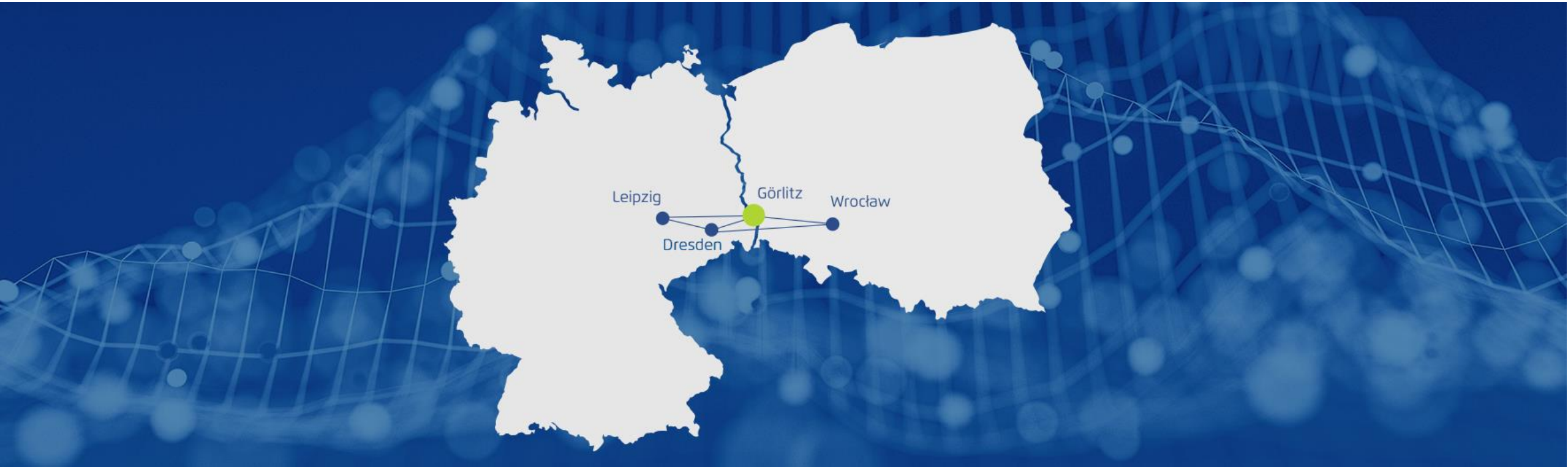
The Center for Advanced Systems Understanding

An institute crossing borders

Michael Bussmann

CASUS
CENTER FOR ADVANCED SYSTEMS UNDERSTANDING

www.casus.science



HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF
TECHNISCHE UNIVERSITÄT DRESDEN
CBG Max Planck Institute of Molecular Cell Biology and Genetics
UFZ HELMHOLTZ Centre for Environmental Research
Uniwersytet Wrocławski

SPONSORED BY THE
Federal Ministry of Education and Research
STAATSMINISTERIUM FÜR WISSENSCHAFT KULTUR UND TOURISMUS
Freistaat SACHSEN

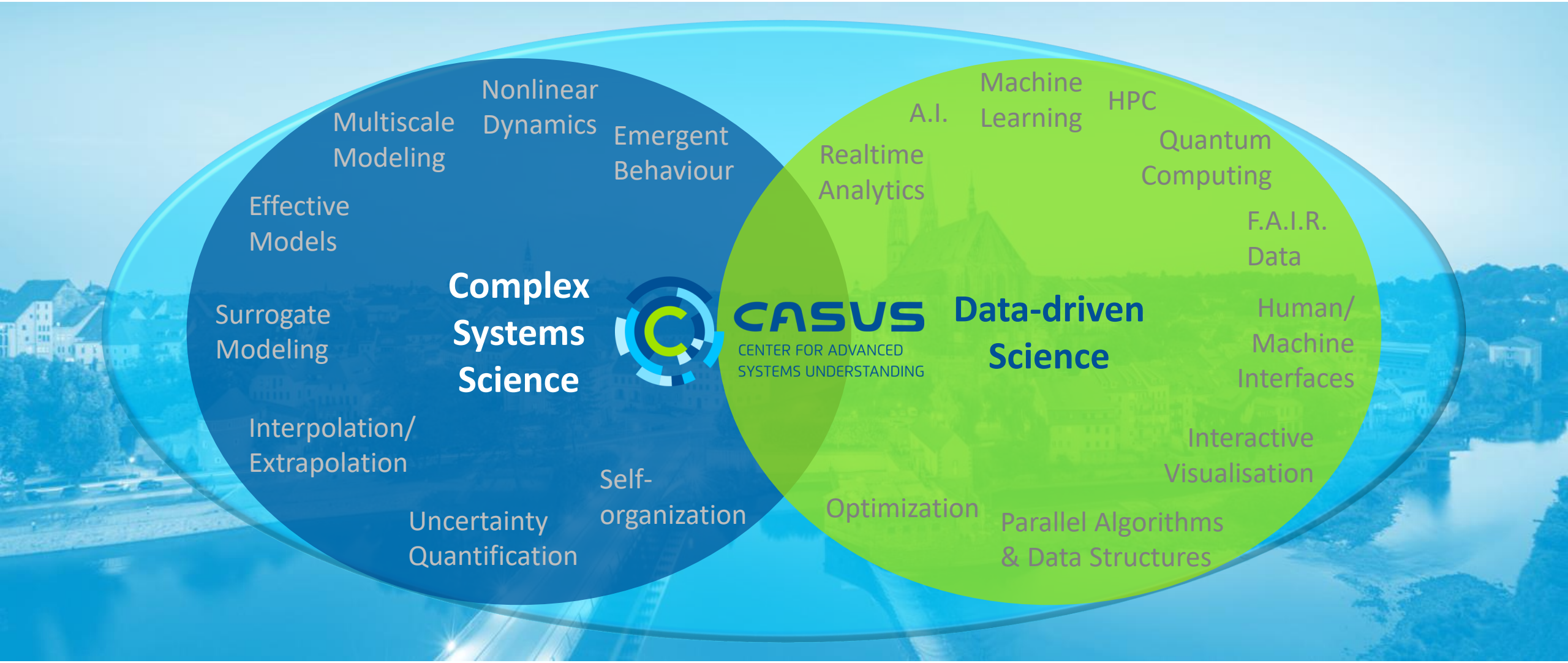
Data science and the COVID-19 pandemic

What have we learned so far?

- The Covid-19 pandemic was a global phenomenon in which science and scientists played an important role
- Data availability, access and openness were seen by many as decisive, yet were far from optimum
- Sustainable solutions to cope with future disruptive events are needed more than ever

Understanding complex systems through data

Excellency in method research enables excellent science



Domain knowledge + digital method excellency + sustainability

Interdisciplinary, diverse research teams as the key to success

Domain knowledge

Physics, Environmental Science, Biology, Health, ...

+

Digital method excellency

Artificial intelligence, Machine Learning, High Performance Computing, ...

+

Sustainability

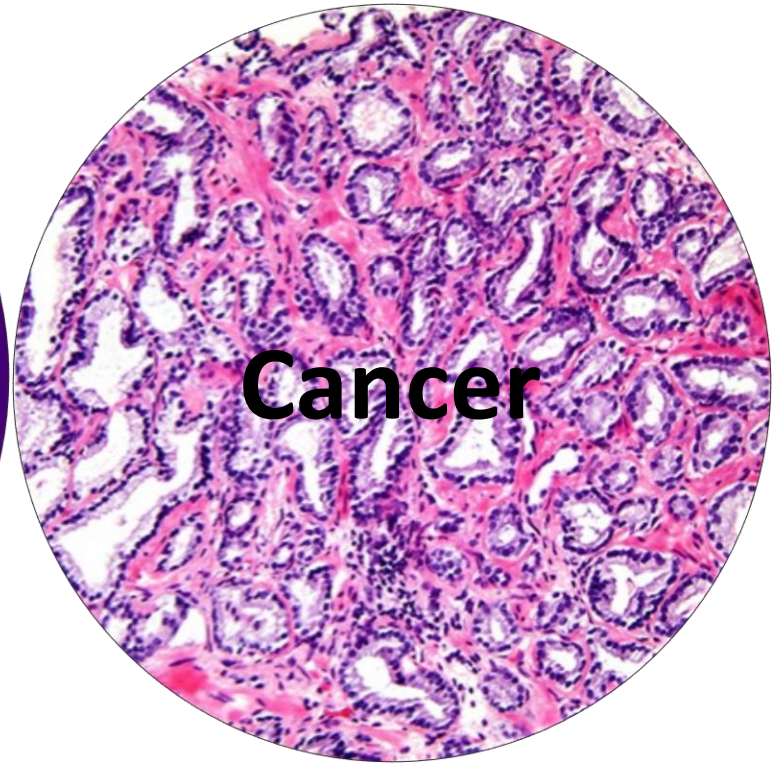
Professional software support & software sustainability

Key ingredients

- **Interdisciplinary research teams** include domain scientists, data scientists, computer scientists and mathematicians
- **Young investigator groups** draw new connections between research areas
- **A dedicated team of research software scientists** provides professional, sustainable software solutions
- **Collaborative funding** supports joint positions between research teams and with strategic partners

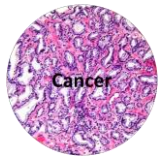
Two focus areas in digital health – Cancer & Infectious Diseases

Combining domain knowledge with digital expertise



CASUS Cancer Research

Real World Evidence databases and methods



CASUS
CENTER FOR ADVANCED SYSTEMS UNDERSTANDING

PIONEER

Largest European Database for patient data on prostate cancer

OPTIMA

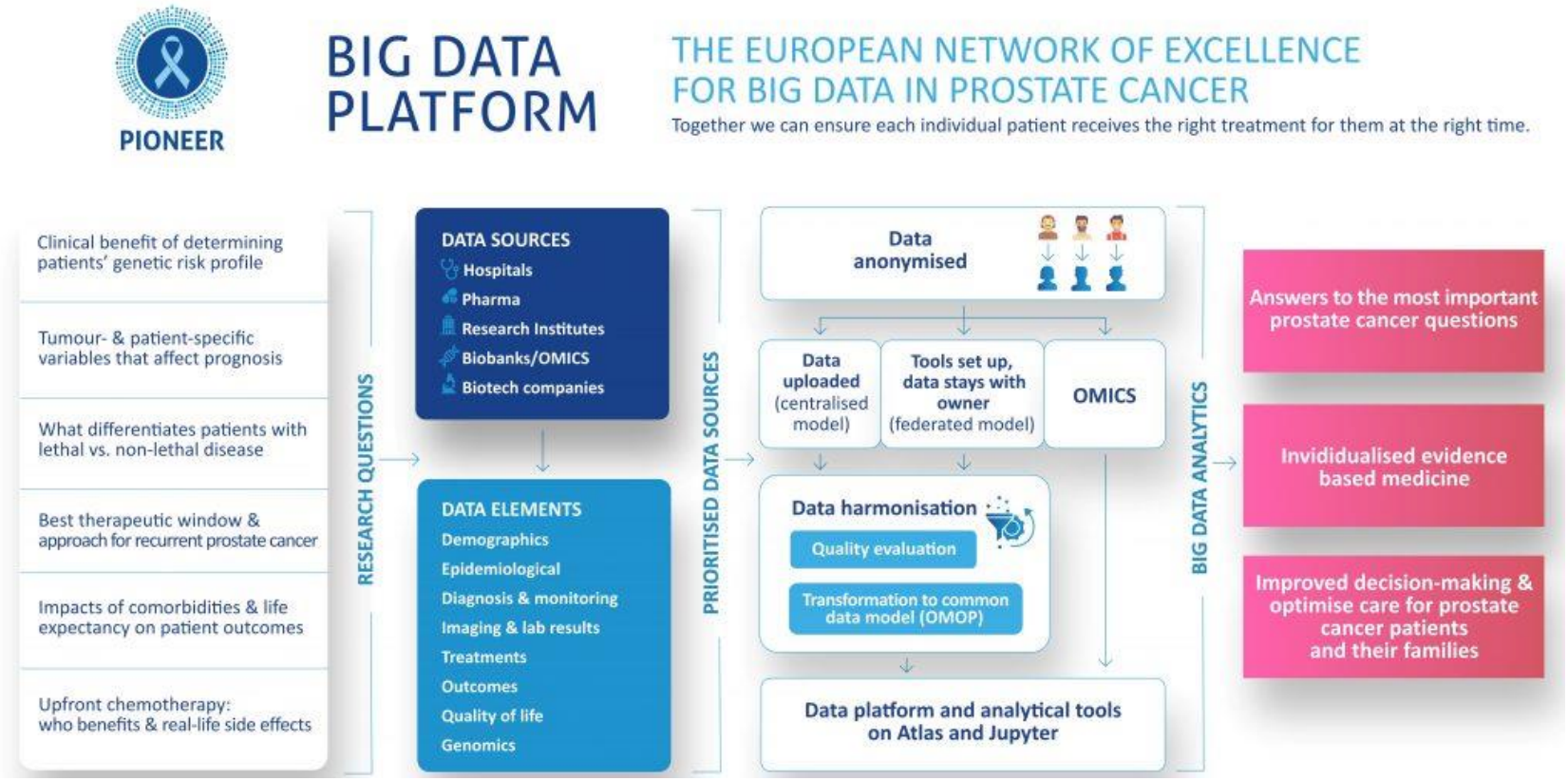
AI-support for better clinical decision making in prostate, lung and breast cancer

SOLACE

Database on lung cancer screening effectiveness

Big Data and real world evidence in Prostate Cancer

100,000,000 patient records



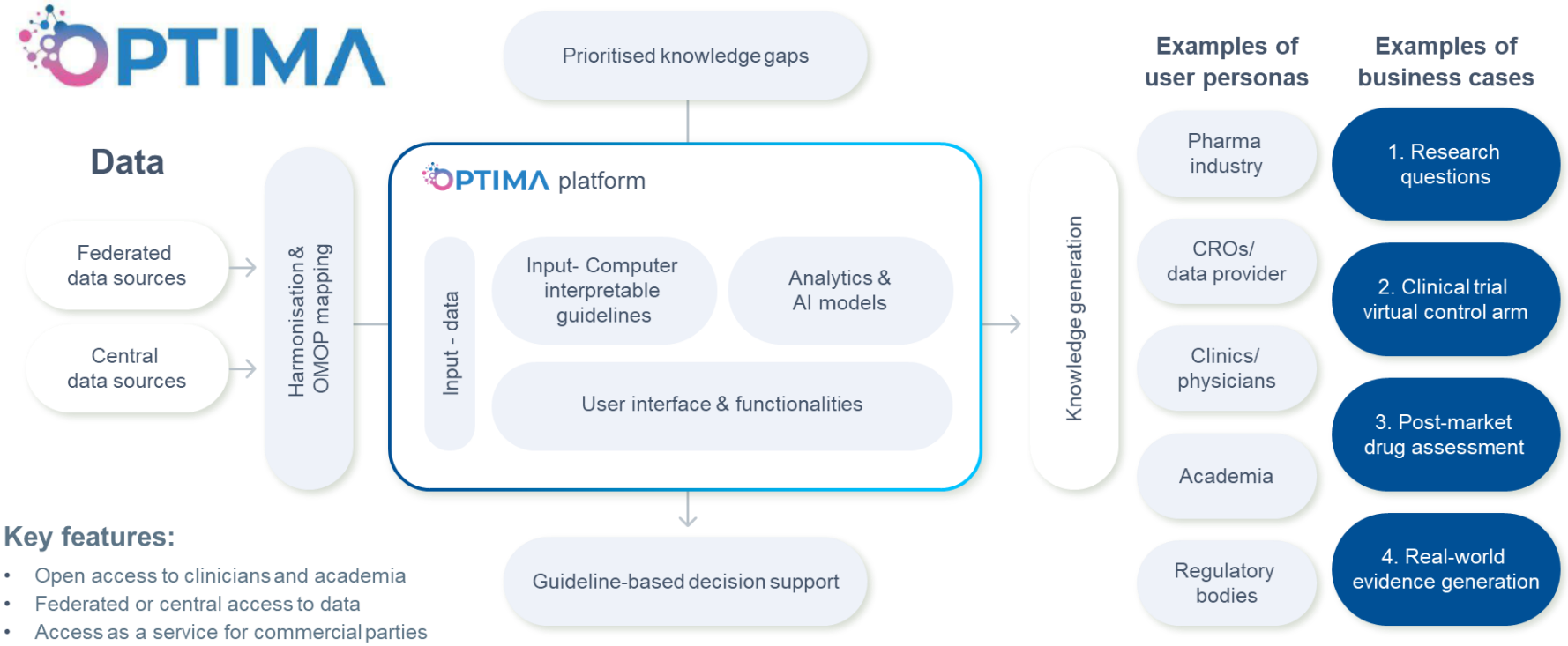
Leader (Bayer) & Co-Leads

Partners

CASUS — **The center for data-driven complex systems science** 7

Tackling cancer through real world data and AI

AI-augmented decision support for clinical cancer treatment



Key features:

- Open access to clinicians and academia
- Federated or central access to data
- Access as a service for commercial parties

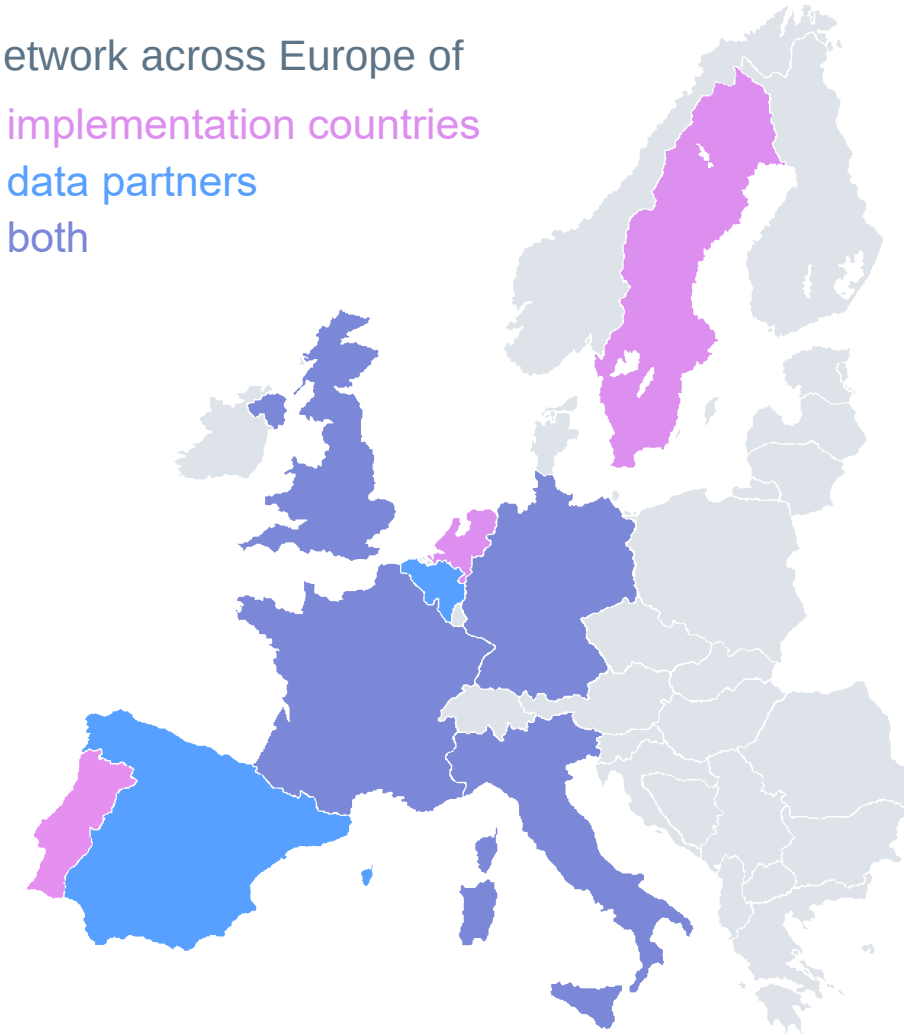
Tackling cancer through real world data and AI

Federated data and a central analytics hub at HZDR

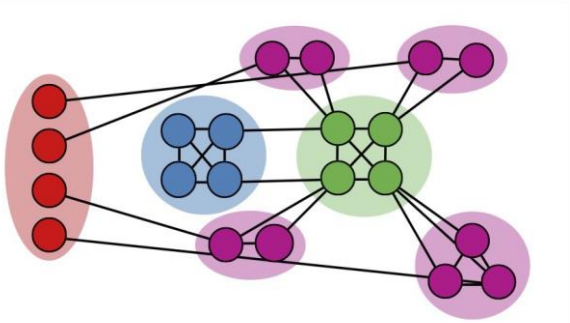
Country	Data provider	OPTIMA partner	Cancer type	OMOP mapping	Access type	Data type(s)	Number of people
France	INSERM*		All three	In progress	Federated	EHR	66 million
Germany	IQVIA (DA)*		All three	Complete	Federated	Ambulatory EMR	37 million
Belgium	IQVIA (LPD)*		All three	Complete	Federated	Ambulatory EMR	2 million
France	IQVIA (LPD)*		All three	Complete	Federated	Ambulatory EMR	7.8 million
Spain	SIDIAP	IDIAPJGol	All three	Complete	Federated	EHR	6 million
Scotland	eDRIS	University of Aberdeen (UoA)	All three	No	Federated	EHR	5.4 million
UK	CPRD	Oxford University (UOXF)	All three	Complete	Federated and Central	EHR	21 million
Italy	SIMG (IQVIA)*		All three	Complete	Federated	EHR	2 million
	Cancer registries and biobanks for AI model building						
Denmark	Danish registry* RKKP		All three	In progress	Federated	National registry	6 million
UK	Oxford University	Oxford University (UOXF)	All three	In progress	Federated and Central	Biobank linked to EHR	400.000
Estonia	Biobank	University of Tartu (TU)	All three	In progress	Federated	Cohort (EHR-XML)	198.000
Germany	Helios clinics	Helios Klinikum Emil von Behring (HC)	All three	No	Federated	Admin, EHR	163.264 patients
Germany	DKG	German Cancer Society (DKG)	Prostate, Breast	No	Federated	Cohort/QA data	100.000 patients
France	ICO	Institut de Cancerologie de l'Ouest (ICO)	All three	No	Federated	Cohort**	47.269 patients
Scotland	ICAIRD & DaSH	University of Aberdeen (UoA)	All three	No	Federated	EHR with imaging	11,708 patients
Czechia	MMCI*		All three	No	Federated	Cohort**	13.587 patients
Netherlands	EMC	Erasmus Universitair Medisch Centrum Rotterdam (EMC)	Prostate	In Progress	Federated/Central	EHR**	8.800 patients
UK	Barts Breast Cancer	Queen Mary University of London (QMUL)	Breast	No	Federated	EHRs, imaging,Seq**	2500 patients
	EFPIA data						
US	OPTUM*		All	Complete	Federated	EHR	56 million
EU and Non EU	Pfizer	Pfizer	Breast	No	Central	Clinical trial; Non interventional, prospective	2000-3000
EU	AMGEN	AMGEN	Lung		Central	Cohort, prospective	1000
EU and non EU	AMGEN	AMGEN	Breast, PCa and Lung	No	Central	Clinical trial; Non interventional, prospective	2000
EU and non-EU	Roche	Roche	Breast and NSCLC	No	Federated	Non-interventional, prospective	~1,000
	Total						>200M

Network across Europe of

- implementation countries
- data partners
- both



Testing as a resource allocation problem



The Where2Test project

- Funded by the Saxon ministry of science, culture, and tourism (SMWK)
- Limited testing capacity emerged as a key constraint
- This problem was largely unstudied in the literature
- Focus on testing within organizations such as businesses, retirement homes, etc
- Developed both underlying network-based models and web applications for end users


Prof Dr Justin Calabrese


Dr Weronika Schlechte-Welnicz


Dr Adam Mertel


Dr Mansoor Davoodi


Dr Abhishek Senapati


Dr Ana Batista

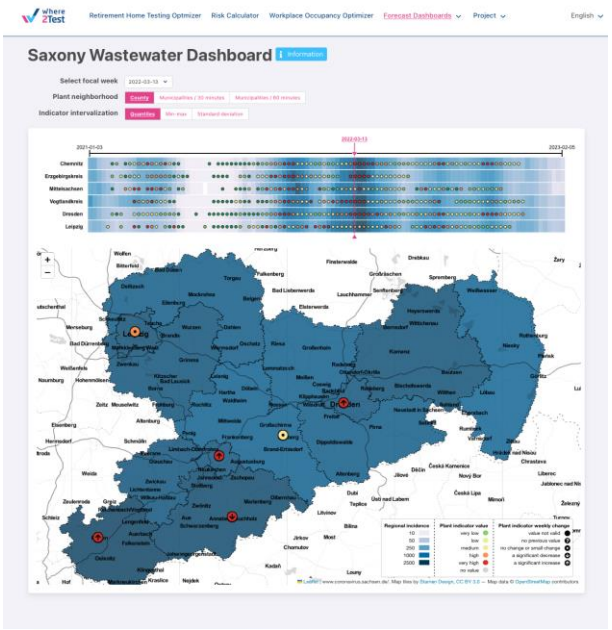

Dr Wildan Abdusalam

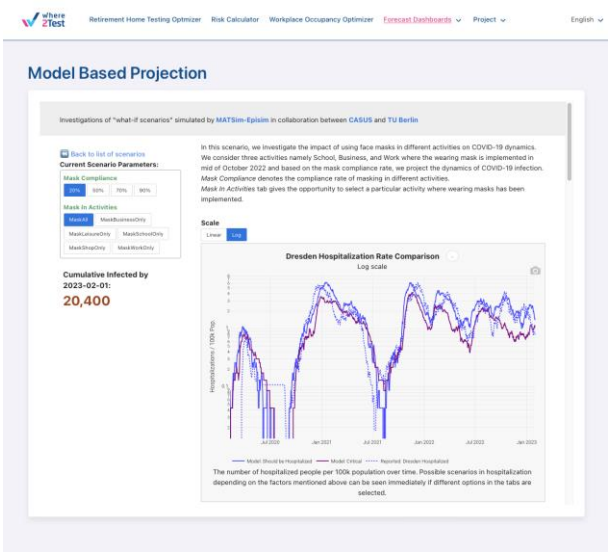

Dr Lennart Schüler


Dr Jiri Vyskocil


Dr Guiseppe Barbieri

The Where2Test platform





www.where2test.de

- COVID incid. dashboards Saxony & nearby regions
- Dashboard for wastewater monitoring in Saxony
- Workplace presence optimization app for institutions
- ODS integrating diverse regional and national data
- Adaptation of EpiSim COVID model for Dresden area

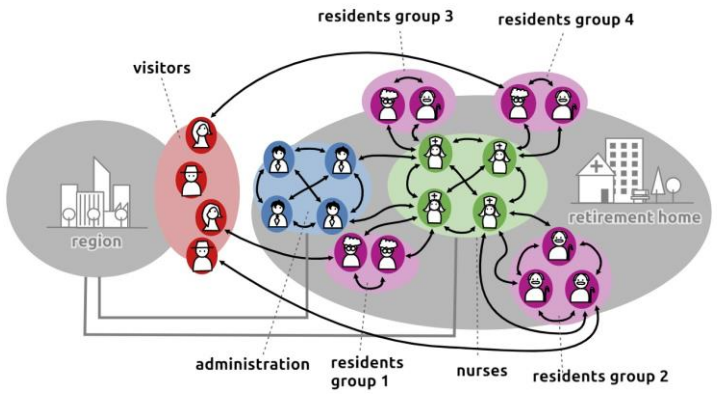
Key papers

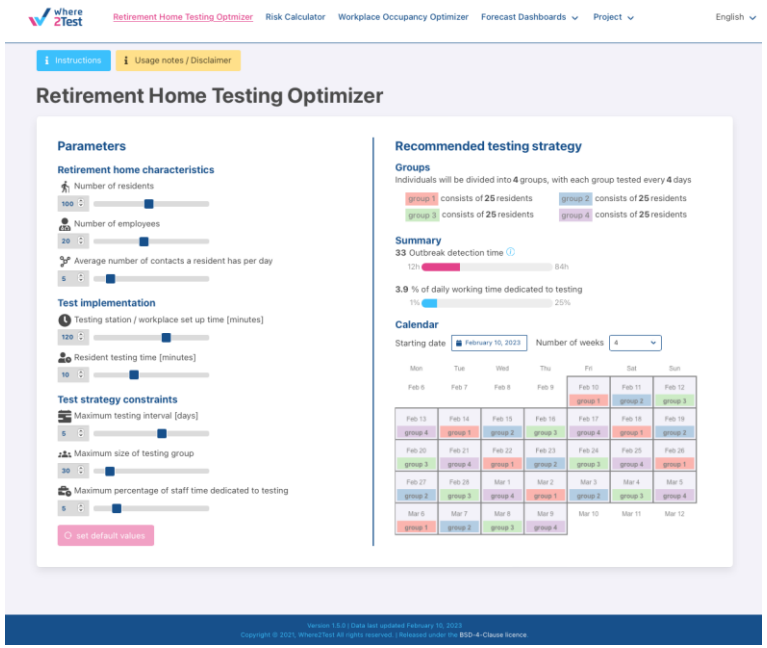
Mertel et al. 2023. *Spatial & Spatiotemp. Epid.*

Davoodi et al. 2023. *PLoS ONE*

Batista et al. In revision. *Comp. & Ind. Eng.*

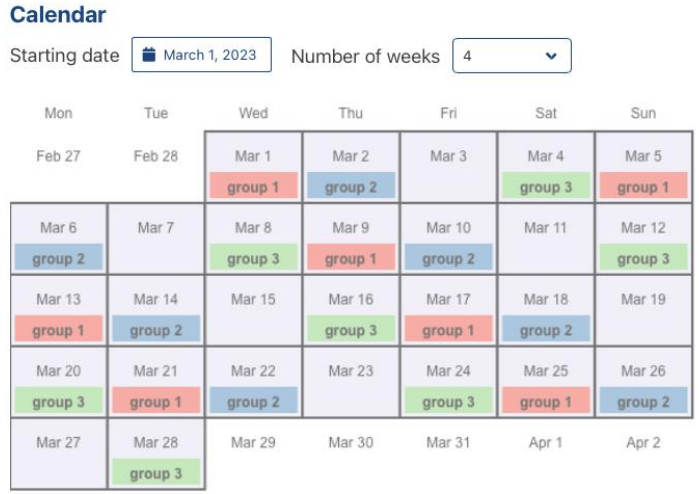
Optimal testing strategies in retirement homes





Retirement home app

- Very high mortality in RHs early in pandemic
- RHs test to identify outbreaks as quickly as possible
- Testing typically done by existing RH staff
- App calculates optimal grouping & testing schedule
- Developed collaboratively with RHs operated by Diakonisches Werk Löbau-Zittau



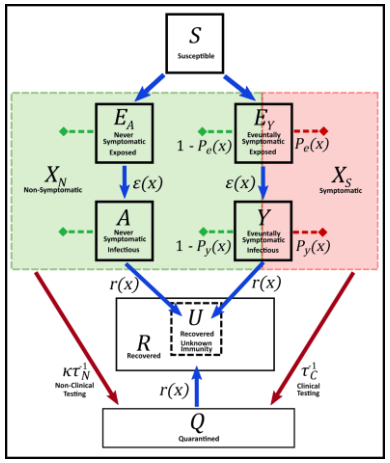
Diakonie Löbau-Zittau

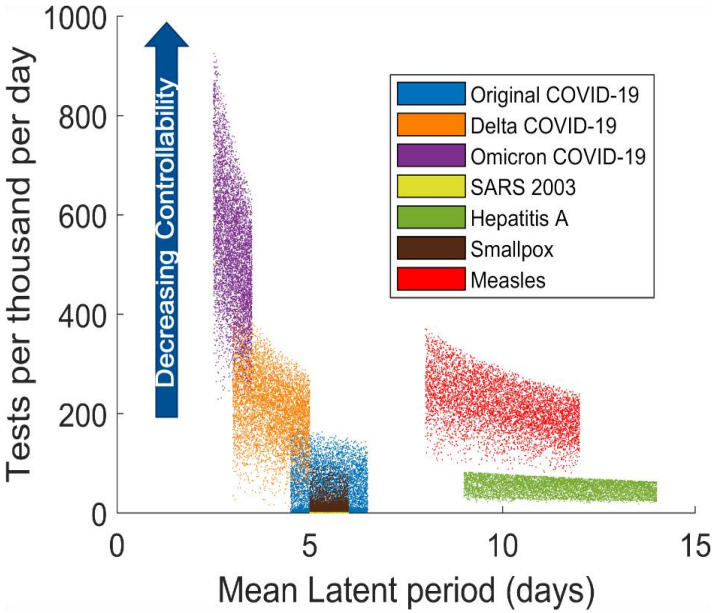
Key papers

Davoodi *et al.* In review. *Ann. Operations Res.*

Davoodi *et al.* In review. *JMIR Aging*

Understanding outbreak controllability across diseases





The optimal control project

- From testing-focused work on COVID to a general model of epidemic control
- Allows direct comparisons across infectious diseases
- Identifies ***combinations*** of factors that make diseases more or less difficult to control
- For COVID, combination of short mean latent period + asymp transmission + large R_0 is key
- Omicron family is a "perfect storm" of these factors

Prof Dr Justin Calabrese

Dr Jeffrey Demers

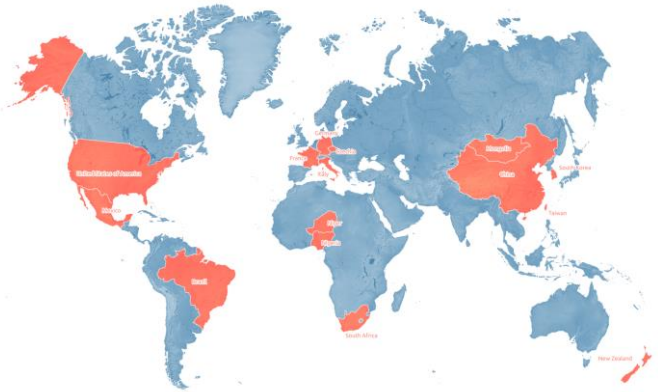
Key papers

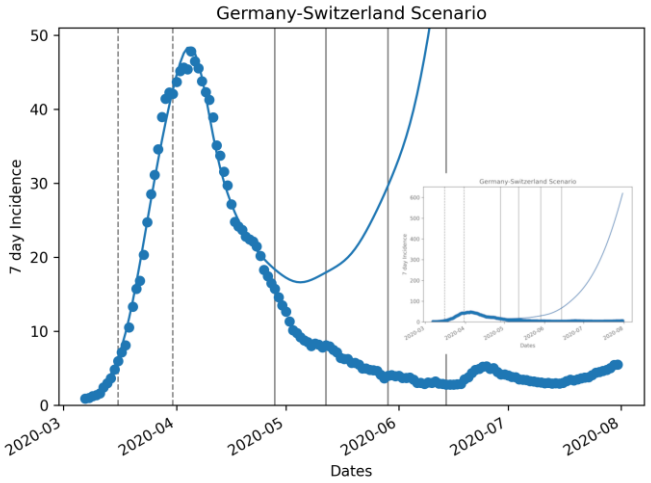
Calabrese & Demers. 2022. *J. Theor. Biol.*

Demers *et al.* 2023. *Infectious Disease Mod.*

Demers, Fagan & Calabrese. In prep.

Data-driven, cross-national analyses of outcomes





The COCAP project

- Pandemic played out differently in different nations
- Unprecedented amount of data available worldwide
- Combines epid + econ + behavioral models with multifaceted data across contrasting nations
- Goal: identify which interventions worked and why
- Emphasis on lessons for future pandemics

Prof Dr Justin Calabrese

Dr Xiaoming Fu

Dr Kai Fan

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

UFZ HELMHOLTZ Centre for Environmental Research

KIT Karlsruher Institut für Technologie

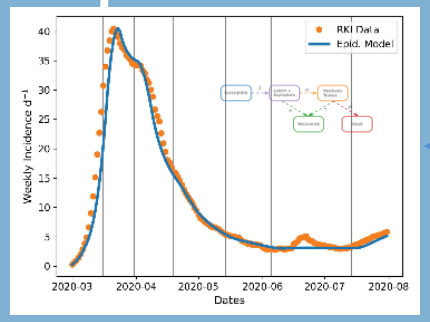
UNIVERSITÄT LEIPZIG

Understanding outbreak controllability across diseases

Interventions

Epidemic state: Infections, Deaths, R-Factor [I_t, D_t, R_t]

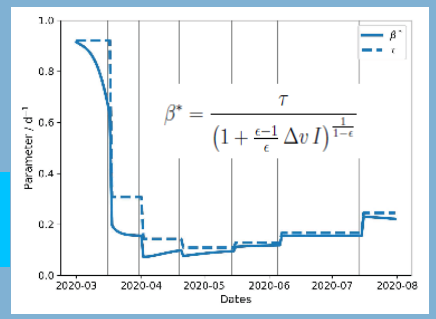
Epid. Model



Schüler et al. 2021

Contact rate
[β_t(Interventions)]

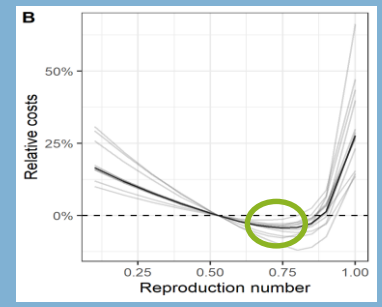
Behavioral Model



Quaas et al. 2021

Economic state
[Y_t]

Economic Model



Dorn et al. 2020

Relative costs

Health status: age structure, obesity

Risk aversion

Sector distribution

National Framework Conditions

CASUS

CENTER FOR ADVANCED
SYSTEMS UNDERSTANDING

data-driven science

understanding complex systems

connecting researchers across borders