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Research Infrastructures and Critical Mass : new challenges in the evaluation of public R&D programmes

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Evaluation of public R&D programmes

- **"An evaluation is an assessment, as systematic and objective as possible, of an ongoing or completed project, programme or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision making process of both recipients and donors." (OECD 1987)**

- ***GOALS – INSTRUMENTS DESIGN/IMPLEMENTATION - SOCIO-ECONOMIC IMPACT***

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Evaluation of socioeconomic impact of public R&D programmes

- An increasingly unified "vocabulary" :

  output – outcomes – impacts ; efficiency vs efficacy vs effectiveness; ex-ante vs monitoring vs ex-post; input/output/behavioural/… additionality; "project fallacy" and separation issue; spread and diffusion issue…

- BUT :
  - Different (implicit or explicit) underlying theory/model as regards S&T&I processes (neoclassical vs evolutionnist vs structuralist vs knowledge-base views…)
  - A lot of complementary or mutually exclusive approaches, methods, tools, metrics…

Evaluation methods

(Fahrenkrog et al. 2002)

Methodology	Type/ Use	Data requirements	Strengths	Limitations
Expert panels / Peer reviews	Qualitative Semi-quantitative Ex-ante Monitoring Ex-post	Project programme data	Evaluation of scientific merits Flexibility Wide scope of application	Peers independence Economic benefits not captured
Network analysis	Qualitative Semi-quantitative Ex-post	Project programme data	Comprehensive empirical material Co-operation linkages	Time involved in collecting the survey information
Cost/Benefit Analysis	Quantitative (with qualitative elements) Ex-ante (especially) Monitoring Ex post	Micro data Profit & Cost estimates	Provides an estimate of socio-economic effect Good approach to assess efficiency Addresses all economic assumptions (by making them explicit)	Requires high technical capacity Depends on assumptions made Careful interpretation of results when benefits are not easily quantifiable in monetary terms
Field/Case studies	Qualitative Semi-quantitative Monitoring Ex-post	Project programme data	Observation of the socio-economic impact Exploratory and descriptive strengths Consideration of context	Results not generalizable
Foresight / TA	Qualitative Semi-quantitative Ex-ante Monitoring	Qualitative data Scenario	Consensus building to reduce uncertainty under different scenarios Combination of public domain and private domain data Articulation and road mapping of development of new technologies	Impossibility to detect major R&D breakthrough
Benchmarking	Semi-quantitative Ex-post Monitoring	Science and Technology indicators	Comparison method across different sectors Support to systemic evaluation of institutions and systems	Data detail requirements Non transferable

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Co-evolution of policy rationale and evaluation rationale

- 1970s modification of peer review to extend criteria
- 1980s interest began in collaborative R&D programmes
- 1990s rise of :
  - Performance indicators
  - Emphasis on technology transfer indicators
  - Commercialisation of research
- 2000s interest in :
  - Evaluation of systemic/network capabilities ex Nat(Reg)SI
  - Aggregate or interactive effects of policy ("policy mix")
  - Effects of "soft" policy tools such as Foresight
  - Strategic and persistent effects on firms of public support ("behavioural additionality")
  - Development of "logic models" linking goals-policy tools-evaluation targets
  - "New instruments" : NoE, IP, ERA-Nets, JPI, RI …

Research Infrastructure (RI)

RI in EU RTD FP7 Capacities programme :
(http://cordis.europa.eu/fp7/capacities/reserach-infrastructures_en.html)

- Aiming at supporting existing or new RI or major upgrades of existing ones, as well as policy development and programme implementation, including support to emerging needs
- €1.85 billions 2007 to 2013 (not to mention the additional potential support from EC Structural Funds, EIB and from Member States)
- European Roadmap for RI elaborated by new 2002-established European Strategy Forum on RI (ESFRI) : more than 40 new RI or major upgrade of existing ones will be developed by 2015-2020 mainly in the fields of environment, biology and energy.

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EC definition of RI

Facilities, resources and related services used by the scientific community to conduct top-level research in their respective fields, ranging from social sciences to astronomy, from genomics to nanotechnologies. This includes :

- Major equiment or group of instruments used for research purposes
- Permanently attached instruments, managed by the facility operator for the benefit of all users
- Knowledge based resources such as collections, archives, structured information or systems related to data management, used in scientific research
- Enabling information and communication technologies- based infrastructures
- Any other entity of a unique nature that is used for scientific research

- "Single sited" (a single resource at a single location) / "distributed" (a network of distributed resources) or "virtual" (services provided electronically)

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"EC" RI : examples

singular large-scale research installations, collections, special habitats, libraries, databases, biological archives, clean rooms, integrated arrays of small research installations, high-capacity/high speed communication networks, highly distributed capacity and capability computing facilities, data infrastructure, research vessels, satellite and aircraft observation facilities, coastal observatories, telescopes, synchrotrons and accelerators, networks of computing facilities, as well as infrastructural centres of competence which provide a service for the wider research community based on an assembly of techniques and know-how.

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RI : challenges for the evaluation - 1

- possible important intangible dimension, which has been representing for long a challenge for the evaluators
- mixture of public and private sources, calling for a more subtile evaluation frame than the one of a pure publicly financed investment
- international dimension as a common rule
- frequent evolution over time, adding new modules / functionalities / data etc requiring a dynamic perspective of the evaluation
- networking of existing facilities vs creation ex-nihilo

RI : challenges for the evaluation - 2

- indivisibilies and scale effects – irreversibility of investment
- public good properties – generic vs specific scope of use – cost of investment & maintenance … determining the rule of access and protection (exclusive access, open access, copyleft type, hybrid solution)
- changing in the understanding of the role of such RI :
  - knowledge hub and a basis for research network creation
  - opening of new research avenues, most often explored with interdisciplinary or multidisciplinary approaches => irreversibility of scientific trajectories

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Methods for evaluating the socioecomic impact of RI - 1

Not start from scratch … but :

- lack of widely accepted and institutionalized framework
- scattered studies

- Surveys :ERID-Watch WP2 Market Study 2008 ("The RI market")
  - *Rather big market ~8-9 B€ per year Increase of 5.5% over the last 10 years - new products (e.g. Medical drugs) - Leading edge technologies - Secondary industrial products (e.g. DNA sensors) - Marketing image & global markets for technologically-based companies*
  - But identified data relate mainly to scientific outputs, not so much to industrial or societal outputs…No comprehensive data to determine socio-economic impacts …no FP6 predefined definitions / measures according to impacts (ex-post reconstruction based on "expert opinions" or feedback from Delphi)
- Few economic quantitative/econometric models (such as I/O models, TFP for decomposing the impact of innovation on productivity, Vector Autoregressive Techniques for modelling time series variables, Spatial models such as 'gravity' models, geographically weighted least squares estimation techniques)

  ex European Spallation Neutron Source in Bilbao : ex ante evaluation

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Methods for evaluating the socioecomic impact of RI - 2

- Numerous more or less detailed case studies
  - CERN
  - Synchrotron Radiation Source (Facilities Council - Uk) S&T:

  Scientific influence– Creating new companies– Technology development– Improving the performance of UK business– Impacts to the local economy– Delivering skilled people to the labour market
  - + GANIL (Particle accelerator, F/EU), Potsdam-Golm Science Park (G), LifeScience Park (Pol), Swansea university (UK), Cenaero, Aeronautics (Bel), Multitel (Bel), DESY - HERA synchrotron (G), Synthesis (UK, natural history collections) …

  = *jobs in RI / in local economy; expenses of RI; start-up incubation; specific issues through examples/success cases*

=> Need of :

- Improvement of overall evaluation framework, better diffusion of thoery, methodologies, practices
- Development of time series and standardised data collected across projects
- Better understanding of long term impacts and specific impacts of RI

=> Willingness to develop new approaches / integrating frameworks

- RIFI Project RI Foresight and Impact
- Call EC "Infra-2010"

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The case of BBMRI

Biobanking and Biomolecular Resources Research Infrastructure www.bbmri.eu

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A pan-European distributed infrastructure of existing and de novo biobanks (*) and biomolecular resource centres providing access thereto. It will include biological material from patients and healthy persons, typically DNA, tissues, cells, blood or other body fluids, with links to clinical and research data. It will also comprise biomolecular research tools and bio-computational tools to optimally exploit this resource for global biomedical research.

- ***50 Organisations (incl. 21 Funding Org), 182 assoc. Partners***
- ***Preparatory phase: 2008-2010; construction phase: 2010-2013***
- ***Estimated costs : Preparation: 5 M€., Construction costs: 170 M€ (to be updated during the preparatory phase), Operation costs: 15 M€/year (to be updated during the preparatory phase)***
- ***Mix between research tools and research results***
- ***Extreme variety of BB (size, contents, …) and hosting actors => network of networks***
- ***RI builders are also users***
- ***Dynamics : new BB may join/be added***

- *(*) A biobank is a repository for human cells, tissues, blood or DNA, which can be linked to data and information on the respective donors. The data could contain information on health and life style*

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The case of BBMRI : Evaluation of the impact (2009-2010)

BETA (parallel studies by Technopolis and FhG-IBMT Saarbrücken)

- (part of) economic impact
- ex-post evaluation
- small-scale study
- focus of effects for "BBN" (BioBank Network) members
- develop a framework and indicators for the evaluation of BBN
- test the feasibility of using the BETA approach to evaluate some socio-economic impacts of biobank networking (BBN) projects
- pilot study applied to 7 representative existing biobank networks (research oriented, human tissues & data, >3years old)
- draw lessons for a possible future implementation in the case of BBMRI (BMS)

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Impact of BBMRI : Evaluation by BETA - 1

Three steps with corresponding effects :

- Setting up of BBN
  - direct effects : economic activities (buildings, equipments, software etc)
  - indirect effects : development and re-use of various knowledge and competences acquired during the setting up phase
- Functionning of BBN : maintenance, presence of staff
- Use of BBN
  - S&T knowledge
  - Networking
  - Commercial : products, drugs, spinoff, standards etc
  - Social / environmental effects

- Enrichment of BBN : network externalities : new cycle of effects

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Impact of BBMRI : Evaluation by BETA - 2

		EPIC/E3N	GenomEUtwin (a)	INCa	GA2LEN	Eurobiobank	SWEDISH National biobank program	MORGAM (a)
"large case" 3/4 members covered								
"small case"" focus on 1 member								
*Bio-bank (and not BB **network**)*								
Aim	Network of Population biobanks		OK				OK	
	Network of thematic biobanks			OK	OK	OK		
	Mix of population and thematic biobanks	OK	OK					OK
	Network of fragmented, diverse collections						OK	
Geographical coverage	Internat.: partners from several countries (EU)	OK	OK		OK	OK		OK
	National: partners from a given EU country			OK			OK	
	Regional: partners located in the same region			OK				
Biological material	Genetic material	OK	OK	probably	OK	OK	OK	OK
	Tissues incl blood	OK	OK (blood)	OK	OK	OK	OK	OK
	Serums and liquids					tbc	OK	
Size	Large number of partners and/or samples	OK	OK		OK	OK		OK
	Small number of partners and/or samples			OK			OK	
Growth dynamics	Increasing	OK		tbc				OK
	Stable		OK		OK	OK	OK	
Funding	Public funding (national, EU, regional subsidies)	OK	OK	OK	OK	OK	OK	OK
	Private funding via NFP foundations / charities	OK	OK	tbc			OK	OK
	Private funding directly from companies	OK						OK
Number of partners/interviews covered		3	4	3	1	1	1	1

(a) one interview has been made with a partner member of both BBN, MORGAM being assocated to GenomEUtwin

16 interviews in total

Name	*Main features*	*nb of interviews*
EuroCryoSaar	research orga. ; thematic BB for internal use evolving towards service/clients oriented BB	2
Medical University of Graz	hospital ; population BB evolving towards disease-oriented BB ; internal / public body use	1

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Impact of BBMRI : Evaluation by BETA - 3

		Frequency	Impact	Possibility of identification	Possibility of quantification
Phase 1	**Direct effects from the setting up of BBN**				
	Human ressources	*	*	Easy	Relatively easy
	Hard/software	**	*	Easy	Relatively easy
	Indirect effects from the setting up of BBN				
	Technology and Knowledge transfers	*	*	Easy	Case depending
	Reputation effects	**	**	Easy	Difficult
	Network effects	***	**	Quite easy	Difficult
	Organisation/methods	**	**	Easy	Difficult
	Human capital	*	*	Quite easy	Relatively easy
Phase 2	**Effects from the use of BBN**				
	S&T outputs	*** publ.; - patents; ** new projects	*	Easy	Relatively easy
	Commercial effects (licensing, spinoff cies, products…)	-	-	Easy	Relatively easy
Phase 3	**Enrichment of BBN**				
	New members	*not relevant*	*	Easy	Very difficult
	New samples, data, collections	*not relevant*	**	Medium	Very difficult

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Impact of BBMRI : Evaluation by BETA - 4

A lot of issues raised as regards :

- **The existence and scope of the effects**
  - **size of the BBN and size of the BB involved, nature of the samples and data stored in the BBN, project-based vs. infrastructure-based BBN, centralized vs. decentralized network, open versus restrictive conditions of access, relative level of development of the BBN partners, different types of partners**
- **Hypothesis on the effects**
  - **vary in order of magnitude, geographical dimensions, dynamics and time frame**
- **The use of the BETA approach for BBMRI**
  - **effects of networking BB versus effects of setting up BB, definition of a network of BB, time frame (point of reference and the enrichment effect / the dynamics of the generation of effects), extreme variety of actors and networks, necessity of an ex-post perspective, complexity of attribution ("project" fallacy), difficulty of a detailed quantification**

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Critical Mass (CM) in the policy "discourse"

- **2000 EC Commission Communication on ERA :**

"… more coherence between measures taken on different policy to attain the CM in the major areas of progress in knowledge…"

- **2004 EC Commission Communication on future European research policy :**

"… EC could encourage companies to invest more in research in Europe through the creation of "centres of excellence" of CM …." "… as bringing together more participants and pooling their resources …" "… depends on the research's topic, the thematic area, the participants and the potential impact…"

- **FP 5 Five-Years assessment (Guy et al 2005) :**

"… strengthening excellence on a research topic by networking the CM of resources and expertise … that must be networked around a joint programme of activities aimed primarily at creating a progressive and lasting integration of the research activities of the network partners while at the same time advancing knowledge on the topic"

- **Even more important in FP6 and FP7 (Piech 2007).**
- **2010 OECD Ministerial report on the Innovation Strategy :**

"… link between CM and capacity of countries to reach excellence in innovation, thanks to attraction of resources to specific locations (pledging for coherence of policy at local/regional, national and international levels)…"

- **2010 EC Communication on the Europe 2020 Flagship Initiative Innovation Union :**

"… Too much fragmentation and costly duplication. We must spend our resources more efficiently and achieve CM …" "… It is essential to create a genuinely unified European Research Area, in which all actors, both public and private, can operate freely, forge alliances and gather CM in order to compete and cooperate on a global scale…"

BUT : CM is never defined precisely and remains a vague concept : no clear empirical and theoretical understanding + mix-up with scale and scope economies

=> EC launch different studies (on-going)

Scale & scope in R&D project(Erascope project) - 1

- Scale: R&D projects may experience increasing returns to Scale because of specialization, complementarities of resources and skills, and more efficient utilization of resources
  - A counter argument: decreasing returns to scale because of higher transaction and administrative costs associated the implementation of a large project
- Scope: increasing returns to scope may arise in the pursuit of multiple "sub-projects" within the same research effort because of e.g., cost savings, cross-fertilization of ideas and intermediate results, etc
  - A counter argument: (as above) diseconomies of scope because of transaction costs to managing a complex project

Adapted from Vonortas, 2010

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Scale & scope in R&D project(Erascope project) - 2

- 1172 observations (750 ROs + 422 enterprises)
- 676 unique projects (328 projects with responses >= 2)
- **Scale**: (number of partners, project budget)
- **Scope (**sub-projects)
- **Projects performance at partner level (**"achievement of project objectives", Knowledge-related "outputs" (e.g., publications), Technology-related "outputs" (e.g., models and simulations), Network-related "outputs", Research-capacity related impacts, Commercialization-related impacts, Product and process innovation (as a result of the project) (two dichotomous variables)
- **Mediators (**Complementarity of resources, Absorptive Capacity, Transaction Costs)
- **Various independent variables for control**

- All "composite" variables used in the analyses (see below) were constructed following Confirmatory Factors Analysis
- Econometric analysis

Adapted from Vonortas, 2010

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Critical mass project : looking for a conceptualization

- Literature review :
  - No single accepted definition, but different "bits" of definitions in various sciences (nuclear physics, biology, economy, management, social networks, etc)
  - Objective driven : new entity, a dynamic and self-sustained reaction or networking process, the production of a public good, a level of competitiveness, …
  - Threshold of "ingredients" that have to be combined in a certain way,
  - Necessity of specific conditions,the fact that something happens thanks to CM
  - Maintenance of CM may be a key issue.
  - Economics : CM vs scale, scope and increasing returns

- The experts' points of view on CM in the context of RD programmes:
  - No single approach to the definition of CM
  - CM allows achieving something / goal driven concept
  - Variety of resources to be pooled
  - Localisation where resources have to be pooled (critical mass for clusters)
  - Management dimension: inventives, leadership and individual characteristics are very important to organize the CM (critical mass for project)

Beta-ISI-Formit, unpublished

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Critical mass in R&D programmes : a proposed definition

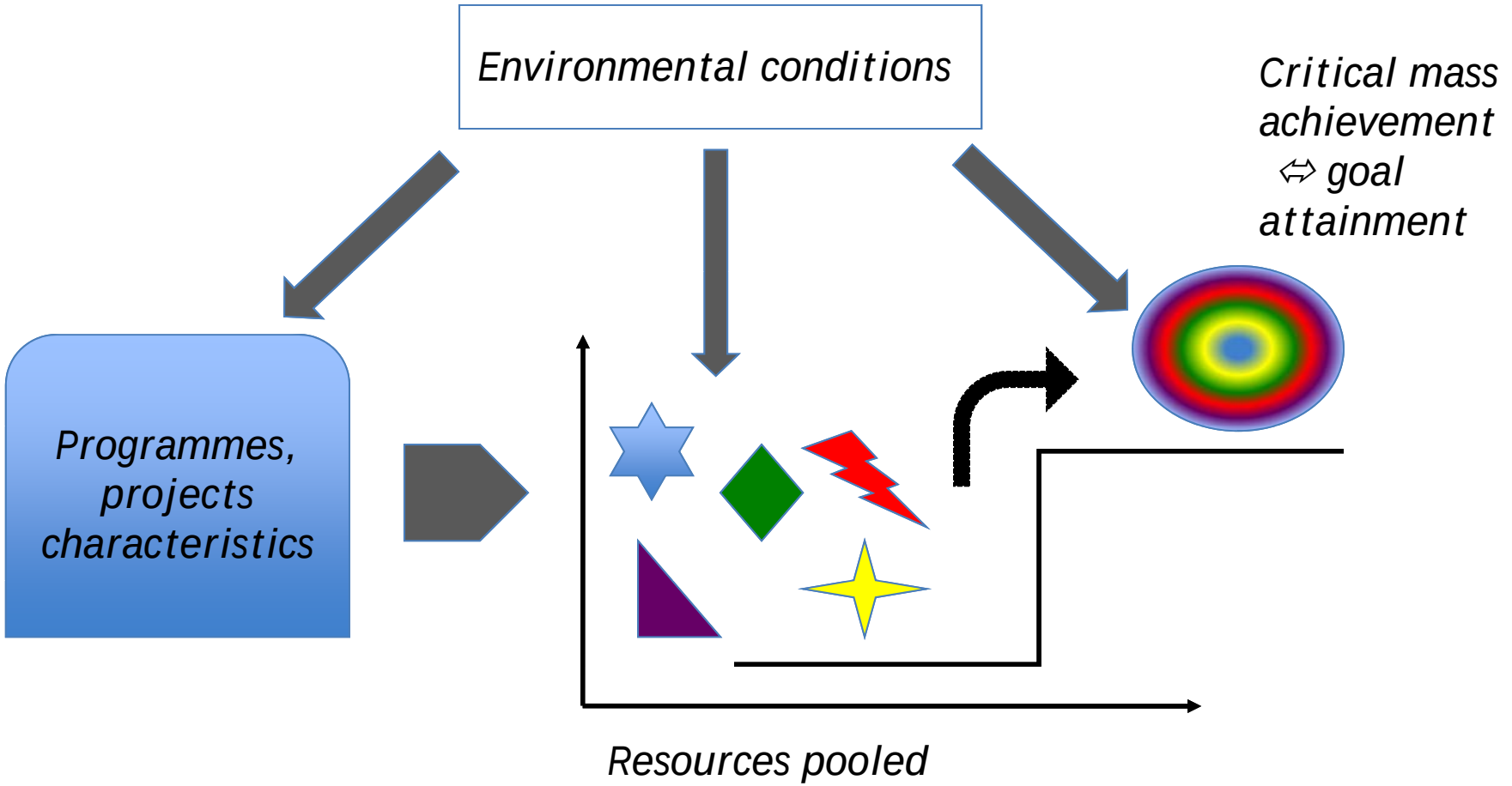
Threshold level of resources pooled thanks to R&D programmes required during a certain period of time in order to:

- address socio-technological or scientific challenge TARGET ORIENTED
  eg Galileo system, developing an electric vehicle, developing a transport system based on electric vehicles, developing a green chemistry for sustainable agriculture, forecasting earthquakes, Human Genome Project
- to secure a certain level of competences in
  - a quite traditional area, i.e. for defensive reasons KEEP ALIVE - MAINTAIN PAST OPTION
    eg basic metallurgy, Ninth Century Persian literature, very old variety of cereals, …
  - a very new area i.e. for prospective reasons GIVE BIRTH - MAINTAIN FUTURE OPTION
    eg wind turbines some years ago
- to reach excellence COMPARATIVE
  eg catch up/stay aside USA-Japan-BRICs, ranking - e.g. leader or be among top 3
- to reach self-sustained dynamics in the development of the area DYNAMICS
  eg involvement of key actors, investment of research funds, etc.

- Variety of resources
- Ways of pooling resources equally important as resources per se
- Time dimension

Beta-ISI-Formit, unpublished

Approach to the evaluation of critical mass



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