

The background of the slide is a spiral-bound notebook with blue grid paper. The spiral binding is on the left side. There are two large black rectangular redaction boxes: one in the upper right quadrant and one in the lower left quadrant. The title text is centered in the lower half of the page.

Charting the Edge of Chaos: Challenges in Mapping Scientific Research

Patrick Lambe

ISKO Conference 2013 - Mon July 8 - slide 1

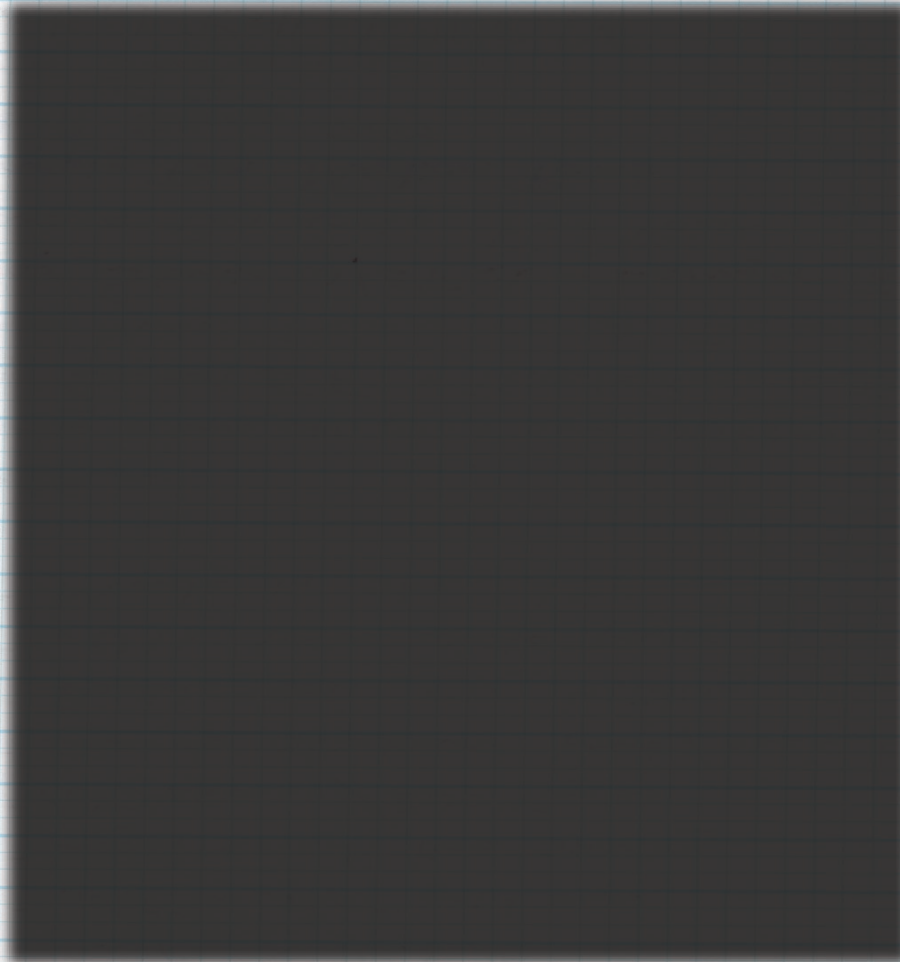
The illusion of certainty

KOS problems in science

Fluidity of scientific vocabulary

Sketches towards an approach

The Demon Uncertainty



The Demon Uncertainty

How does one go about "incorporating uncertainties" into ontologies when domain experts are in disagreement regarding the terms, relationships, assertions, and so on that should be part of them? Probabilistic ontologies? *TaxoCop May 31 2013*

through **consensus building**, governance, ontology mapping, use of thesauri, and, perhaps, leveraging PR-OWL

typically handled by the use of SEE, SEE ALSO and PREFERRED or NON-PREFERRED references to address uncertainties. In addition, and to break out of arguments revolving around personal term preferences, reference known authorities such as Library of Congress and others. **Trying to build on idiosyncrasies is a slippery slope.**

seems like an ideal application for a Topic Map. One of the more important features of Topic Maps is the concept of scope, which allows you to state **what context a particular statement/assertion in the model is valid in**, such as the context of a particular domain expert's worldview.

Scope Notes clarify how a term is to be interpreted for your project, if it could have another meaning in another context. Another differentiator, Related Terms also reflect intended meaning. As for the term selection, ultimately the person managing the vocabulary **must settle the squabble and make the decision.**

the W3C's SKOS, in addition to allowing for storing things like scope notes and information about related terms, includes properties for storing exact match relationships but also **broad match and close match relationships.**

ontologies are part of the larger definition of "controlled vocabularies" after all, so keep it controlled. Adding too much **ambiguity and potential for uncertainties makes the results uncertain.**

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Pursuing Science

“The ability to achieve innovation in a competitive global information society hinges on the capability to swiftly and reliably find, understand, share, and apply complex information from widely distributed sources for discovery, progress, and productivity.”

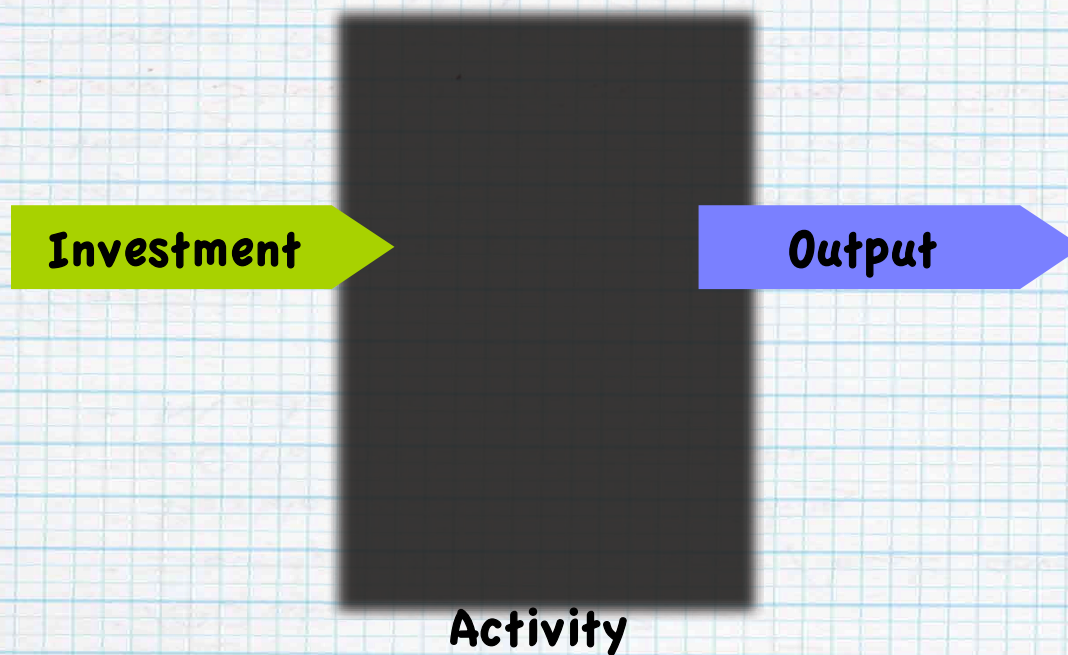
(Interagency Working Group on Digital Data, 2009).

Pursuing Science

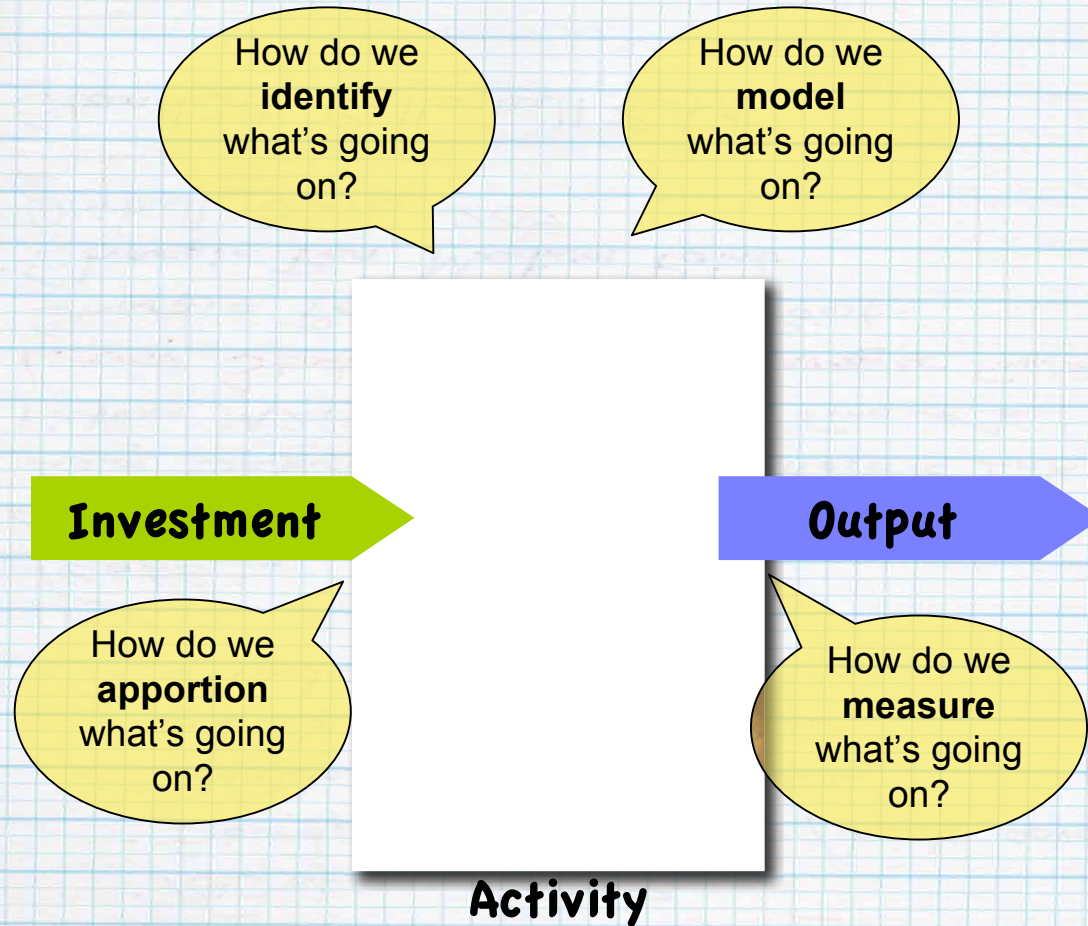
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Science Policy Questions



Science Policy Questions



Science Policy Questions

Typology of career trajectories?

How do we identify what's going on?

How do we model what's going on?

CIP

Typology of networks?

CPC

FOSE (1978)

Frascati-NABS

Frascati-FOS (2006)

Investment

Output

Frascati- Research Type

NRC (2010)

How do we apportion what's going on?

How do we measure what's going on?

NAICS

O*NET

SOC

Activity

KEY

- Relatively unproblematic, granular, maintained
- Problematic, not granular, or in development
- Severely problematic, subject of inquiry
- Unavailable, unaddressed?

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Inter-disciplinarity

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Emergence of new fields

Activity

Topic Modeling & Science Mapping

Modeling Knowledge Diffusion

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Science Policy Questions

Typology of career trajectories?

Typology of networks?

We want to measure impact in:

- Training skilled graduates
- Careers in Science & Engineering
- Creating new scientific instrumentation & methodologies
- Forming networks & stimulating interactions
- Creating new firms
- Creating employment

CIP





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Science Policy Questions

- Contribution of research to GDP, productivity, wages, employment?
- Flow of new knowledge into economic activity?
- Solutions to industrial problems, infrastructure, health?
- Socio-economic outcomes and policy challenges?
- Short term benefits vs long term benefits of basic research?

CIP

CPC

Frascati-NABS

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Modeling Knowledge Diffusion

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Science Policy Questions

Typology of career trajectories?

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FOSE (1978)

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(2006)

NRC (2010)





- Are we providing the right kind of STEM education?
- What are the skill sets we need to be developing?
- Which science-related job areas should we be focusing on?
- How do we match supply to the demands of the job market?

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Inter-disciplinarity

Emergence of new fields

Topic Modeling & Science Mapping

Modeling Knowledge Diffusion

- How do we assess the nation's progress in science & technology?
- How do we know where future efforts should be directed?
- How do we identify and measure new opportunities when the ecosystem keeps changing?





CIP

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The Big Picture

Typology of career trajectories?

Typology of networks?

FOSE (1978)

Frascati-FOS (2006)

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Inter-disciplinarity

Emergence of new fields

Topic Modeling & Science Mapping

Modeling Knowledge Diffusion

We need to deploy a combination of taxonomies to describe and measure the science & engineering enterprise



Some taxonomy elements are relatively stable, others very problematic

Activity

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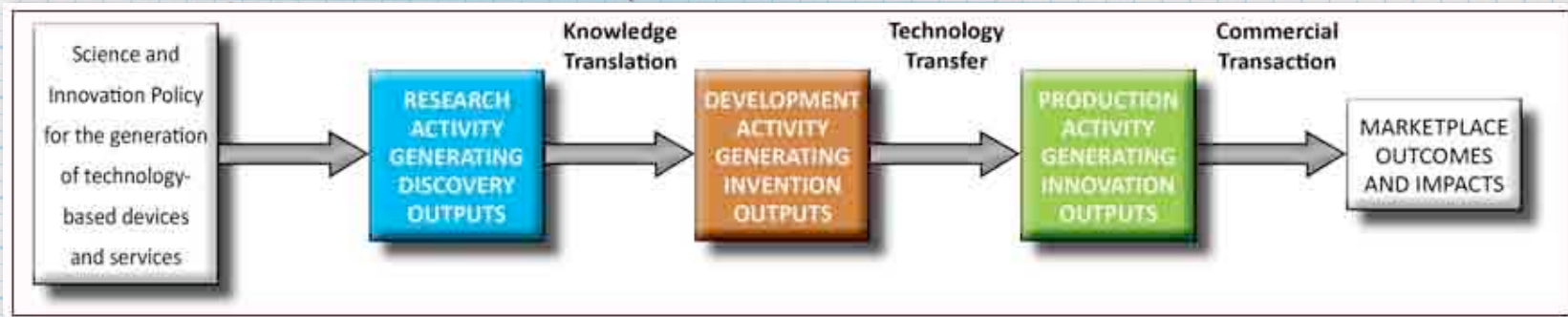
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Facets?

Can a faceted classification system meaningfully describe science activity?

NO



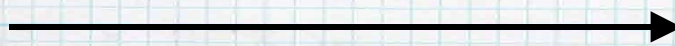
Joe Lane, Stage Gate Model from Research to Commercialisation (NSF Expert Meeting October 2012)

Types of Research

??Disciplines??

??Socio-economic objectives??

Data accessibility

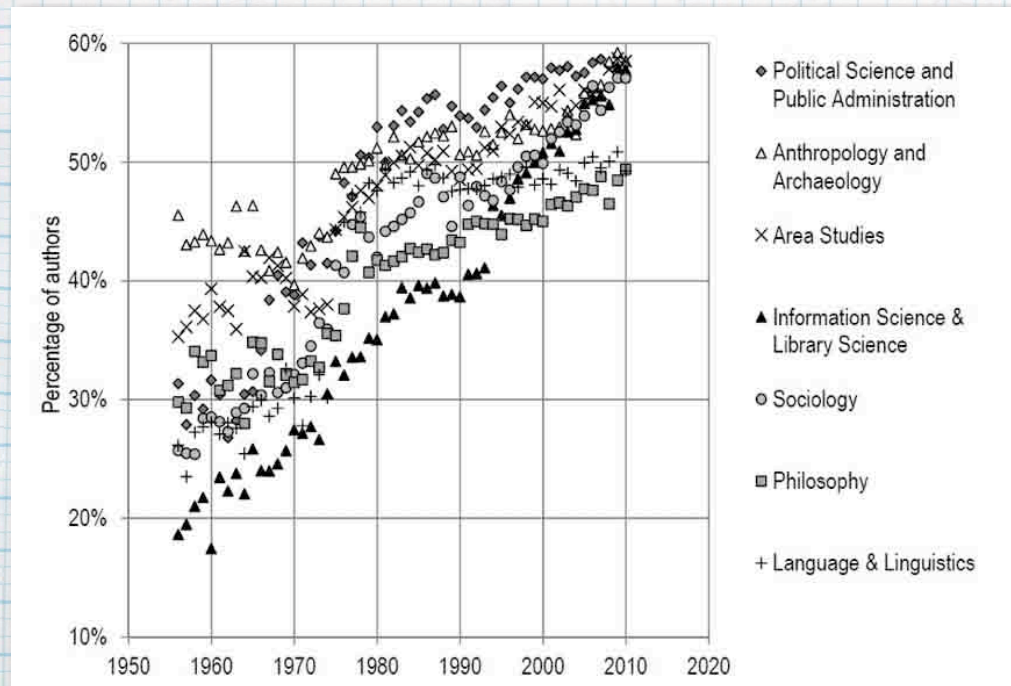


Data inaccessibility

Communities?

Can communities of researchers be used as a proxy for measuring and describing a field of research?

NO



Cassidy Sugimoto, *Percentage of authors also publishing in another specialty for indicated specialties, 1956-2010 (NSF Expert Meeting October 2012)*

Communities are dynamic

Affiliations change

Topic language changes

Authors publish outside their main fields

Topic Models?

Can topic modelling be used to identify stable fields of research and track their evolution?

NO

Scale of cluster	Stability
~ 10 fields for all of science	100% are stable over a year
~500 disciplines for all of science	> 99% are stable over a year
~8,000 specialties	95% are stable over a year
~100,000 problems	56% are stable over a year

This model reveals that a clustering technique based on citations and text analytics could reveal topic organization in science and technology; however, it is highly dependent on the scale. The classification system is stable on the aggregate level, but not stable on the highly detailed level.

Kevin Boyack, Scale and Stability of Topic Clusters Over Time (NSF Expert Meeting October 2012)

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Phenomenon in Search of a Mechanism



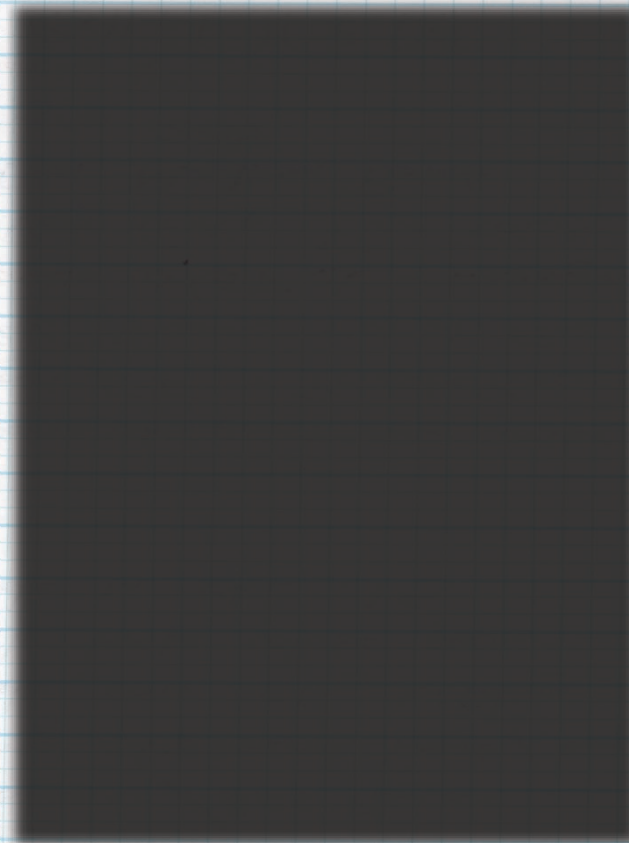
The story of RNA interference
(RNAi)

Phenomenon in Search of a Mechanism

Investigating mechanisms for how genes get silenced when external RNA is introduced

- 1990 Cosuppression - both introduced genes and endogenous genes silenced
- 1992 Quelling - introduced gene “quells” endogenous genes
- 1995 RNA silencing - par-1 mRNA message silenced by introduced RNA
- 1998 RNA interference (RNAi) - the trigger for silencing is double stranded (dsRNA) not single stranded (ssRNA) - authors coined “RNAi” - term adopted because the research represented a critical move forward in understanding the mechanism for gene silencing
- 1999 Subsequent research refines finding to show short strand dsRNA mediates suppression - foundation for gene therapeutics patent (later rescinded)
- 2001 Further research shows that short dsRNA (small interfering RNAs - siRNA) can suppress genes in mammals without inducing interferon response - another important therapeutic patent is granted

Mechanisms in Search of a Field



From Transposons to Mobile DNA
via Horizontal Gene Transfer

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Mechanisms in Search of a Field

Genetic engineering - convergence of multiple lines of enquiry

- 1940s Transposons and other mobile DNAs - can move between locations in a genome, or between species
- 1959 Mobile genetic traits - mobile antibiotic resistance genes in bacterias
- 1971 Horizontal gene transfer (HGT) - to explain how unrelated flowering plants can share similar traits within the same ecosystems
- 1975 Recombinant DNA - safety standards to guard against risks of unintended consequences of gene transfer between species
- 1980s Transgenic research - Recombinant drugs (human insulin), genetic modifications of plants and mice, US approval for foreign gene transfer into humans
- 1990s HGT - used as a framework to explain evolutionary conflicts; first commercially grown genetically modified crops
- 2010 Mobile DNA - new journal launched

Battle for the Field



Genetic Algorithms vs Evolutionary Computing

Battle for the Field

Genetic Algorithms vs Evolutionary Computing

- 1950s Adaptive systems research - algorithms for adaptive computing systems behaved differently in small vs large population samples - parallels with variation genetic drift in large populations
- 1962 Principles of genetic algorithms formulated (John Holland)
- 1962 Evolutionary programming (Larry Fogel)
- 1966 Evolutionary computing (Larry Fogel et al)
- 1975 Genetic algorithms - classic textbook and research on adaption in natural and artificial systems
- 1980s Genetic algorithms - applicability to oil pipelines, search, machine learning; first international conference on GA; patents and products
- Today: some practitioners still insist that evolutionary computing is the proper label and do not accept genetic algorithms as the name for the field

Led by the Crowd



The story of cold fusion

Led by the Crowd

Popular imagination leads the language and the rejection of the language

- 1934 Rutherford attempts low temperature nuclear fusion
- 1947 Muon-catalyzed fusion postulated
- 1956 “Cold fusion” coined by New York Times to describe Luis Alvarez’ discovery of muon-catalyzed fusion
- 1980s Muon-catalyzed fusion, cold fusion, piezonuclear fusion - parallel terms for funded projects in the same field of research
- 1989 Pons and Fleischmann claim to have achieved cold fusion on a table top apparatus at room temperature - nobody can replicate their results; National Cold Fusion Institute founded
- 1992 - Japan founds New Hydrogen Energy Program (closed 1997); Pons and Fleischman hired by Toyota IMRA Lab
- 1998 - Toyota IMRA Cold Fusion Lab closes
- 2011 - NASA begins Low Energy Nuclear Reaction (LENR) program

Umbrella Constructs & Strategic Ambiguity



Labels as umbrella constructs in
the social sciences

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Umbrella Constructs

JT Dillon 'The multidisciplinary study of questioning' *JEdPsych* 74.2 1982

- 15 disconnected disciplines studying questioning ranging from logic, linguistics, psychology, education, investigation, library science, research methods - with common issues and complementarities

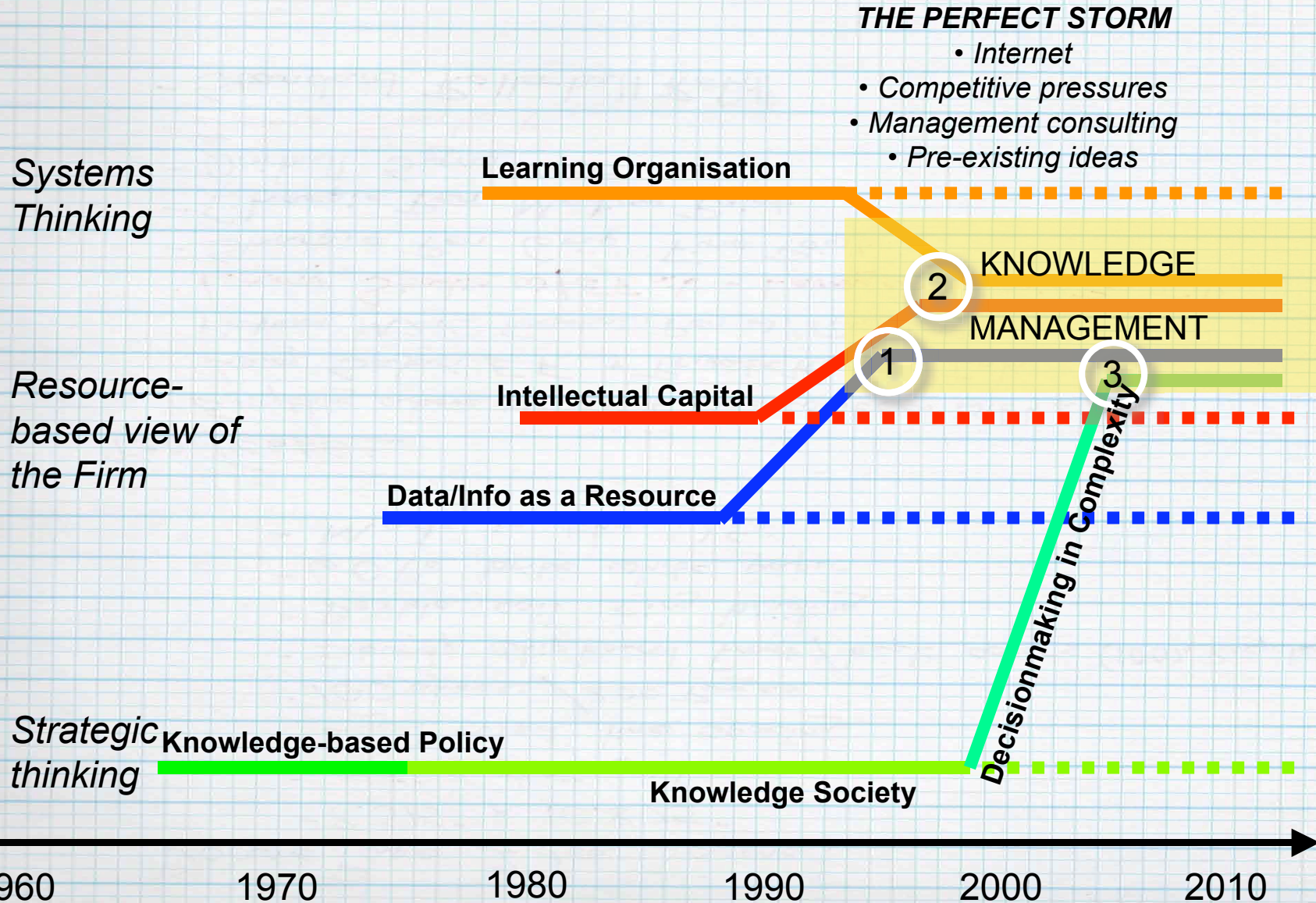
Umpleby & Dent 'The origins and purposes of several traditions in systems theory and cybernetics' *Cybernetics & Systems* 30 1999

- Systems thinking emerged in 7 distinct traditions for different purposes: general systems theory, systems approach, operational research, system dynamics, learning organisation, total quality management, cybernetics - different traditions have different understandings of the same language

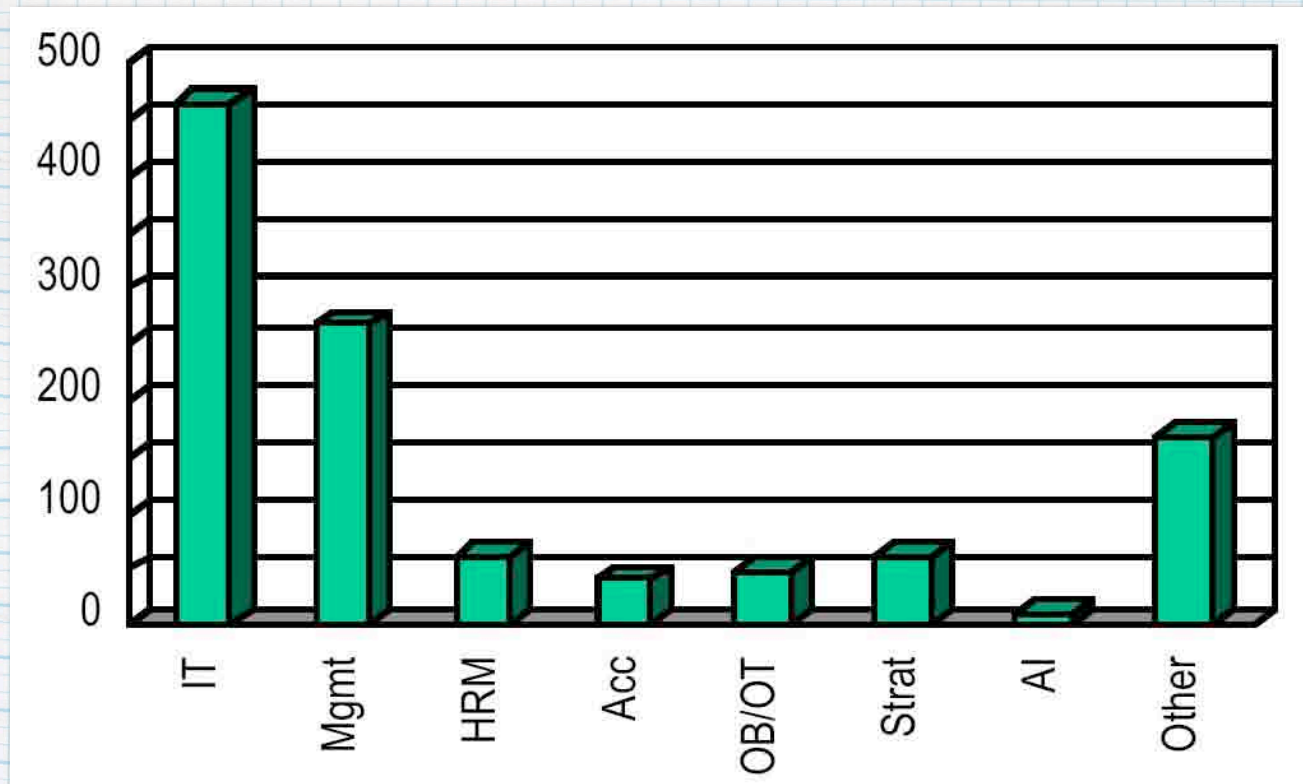
Berry et al 'Three traditions of network research' *Public Administration Review* 64.5 2004

- Social network analysis, policy change networks, public management networks - parallel disciplines investigating similar issues, leads to confusion about network studies - scope for cross fertilisation identifying issues and using methodologies

The origins of Knowledge Management



Colonisation of KM

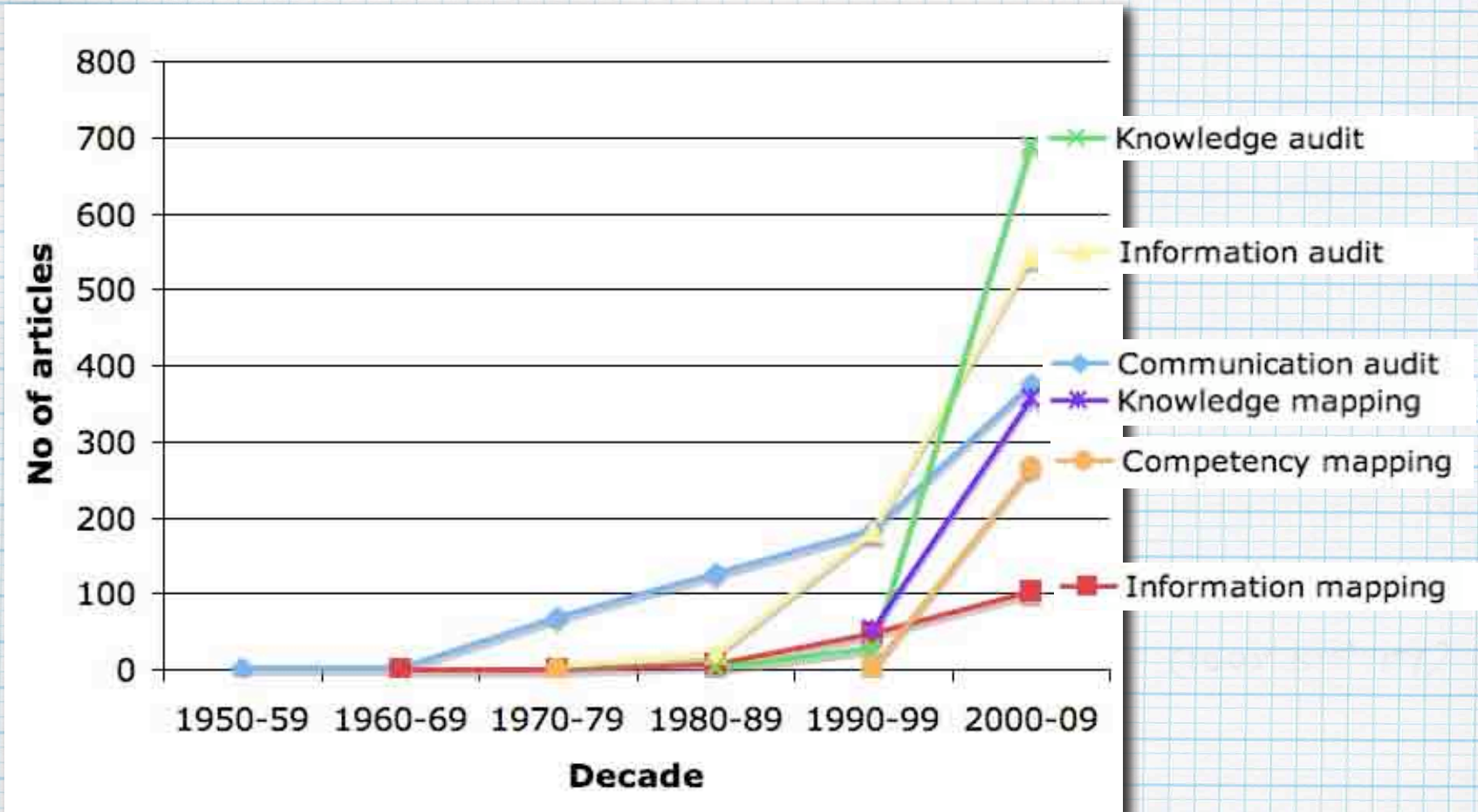


KM articles by profession 1990-2000

“... a consequence of the stylizing of KM by different professional groups is that, when applied in organizations, it could become an example of the very problems that it seeks to address. These concern problems of developing, sharing, integrating and re-cycling knowledge that is increasingly distributed across organizational, occupational and professional boundaries.”

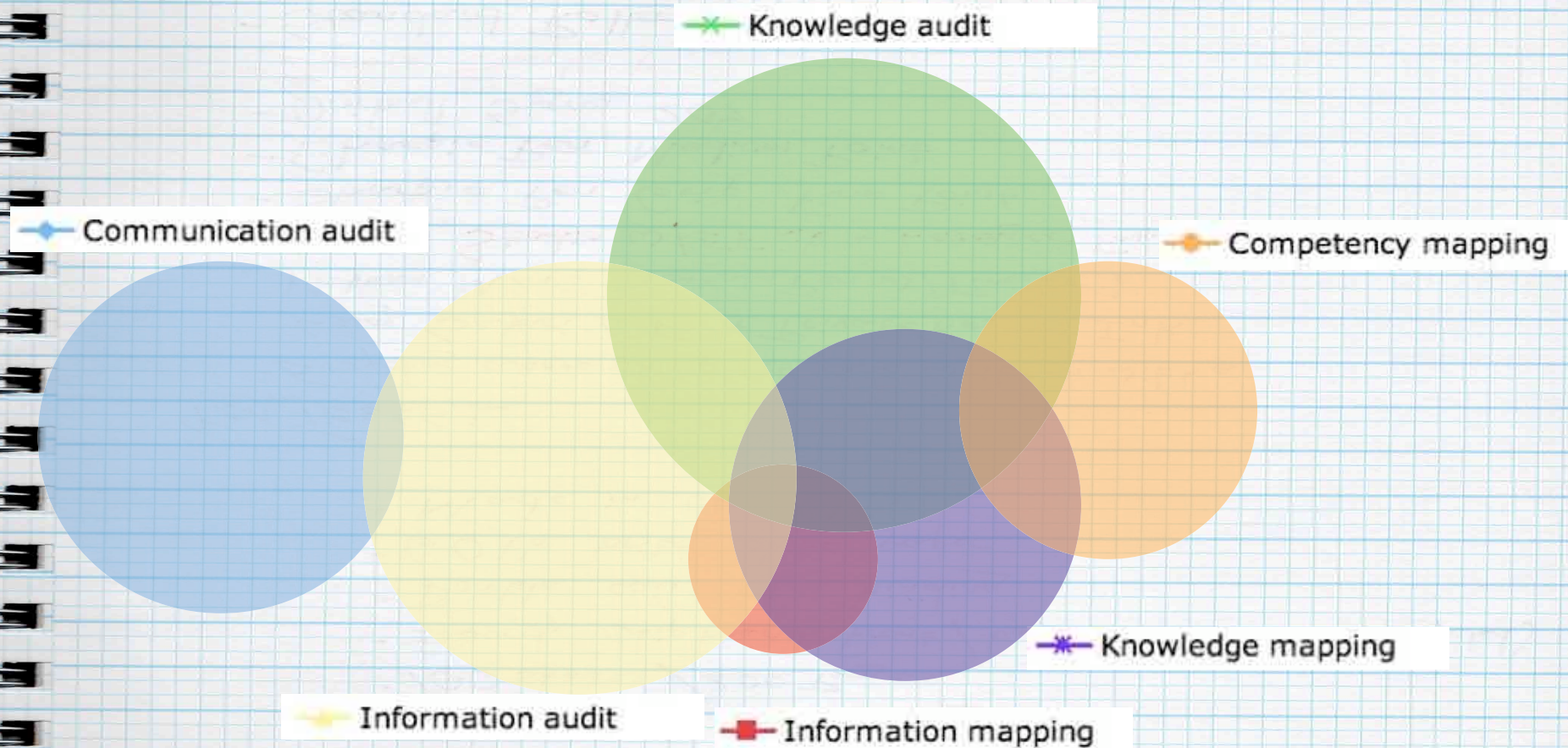
Swan and Scarborough ‘The paradox of “Knowledge Management”’ *Informatik 1* 2002

Knowledge Audit Antecedents



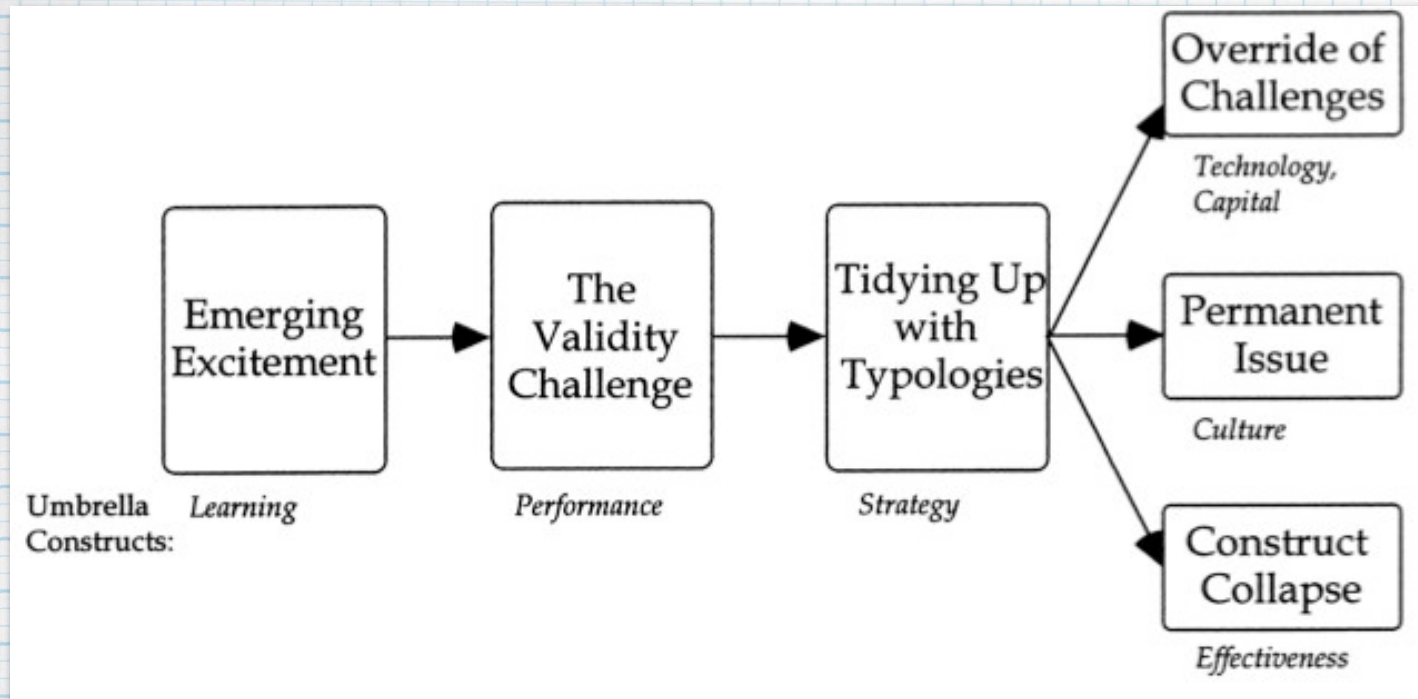
Articles, chapters and dissertations in English retrieved by Google Scholar Feb 2013

Conceptual Overlap 2000-2009



Based on keyword analysis of 2,333 articles, chapters and dissertations in English retrieved by Google Scholar Feb 2013

Umbrella Constructs



- Sensemaking - things seem to belong together
- Strategic ambiguity - to generate dialogue between disciplines where there is no unifying paradigm - eg organisational studies

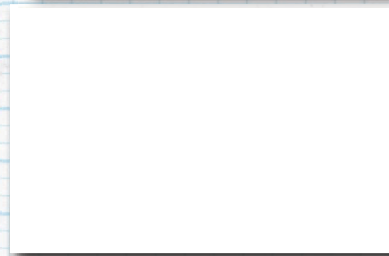
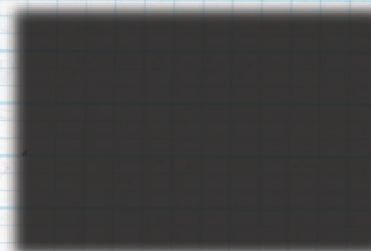
Hirsch & Levin 'Umbrella advocates versus validity police: a life-cycle model'
Organization Science 10.2 1999

Drivers for Term Development and Adoption

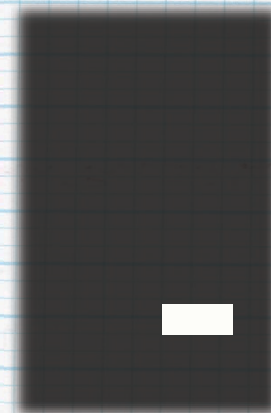
Knowledge building dynamics



Social dynamics



Incentives dynamics



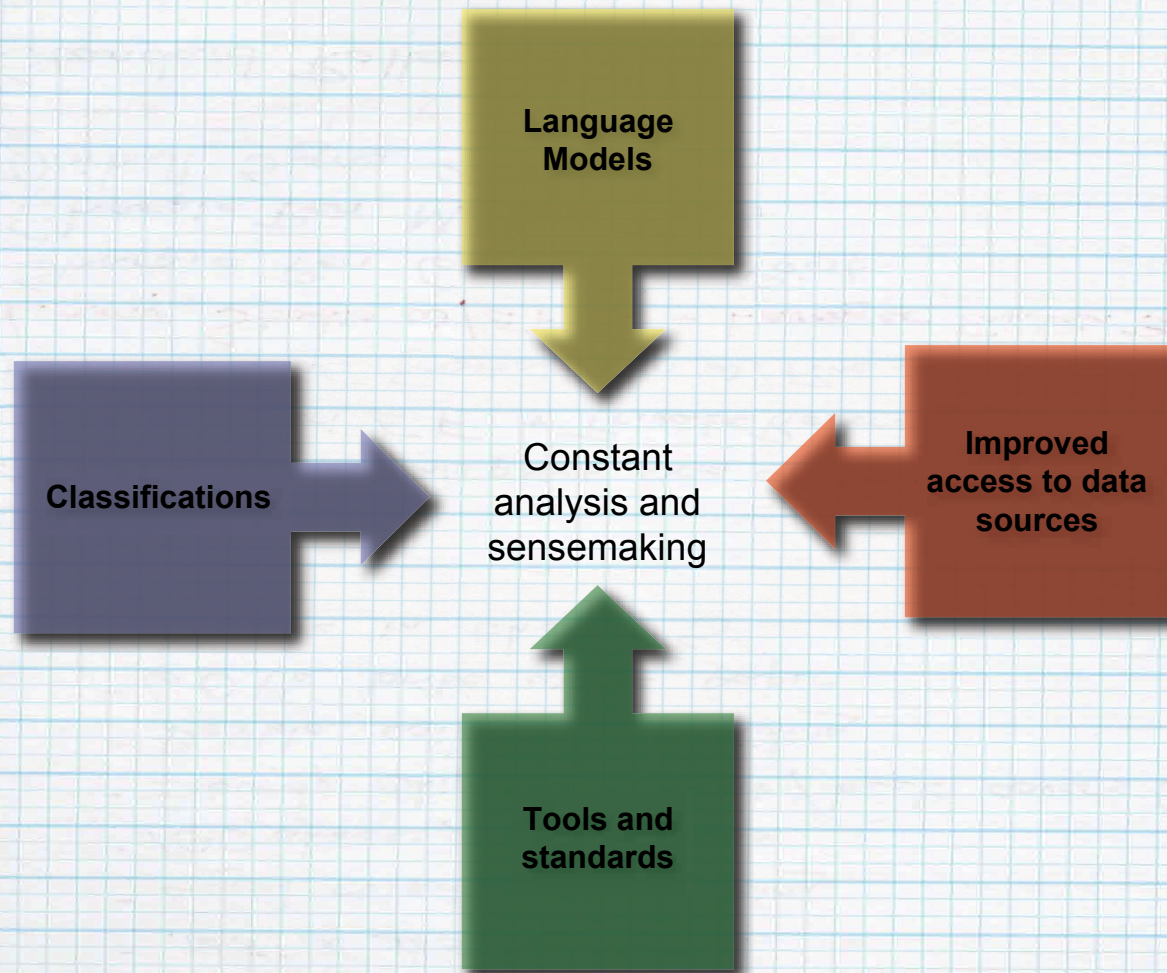
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Sketches Towards an Approach



The Demon Uncertainty



Cons:

- Data availability diminishes the closer you get to commercialisation
- Curation and technology-intensive
- Adoption

Pros:

- Can provide some input to some policy questions
- Can describe interdisciplinarity and emerging fields
- Can provide data for modelling research trajectories over time

Acknowledgements

References to issues in the classification of science activity: thanks to the National Center for Science and Engineering Statistics, National Science Foundation

References on strategic ambiguity and umbrella constructs: thanks to Diarmuid Pigott, personal communications Aug-Sept 2011

References on evolution of labels for fields of research: thanks to Dr Jeff Alexander, SRI International, personal communication July 2013



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