Linking Human Resources in Science and Technology and Innovative Performance

Developing Concordance Schemes and Indicators to Enable the Analysis of

Education - Science – Technology – Industry Relationships

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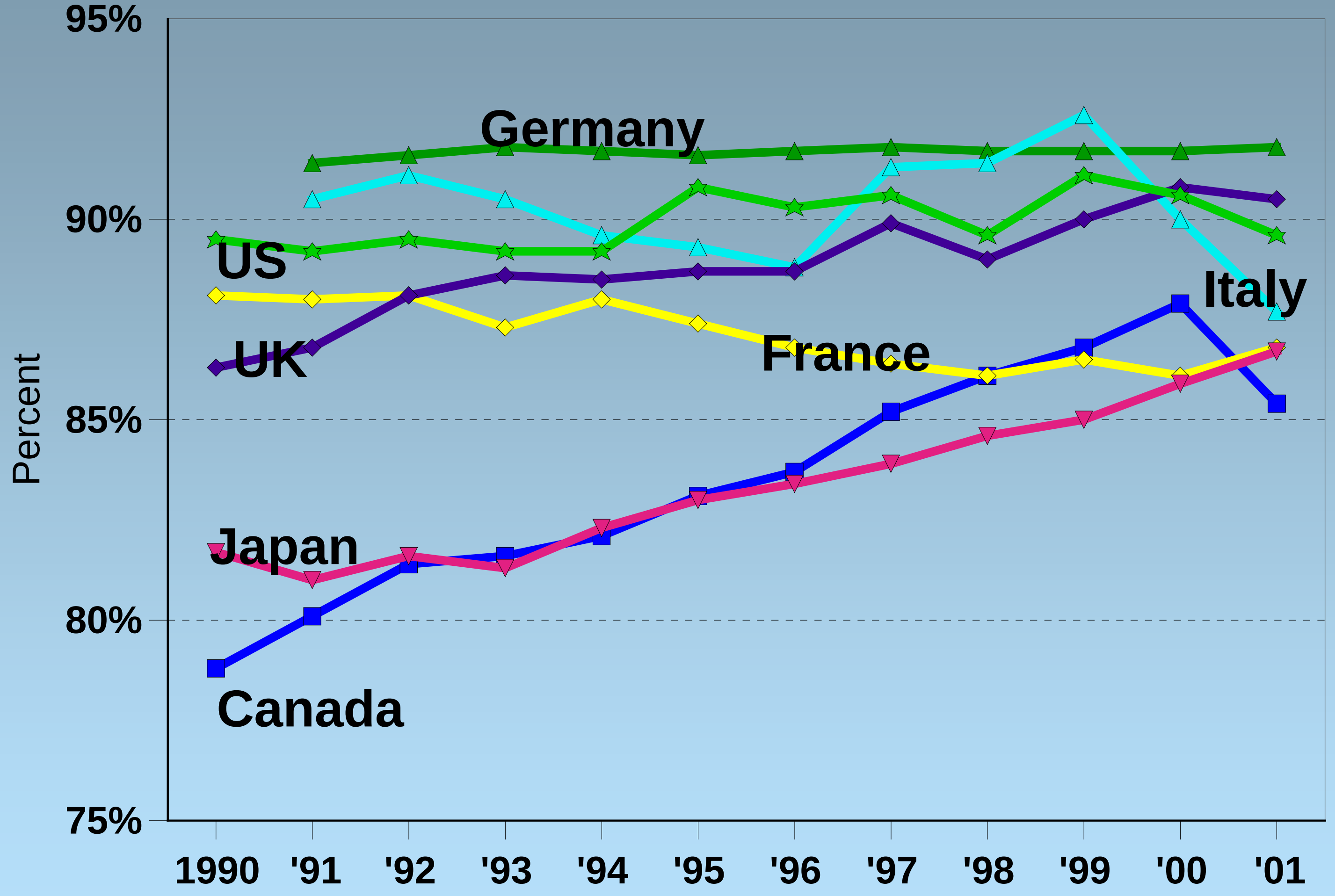
Blue Sky   Ottawa 2006

LINKST

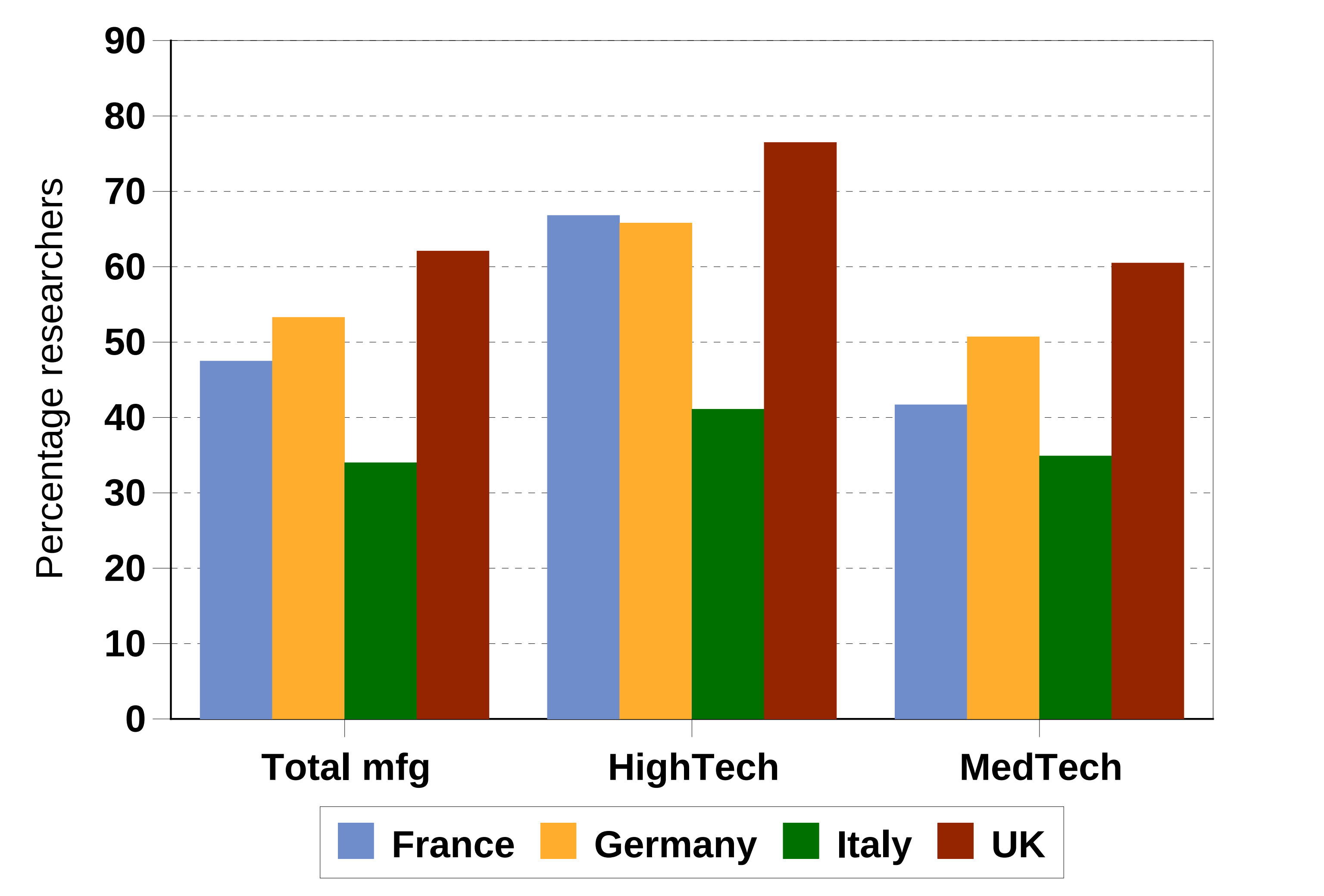
- A study to examine:
  - The scientific and educational base of high and medium-high technology intensive manufacturing industries
  - Methodological requirements and impediments to carrying out such an analysis
- The study team: UNU-MERIT (UNU/U. of Maastricht)
  INCENTIM (K.U. Leuven)
  CWTS (U. of Leiden).
- The research team brings together expertise in citations, patents, R&D, S&T and human resources indicators.

HTMT manufacturing R&D expenditures as a share of total in manufacturing, 1990 to 2001.



Source: UNU-MERIT based on OECD data.

Percentage of researchers among R&D personnel in manufacturing industries, 2003.



Source: UNU-MERIT based on Eurostat data.

The challenge — develop a methodology to explore the scientific knowledge base of HMHT manufacturing industries by field of education.

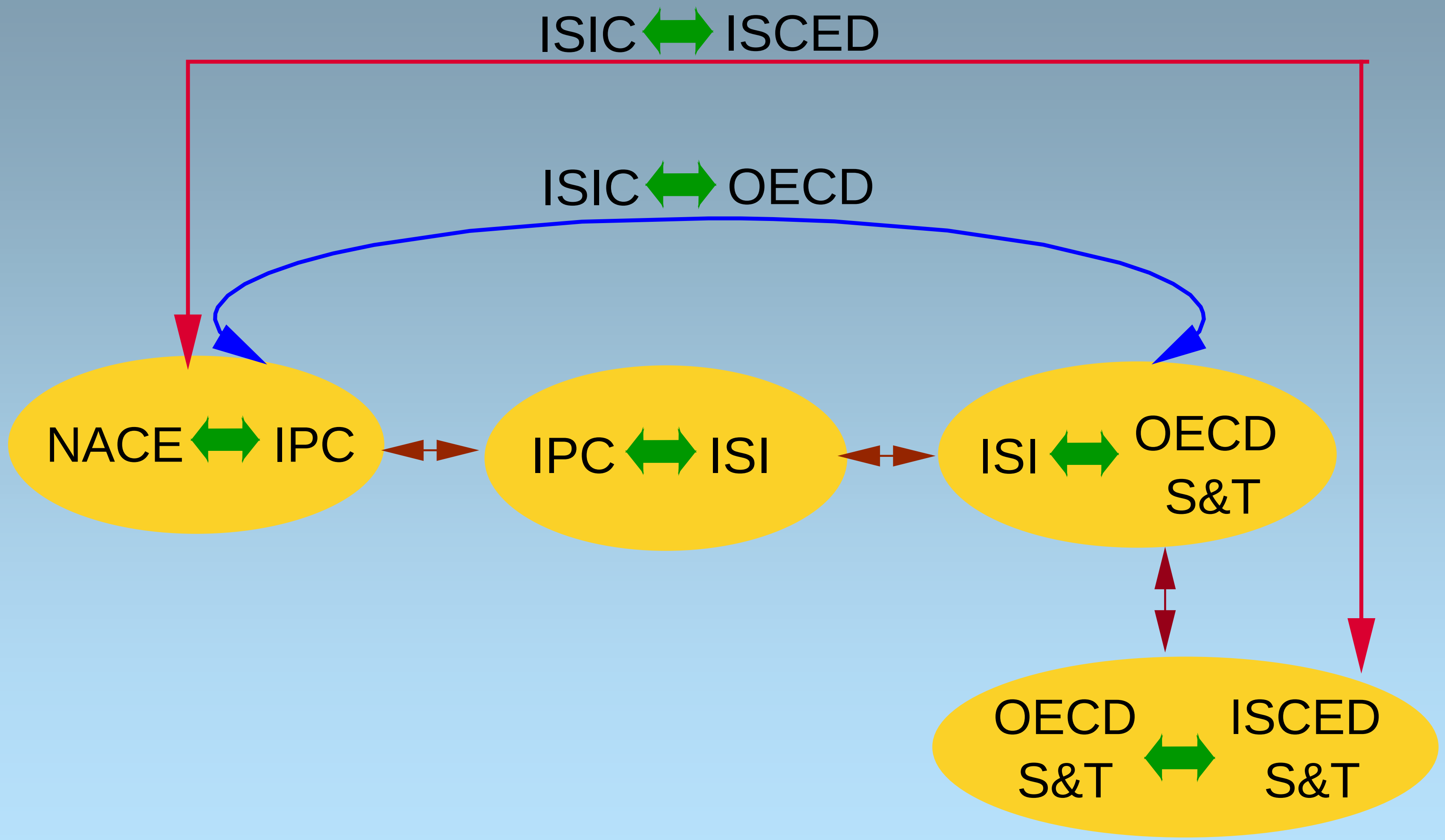
Necessary ingredients:

1. Concordance table to link scientific and technology fields by means of non-patent citation data (NPRs): developed by INCENTIM & CWTS

2. Concordance table to link OECD fields of S&T and ISCED fields of S&T: developed by MERIT & CWTS

3. Concordance table(s) between technological fields and industries: adopting accordance tables developed by Johnson (OECD) and OST/FhG-ISI (EC).

Moving from patents and non-patents references to ISIC and ISCED



Source: LINST study.

Relevance of the concordance:

1. Identify the scientific and education base of technological fields and industries.

2. Analyse relationships between innovative performance (technological, economic), scientific capabilities and human capital now enabled with the concordance tables.

3. Translate obtained insights into policy recommendations (national/regional, industry level).

Extract: Concordance Table for S&T

IPC Codes	Total	Bio chem research methods	Bio chem & molecular bio	Biotech & applied microbio	Cell biology	Chemistry, medicinal	Chemistry, multidisc	Chemistry, organic
A-01 Agriculture +	9,418	218	4,727	1,204	1,373	379	366	528
A61 Med/vet scs	35,870	1,003	13,473	1,609	3,826	3,720	3,035	3,569
C07 Chem, organic	44,494	1,703	18,277	2,511	4,930	3,298	4,197	6,947
C08 Macromolecular	1,742	49	311	111	58	61	632	450
C12 Biochemistry	41,550	2,311	22,345	5,143	6,787	365	1,241	753

Source: © INCENTIM/CWTS

Examining the relationship between technological performance and human capital: Elements

- Analysis on the level of national innovation systems.
- Countries: France, Germany, Italy, United Kingdom, Canada, United States, and Japan.
- PhD Degrees awarded 1990 – 2000: Number of PhDs within Science & Engineering, normalized by population.
- Technological Performance: EPO Patent Applications 1990-2004, normalized by population, allocated to High Tech, Medium High Tech, Medium Low Tech, Low Tech Industries (OECD classification)
- Country allocation based on inventor nationality, full count in case of multiple nationalities (Approach based on assignee nationality yields similar results).
- R&D expenditures for 1990 to 2000 by industries: High Tech, Medium High Tech, Medium Low Tech, Low Tech.
- Time lag (between education and technology): three and four years.



Preliminary findings

Does education (PhDs in S&E) contribute to HT technological performance?

	R&D Expenditures HT	**HT Productivity**	**PhD S&T**
R&D Expenditures HT	1		
HT Productivity	.258	1	
PhDs in S&T	.481**	.538**	1

** Correlation is significant at the 0.01 level

Source: INCENTIM

Does educational strength (PhDs in S&E) contribute to HT technological performance? Fixed Effect Analysis

PhD S&E (by population)	B	1.727583***
	SE	(.5454607)
R&D Expenditures HT	B	.0000153**
	SE	(5.77e-06)
Period	B	-8.95e-06
	SE	(8.04e-06)
Cons	B	-.0005727**
	SE	(.0002556)
N		42
Number of groups		7

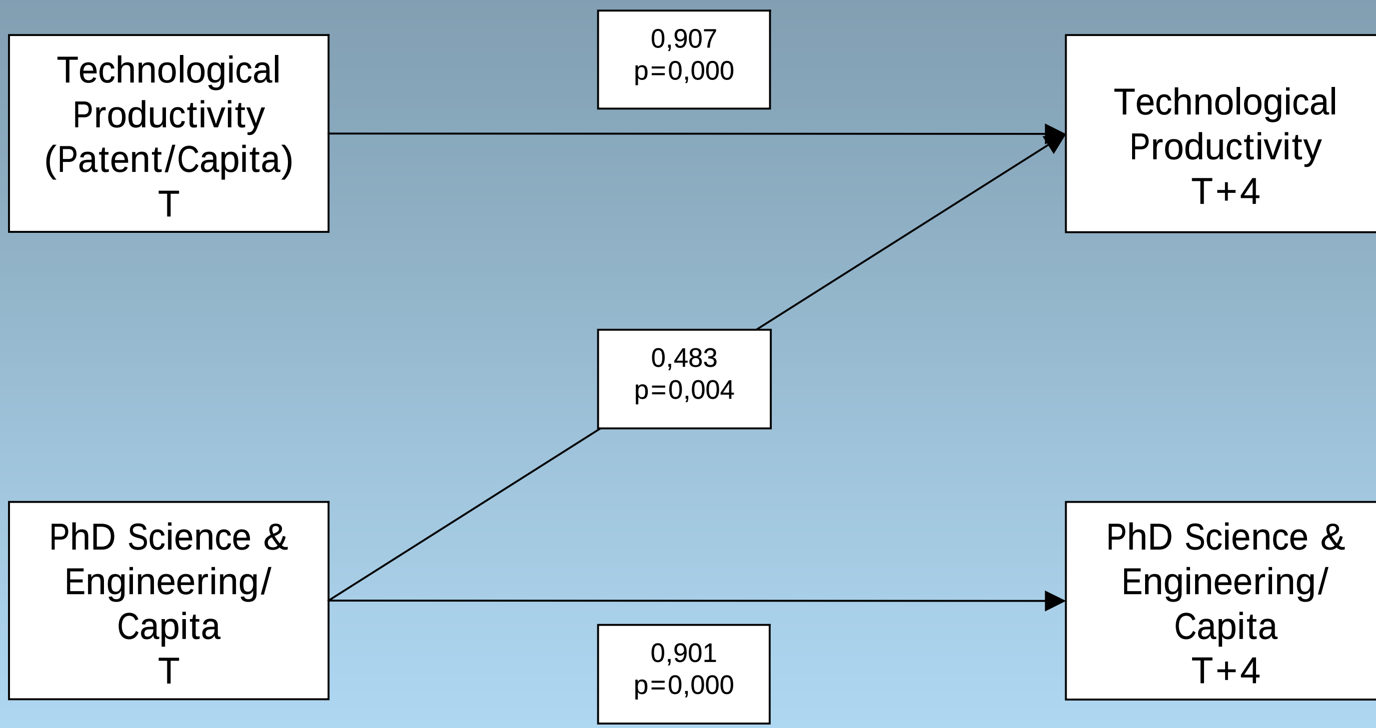
- Findings suggest a distinctive and considerable impact of educational strength on technological performance.

Does educational strength (PhDs in S&E) contribute to technological performance in general?

	Partial Correlation (controlling for R&D expenditures and Added Value within Industry)	Significance
High Tech Industries	0,532	p=0,000
Medium High Tech Industries	0,428	p=0,018
Medium Low Tech Industries	0,580	p=0,000
Low Tech Industries	0,405	p=0,018

- Findings suggest a positive relationship — between PhDs in S&E and technological output — and this is not limited to HT and applies across industries.

Disentangling Causality: Path Analysis



Partial Correlation coefficients obtained when controlling for R&D Expenditures (at T) within HT industries.

To recap . . .

- There are significant correlations suggesting human capital (in this case PhDs in S&E) contribute to technological performance – this is perhaps not unexpected BUT
- Variations in PhD 'strength' seems to be more important than variations in R&D expenditures.
- Testing on other industries show similar effects (HT, MHT, MLT, LT).

Measurement & Indicator Implications

- The high correlations between human capital (as measured by PhDs in S&E) and technological performance (as measured by patents) suggest a need to expand indicators to consider the link of human capital and scientific and technological performance.
- Preliminary results suggest this methodology is valid for further development and it would be useful to apply at the EU and OECD level.
- The methodology presents an opportunity to use existing data and indicators to develop new indicators for human capital and scientific and technological performance.

Policy Implications —

- Policy focus is on increasing performance by increasing R&D expenditure:
  - E.g. fixation on R&D intensity goals:
    - EU Barcelona target of 3% of GDP by 2010;
    - Canada's goal to rank 5th in the world in terms of R&D intensity by 2010.

BUT preliminary results suggest this focus is too narrow.

- Human capital has a growing role in the knowledge-based economy *(KEI project);* policy needs to support measurement and indicator development on human capital for integration with economic performance measures.