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ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG  
AUSTRIAN INSTITUTE OF ECONOMIC RESEARCH

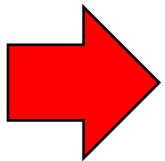
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# Mapping of innovation potential & methods

## Jürgen Janger

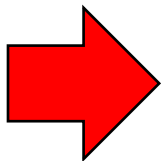
- 1. Mapping of innovation potential – how to do it: innovation as a production process**
- 2. Innovation mapping: how it is done in practice – innovation union scoreboard and others**
- 3. Conclusions**

- **Monitoring of innovation efforts, country benchmarking: innovation trends over time**
- **Analysis of effectiveness of (public) efforts**
- **Identify bottlenecks for further improvement of national innovation system**
- **Innovation strategy: funding decisions in overall system**



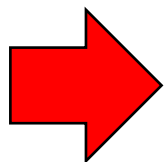
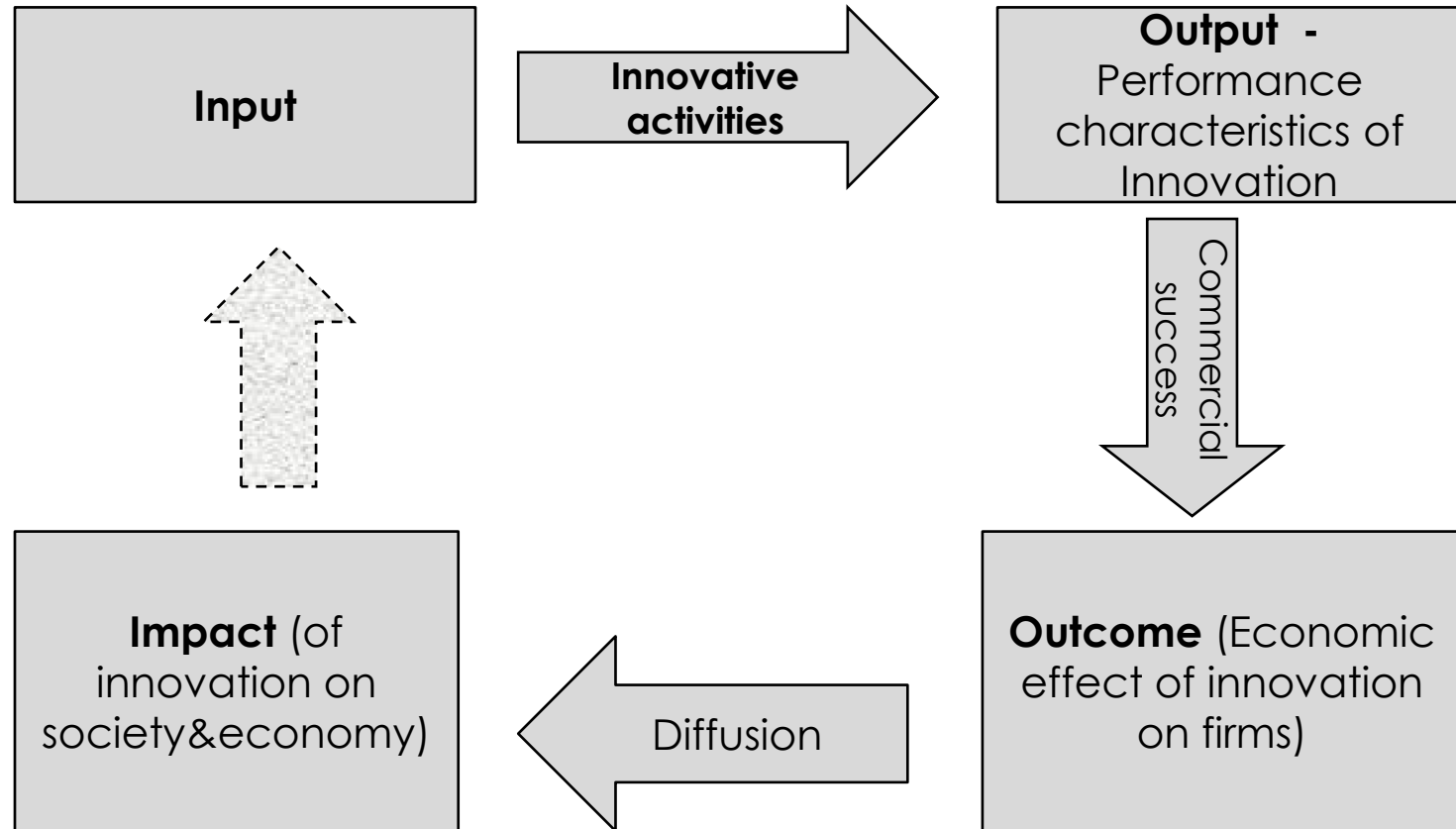
**Proper innovation measurement reduces uncertainty for policy-making (and improper measurement increases it)**

- **R&D (Frascati Manual): „systematically increasing stock of knowledge“**
- **Innovation (Oslo Manual, Community Innovation Survey):**
  - Introduction of new or significantly improved product
  - Introduction of new or significantly improved production processes
  - Implementation of organisational innovation (e.g. new workplace organisation)
  - Implementation of marketing innovations (e.g. new packaging)



**„Innovation“ focuses on new or improved stuff in the marketplace (not just being researched, or knowledge)**

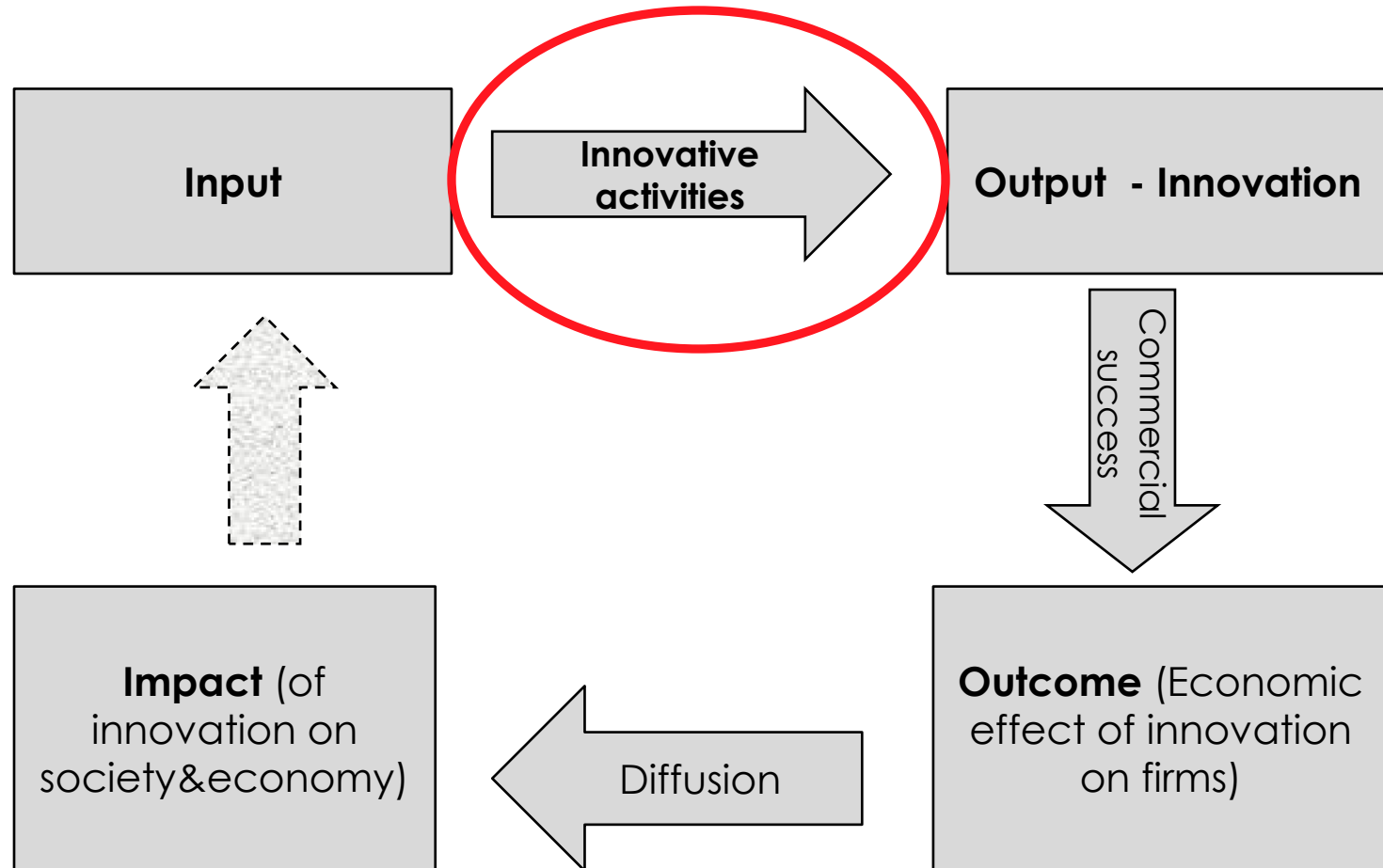
# Production process of innovation: what is there to measure?



**Justifying innovation inputs without measurement of outcome/impact difficult – measurement of all the components needed for proper mapping**

- **Monetary resources**
  - Public&private R&D expenditure
  - Non-R&D Innovation expenditure (new equipment, licenses, software, training, design, etc.)
- **Human resources**
  - S&E graduates, researchers per 1.000 workforce etc.
- **Knowledge input/Science base**
  - Scientific publications (quality, quantity)
  - Doctorate students etc.
- **Physical research, ICT-infrastructures**
- **Collection through standardised surveys (separate for R&D and innovation – R&D more precise, full sample of firms etc.)**

# Production process of innovation: what is there to measure?

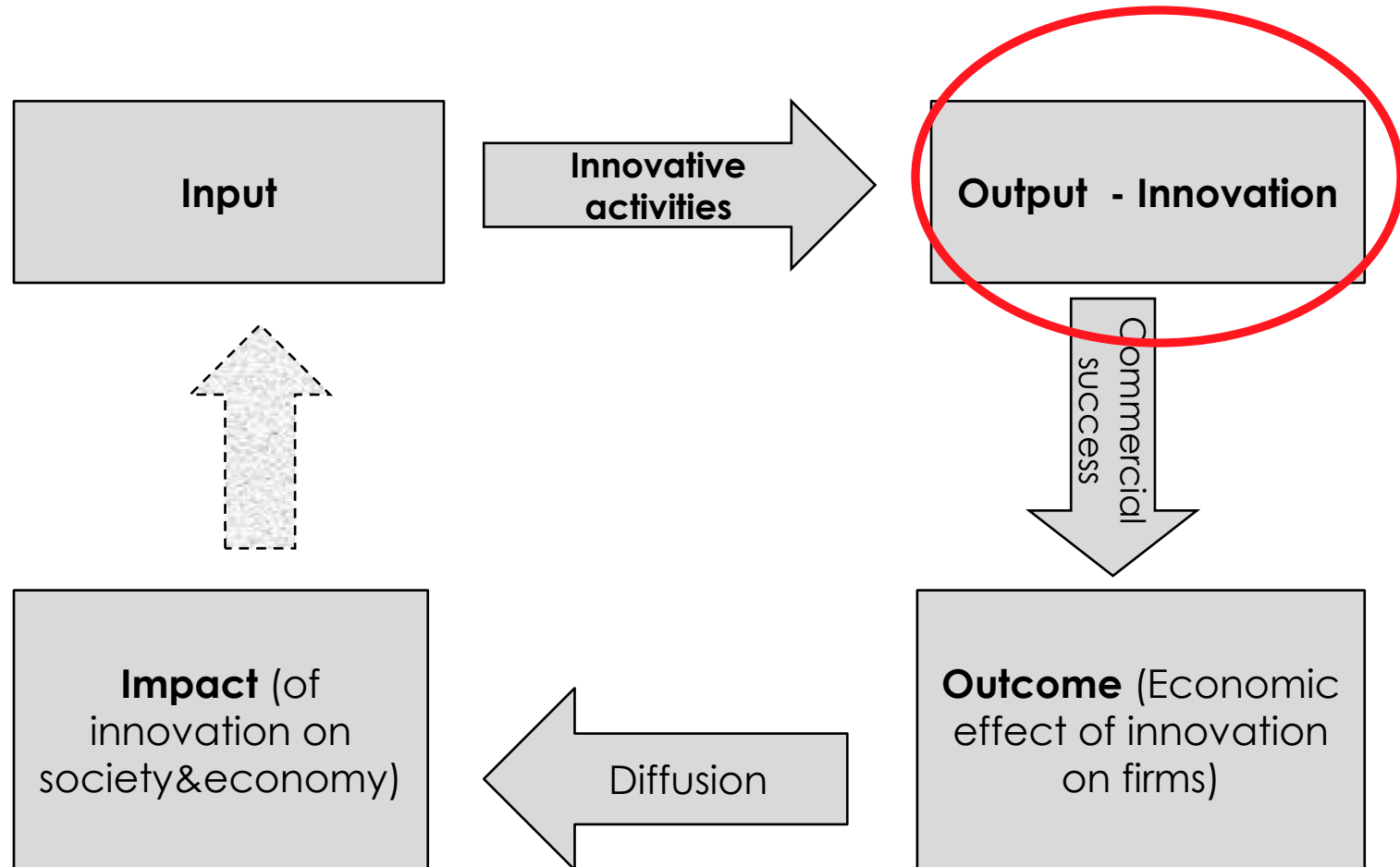


- Sources of knowledge, partners of innovation cooperation
  - Other firms (suppliers, customers, SMEs...)
  - Universities and public research organisations
- Relationships between inputs: e.g. how many researchers per € of innovation expenditure (labour- vs. capital-intensive innovative activity)
- Barriers to innovation, reasons to innovate
- Of course, big black box – lots of firm-specific, tacit knowledge!
- Collection through standardised surveys (e.g. community innovation survey)



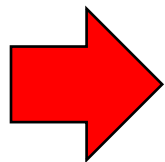
- R&D ratio (Europe 2020 – 3% of GDP)
- Obsession about enough science&engineering graduates? (in US at beginning of cold war)
- Business science-links (how universities&public research organisations are involved in firms' innovative activities – ivory tower universities?)
- Quality of science base (rankings of universities, Europe vs. US) – the „European paradox“ of strong science not being transformed in economic performance – actually a myth
- Share of foreign R&D funding

# Production process of innovation: what is there to measure?



- Incremental improvements („inching-up“, perfective technological progress) vs. radical innovation (metamorphic progress)
- differentiate i) technological characteristics of product vs. ii) product services enabled by technology
- radical technological innovation & incremental service improvement (e.g. jet engine – air passenger transport)
- Incremental tech. innovation/radically new service (iphone/ipad)
- Radical & radical (internet – whole new industries, transformation of existing ones)
- Incremental inching up actually dominates!

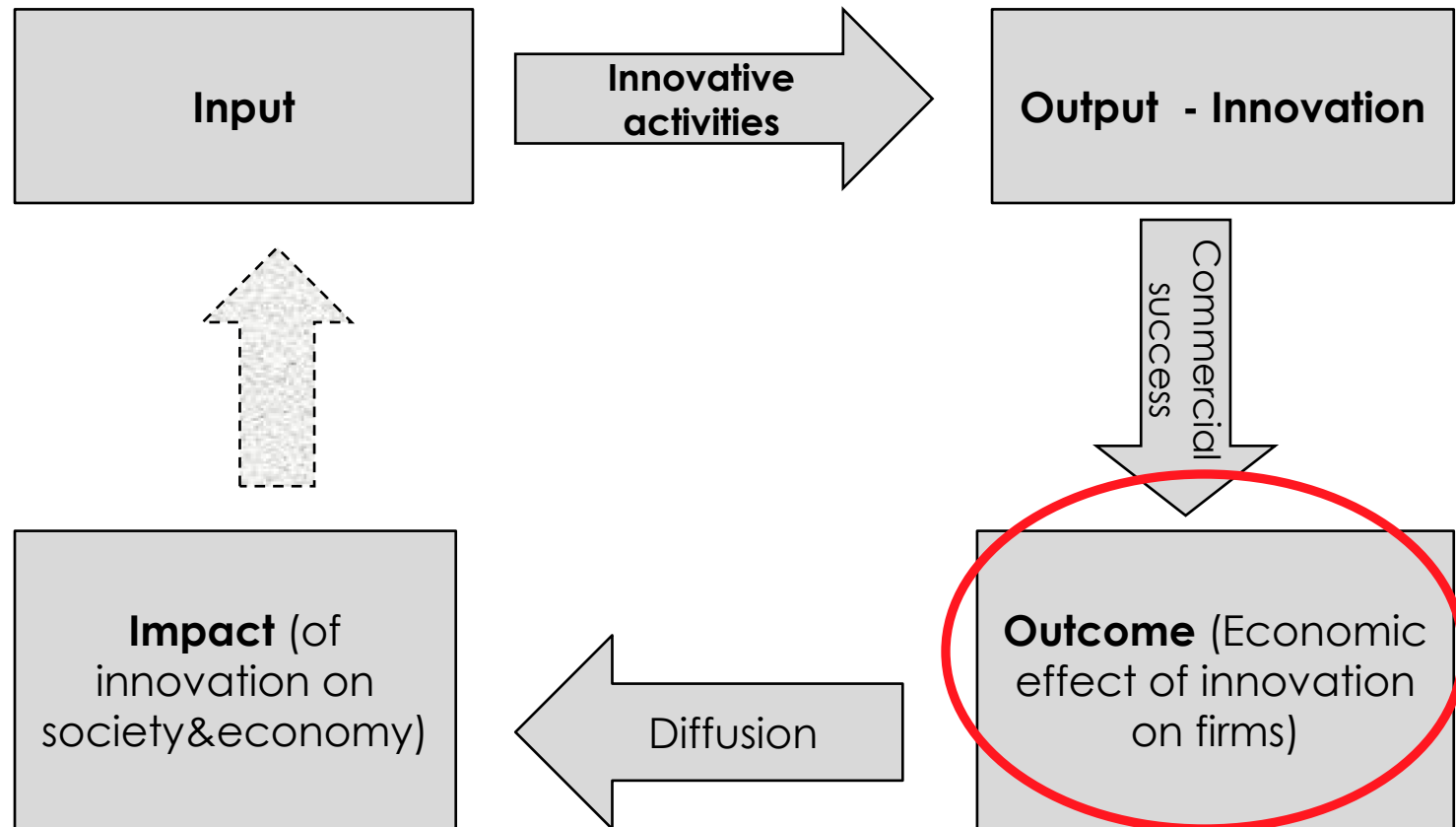
- Before innovation surveys 70/80ies:
  - patents – not an innovation, & not all commercialised; but still important role
  - literature-based innovation description (technological) – cannot be compared across technologies/countries
- Innovation surveys: firms which have introduced innovation
  - E.g., share of firms having introduced an innovation
  - No information on quality of innovation (degree of novelty)
  - Subjective interpretation of firm



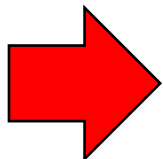
**Innovation output is about performance of products/processes, but often inadequately measured**

# Production process of innovation: what is there to measure?

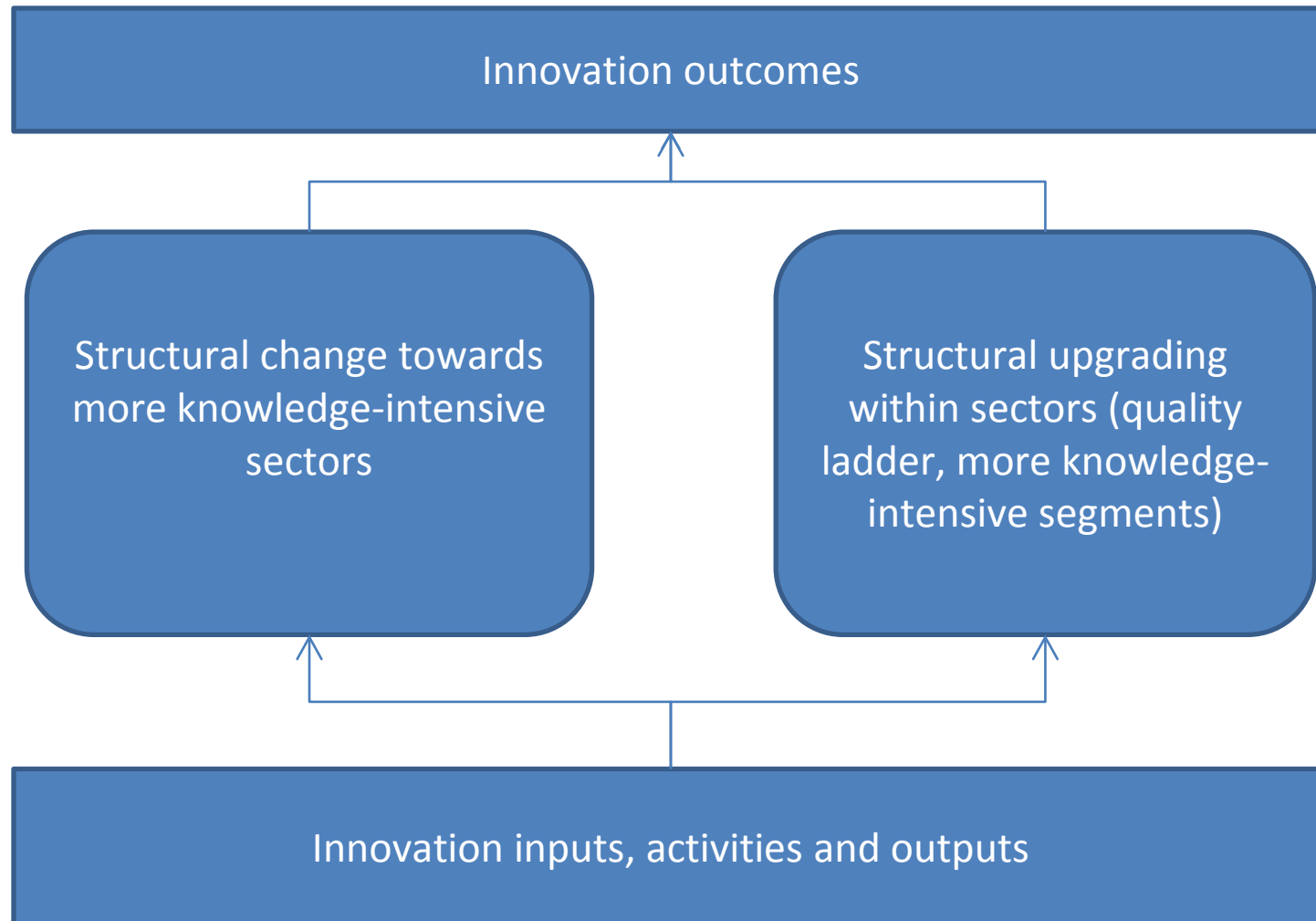
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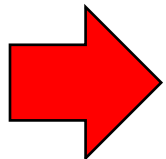
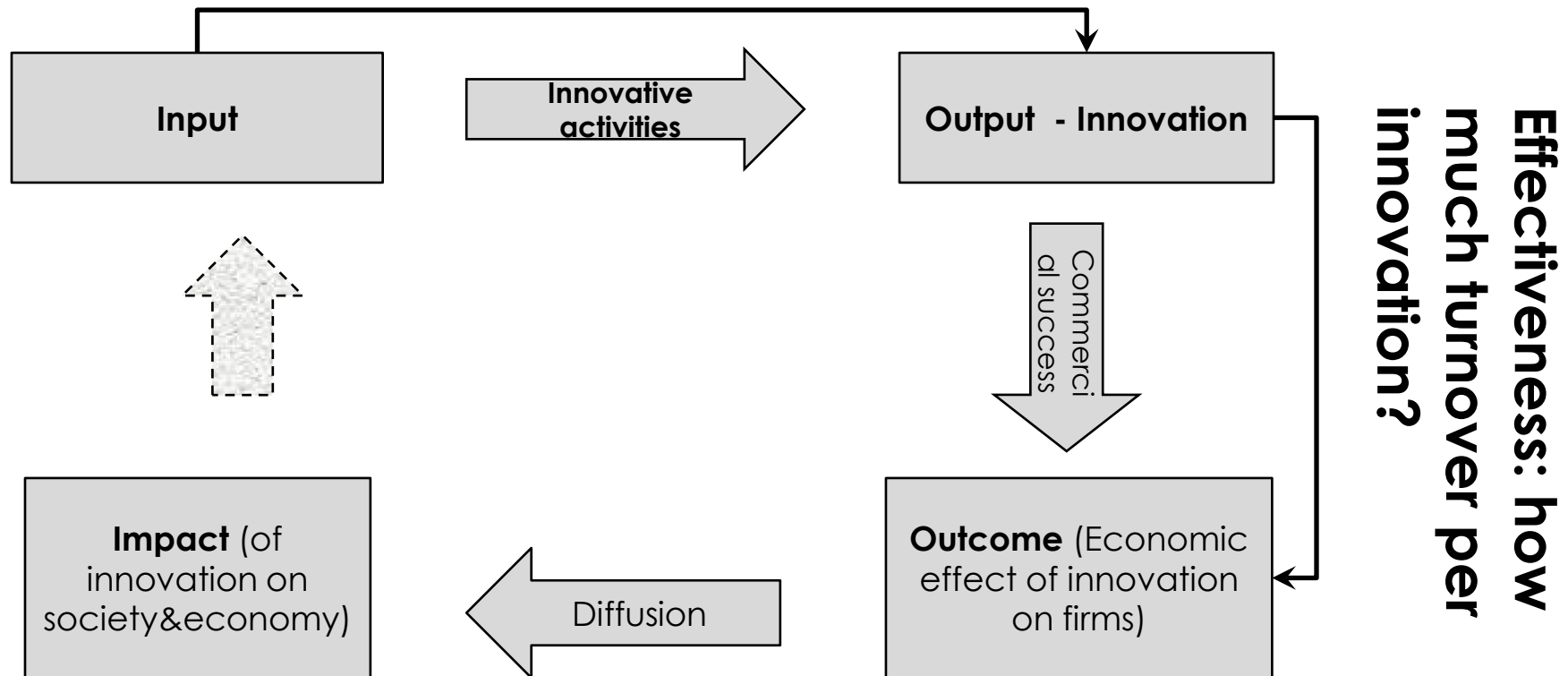
- **Economic benefits at firm level: turnover, profits, employment, productivity**
  - E.g. share in turnover of innovations (product innovation)
  - E.g. cost reduction through innovation (process innovation)
  - Productivity impact: as a rule, needs econometrics as many factors affect productivity
- **Two components of measurement at country level**
  - Structural change towards more knowledge-intensive sectors (e.g., share of knowledge-intensive sectors in total value added, as in IUS)
  - Structural upgrading, climbing up the quality ladder: economic benefit is defending competitive advantage through moving up the quality ladder, moving to a more knowledge-intensive segment of a sector



**Innovation outcome is about commercial impact of innovation on firm which has introduced it – a „sales-weighted“ output measure**



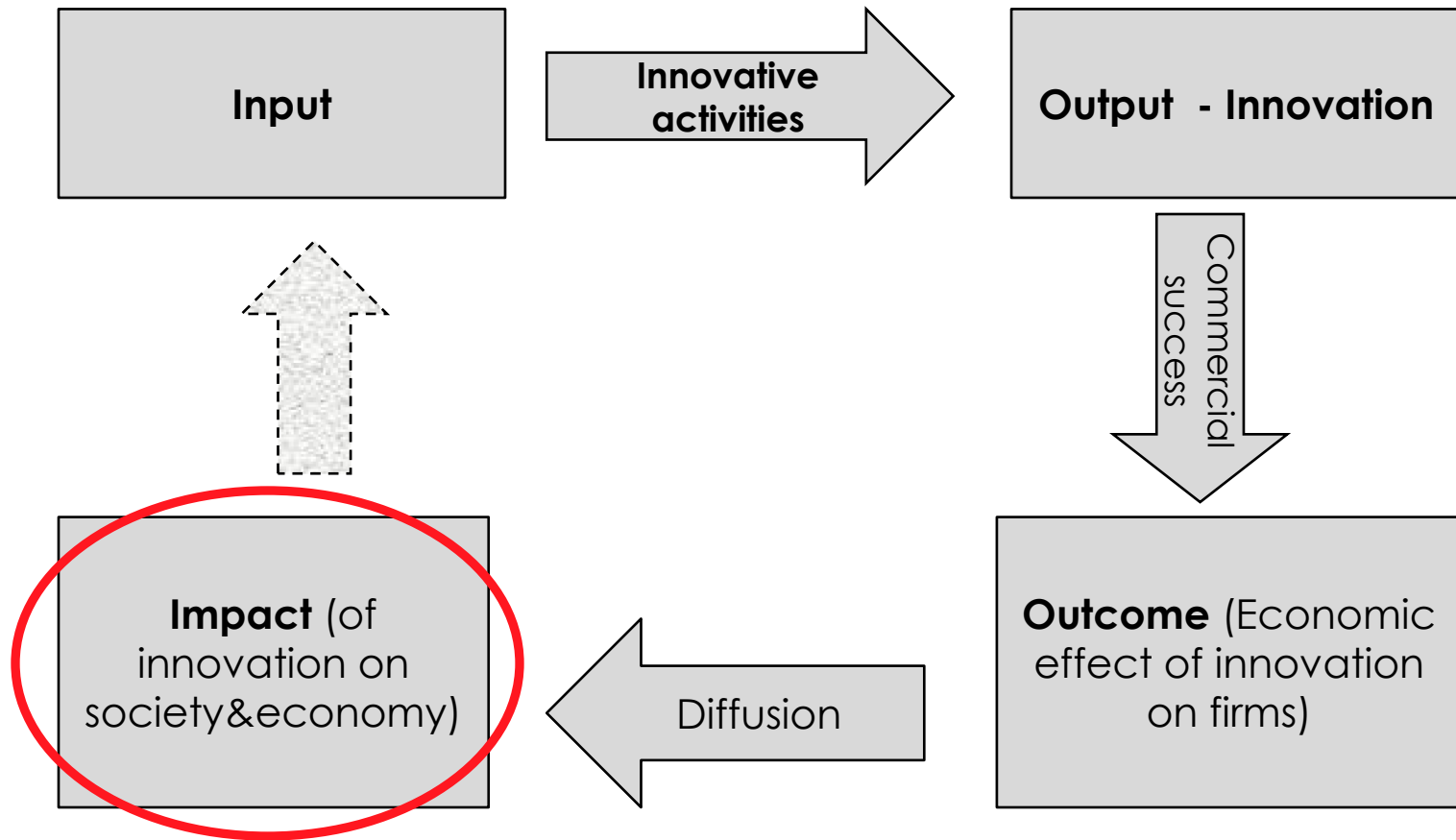
**Efficiency: how much output per input?**



- Usually not in indicator sets, additional analysis necessary
- Improper measurement leads to wrong conclusions!!



# Production process of innovation: what is there to measure?



- Impact of innovation on economy (GDP, productivity, employment...) und society (e.g. health, climate, ageing... )
- Economic impact needs econometric studies over several countries/years
  - E.g. R&D expenditure vs. productivity (return on R&D)
  - E.g. Innovations and productivity
- Not suitable for indicators – result = 1 number over several countries/years, e.g. elasticity of productivity with respect to increase in R&D expenditures

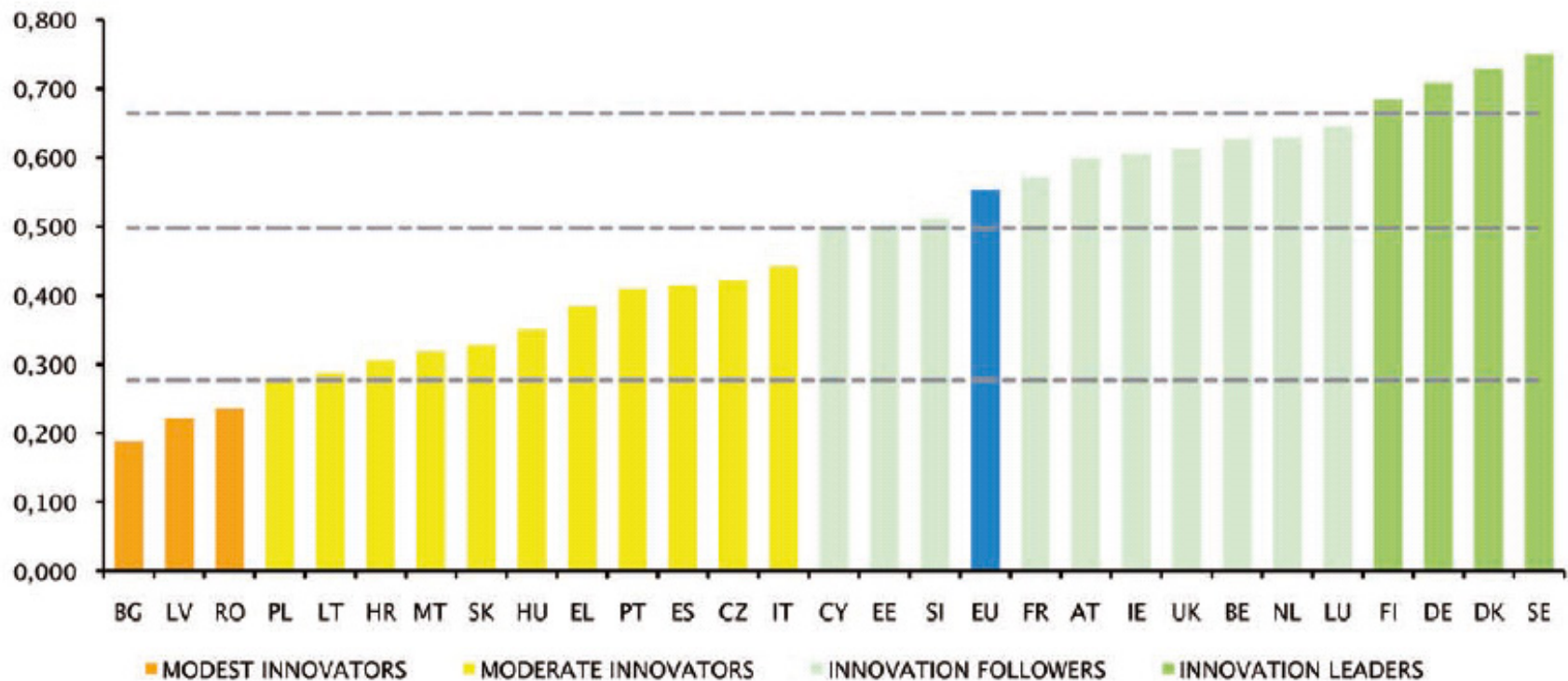
- **Less strong than input/process indicators – related to measurement issues – which examples can you think of?**
- **Results on impact of innovation:**
  - general information for public – „R&D, innovation is good for us“; good for priority-setting in overall public budget
  - Less useful for operational/strategic allocation decisions within R&D/innovation budget – where to invest
  - Not suitable for yearly monitoring, country benchmarking
  - General problem of R&D, innovation subsidy programmes – effects of programmes can rarely be directly linked with wider economic developments

- **Part II: Mapping innovation potential – some examples**
  - **Innovation Union Scoreboard**
  - **Output Indicator of European Union**
  - **Innovationsindikator.de**
  - **Global Innovation Indicator**

- [http://ec.europa.eu/enterprise/policies/innovation/policy/innovation-scoreboard/index\\_en.htm](http://ec.europa.eu/enterprise/policies/innovation/policy/innovation-scoreboard/index_en.htm) - you can download the excel database as well
- **Methodology:**
  - 25 indicators, values normalised
  - simple average of indicators (linear weighting) = Innovation Summary Index...
  - ...which determines ranking of 28 EU-countries, plus some non-EU countries (fewer indicators)
- Indicators used follow innovation model presented

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <p><b>ENABLERS</b></p> <p><b>Human resources</b></p> <p>1.1.1 New doctorate graduates</p> <p>1.1.2 Population completed tertiary education</p> <p>1.1.3 Youth with upper secondary level education</p> <p><b>Open, excellent and attractive research systems</b></p> <p>1.2.1 International scientific co-publications</p> <p>1.2.2 Scientific publications among top 10% most cited</p> <p>1.2.3 Non-EU doctorate students</p> <p><b>Finance and support</b></p> <p>1.3.1 Public R&amp;D expenditure</p> <p>1.3.2 Venture capital</p> <p><b>FIRM ACTIVITIES</b></p> <p><b>Firm investments</b></p> <p>2.1.1 Business R&amp;D expenditure</p> <p>2.1.2 Non-R&amp;D innovation expenditure</p> | <p>Inputs</p>     |
| <p><b>Linkages &amp; entrepreneurship</b></p> <p>2.2.1 SMEs innovating in-house</p> <p>2.2.2 Innovative SMEs collaborating with others</p> <p>2.2.3 Public-private co-publications</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <p>Activities</p> |
| <p><b>Intellectual Assets</b></p> <p>2.3.1 PCT patent applications</p> <p>2.3.2 PCT patent applications in societal challenges</p> <p>2.3.3 Community trademarks</p> <p>2.3.4 Community designs</p> <p><b>OUTPUTS</b></p> <p><b>Innovators</b></p> <p>3.1.1 SMEs introducing product or process innovations</p> <p>3.1.2 SMEs introducing marketing/organisational innovations</p>                                                                                                                                                                                                                                                                                                            | <p>Outputs</p>    |
| <p>3.1.3 Employment in fast-growing firms of innovative sector:</p> <p><b>Economic effects</b></p> <p>3.2.1 Employment in knowledge-intensive activities</p> <p>3.2.2 Contribution of MHT product exports to trade balance</p> <p>3.2.3 Knowledge-intensive services exports</p> <p>3.2.4 Sales of new to market and new to firm innovations</p> <p>3.2.5 Licence and patent revenues from abroad</p>                                                                                                                                                                                                                                                                                         | <p>Outcomes</p>   |

Figure 3: EU Member States' innovation performance



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- **Results: country rankings quite stable at top; 4 innovation leader countries already top in 2006 (UK dropped out); IL good in all dimensions but CH better**
  - **Performance groups also quite stable, rank changes rather within groups; exception moderate innovators**
  - **Process of convergence, but slow; innovation growth leaders Portugal, Estonia and Latvia**
  - **Biggest country differences in science quality& univ-ind. Cooperation, smallest in human resources**
  - **To achieve high level of performance, countries must perform well in all dimensions**

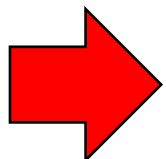
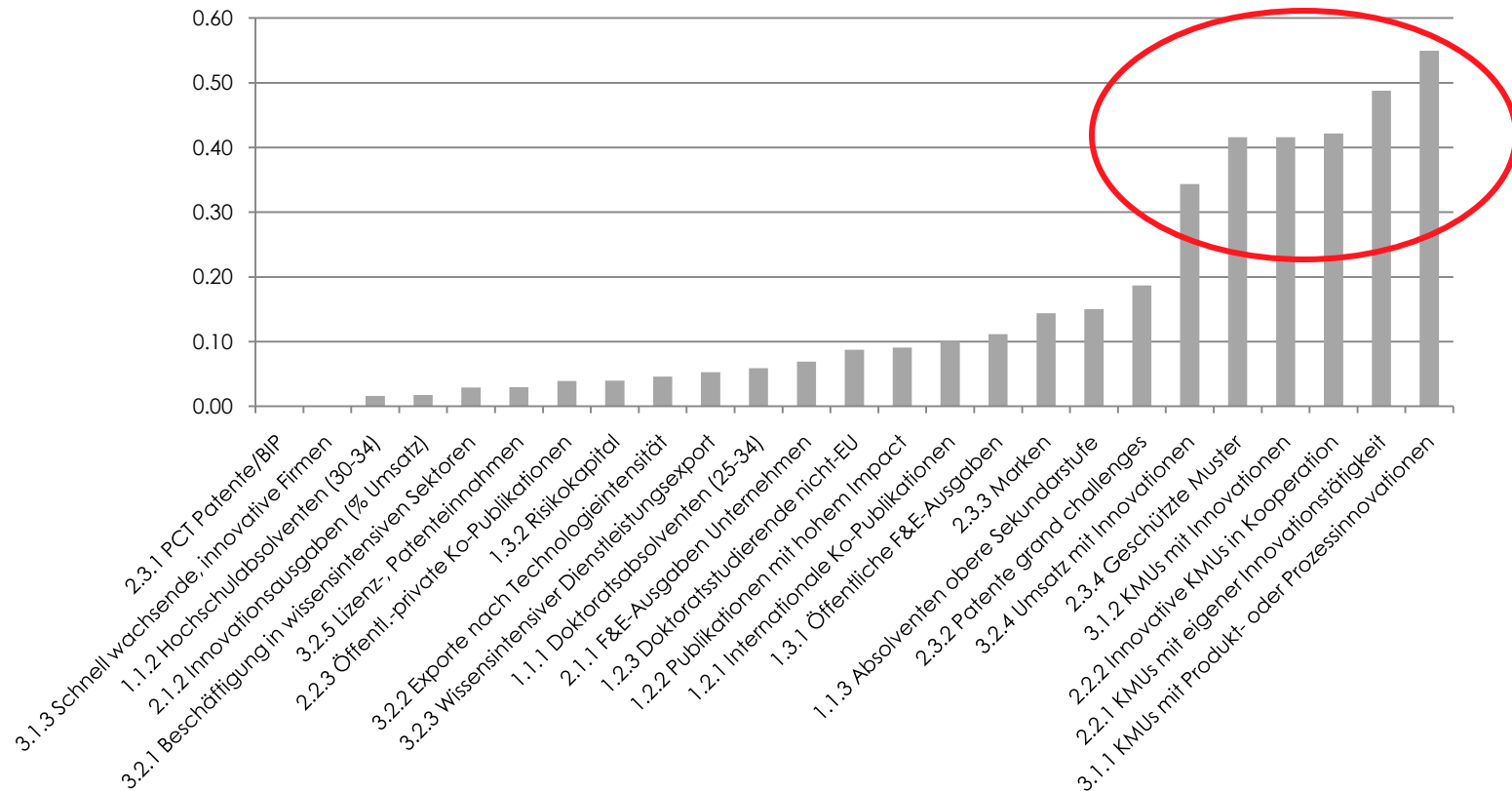


- **Not totally wrong, rather high correlation GPD/capita with IUS index**
- **Problems of IUS**
  - **Volatility of innovation survey based measures**
  - **Correlation/weighting of indicators**

Varying role of innovation for economic performance according to level of development
  - **Measurement of outcomes**

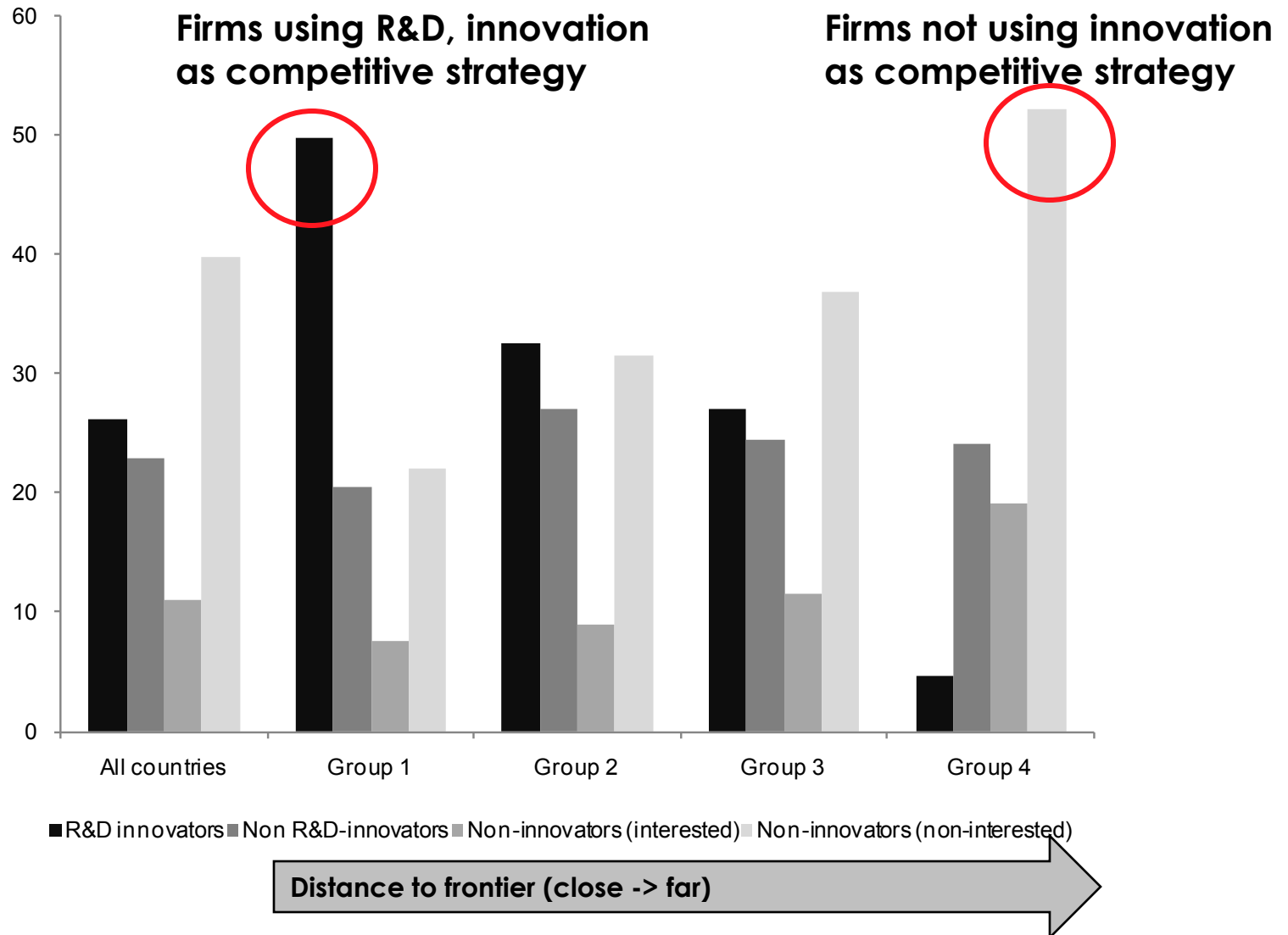
Measure of variation (1=high)

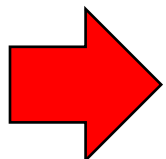
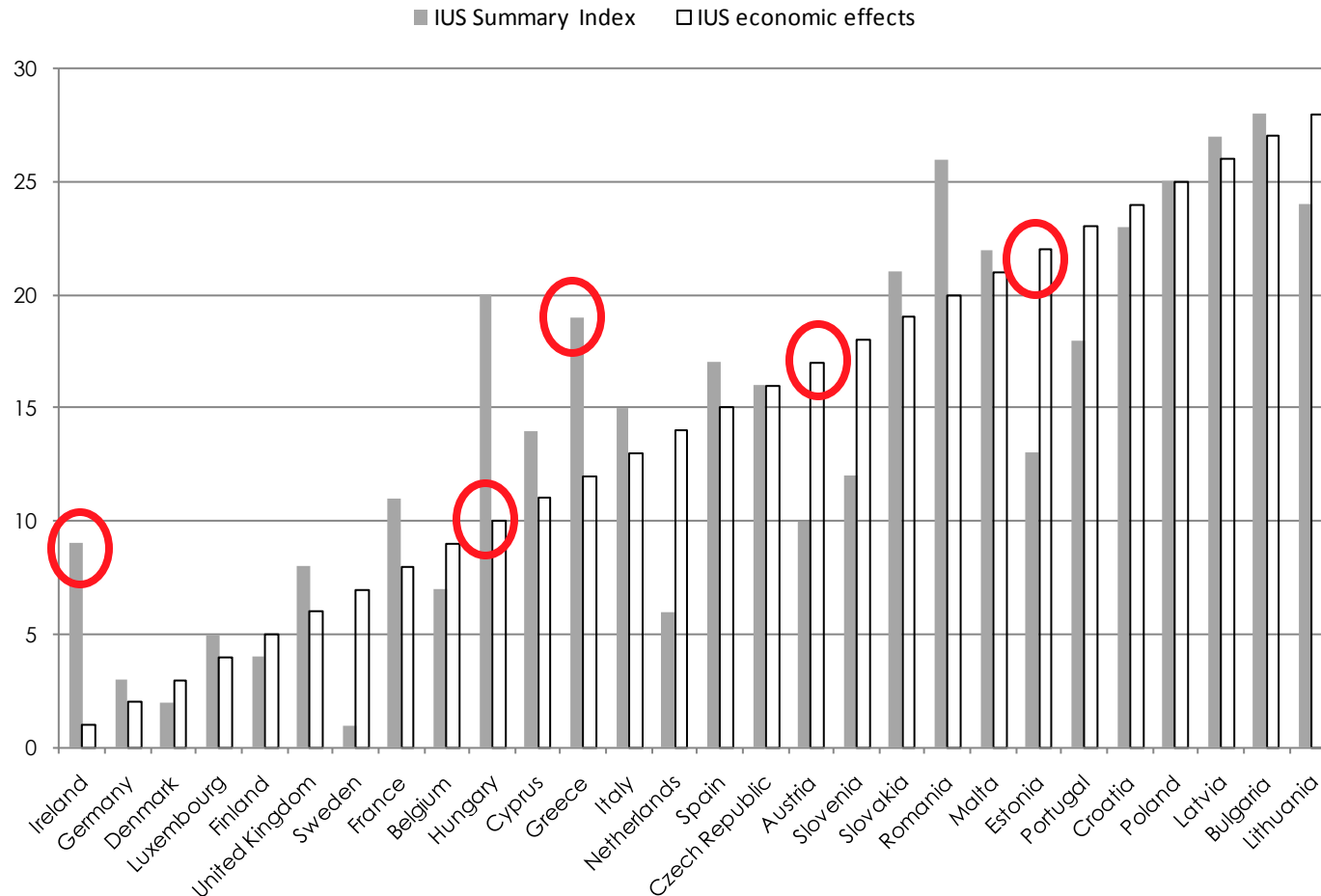
High volatility of CIS indicators



**Due to sampling of firms and subjective interpretation of innovation by firms**

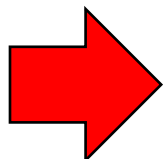
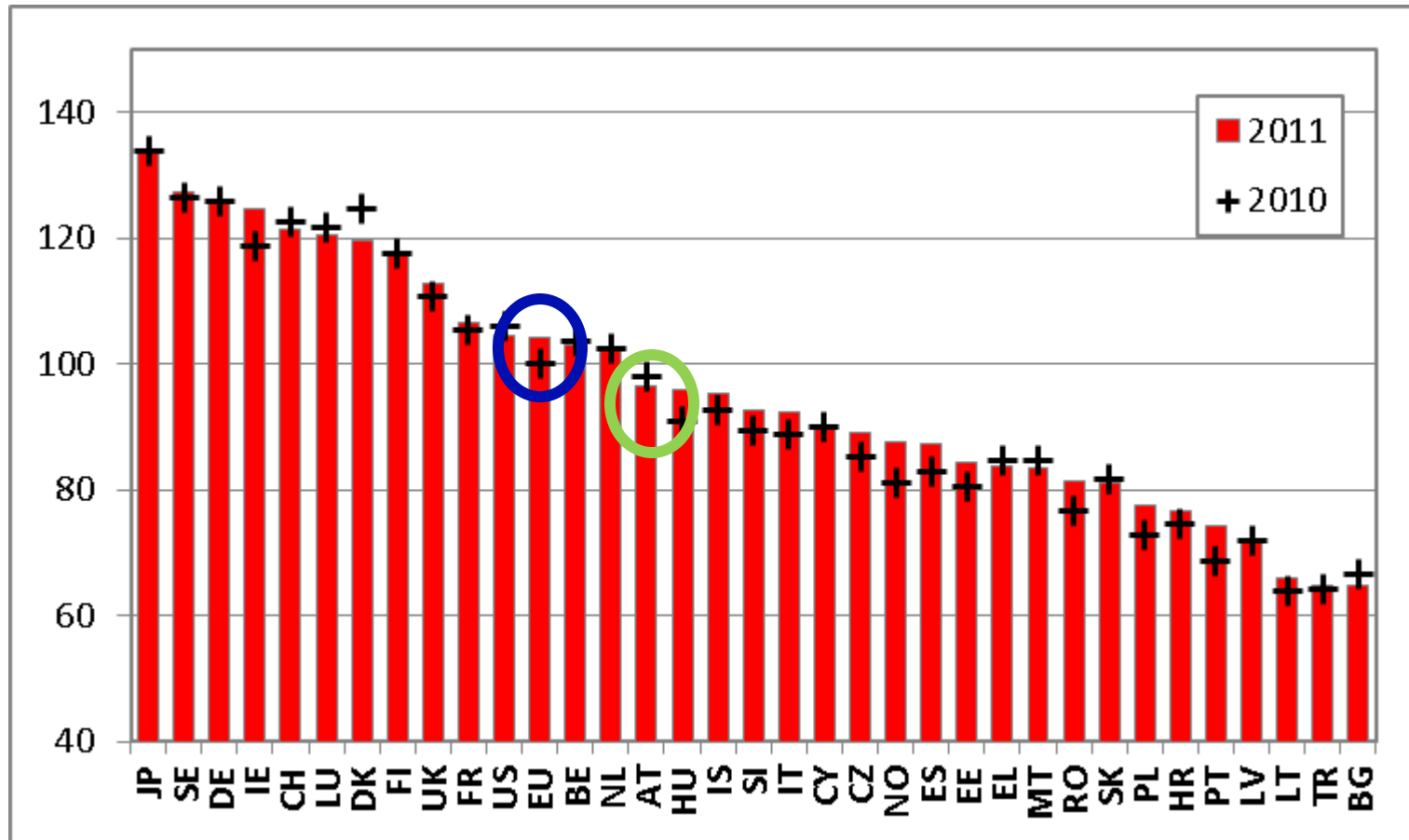
# Share of firms using innovation strategy as main competitive strategy



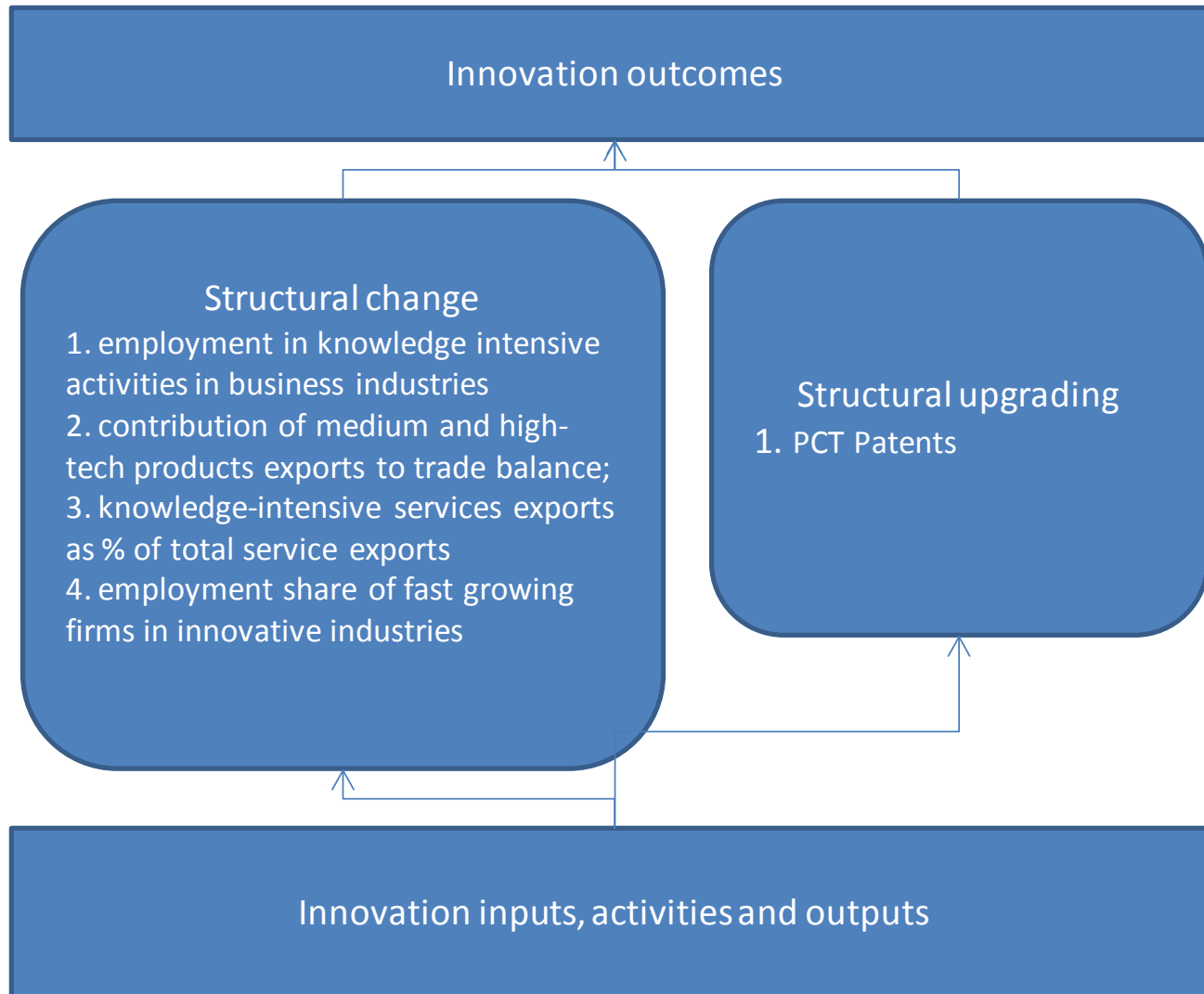


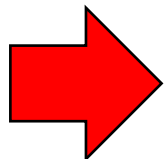
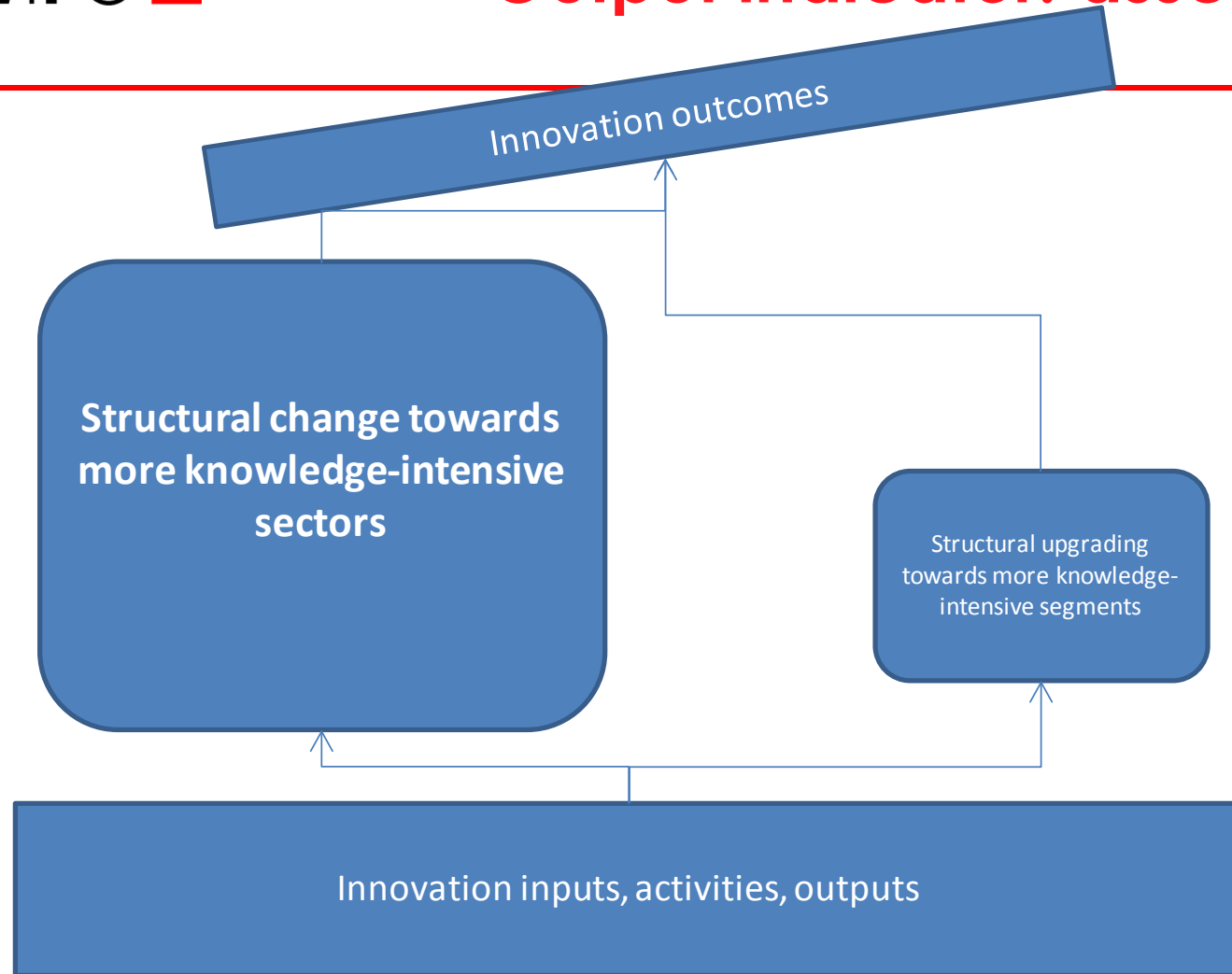
**Focuses on structural change, not upgrading; problems with indicators**

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- 3.2.1 Employment in knowledge-intensive activities: knowledge intensity via sector classification; problems of global value chains in manufacturing
  - 3.2.2 Contribution of medium high tech product exports to trade balance: medium high tech measured via sector classification
  - 3.2.3 Knowledge-intensive services exports: heavily distorted through tourism in denominator; knowledge-intensity measured through sector classification
  - 3.2.4 Sales of new to market and new to firm innovations: CIS-based, volatile and subjective
  - 3.2.5 Licence and patent revenues from abroad: reflects tax minimisation strategies of firms (NL, IL first)



**Focuses on structural change, not upgrading; problems with indicators**





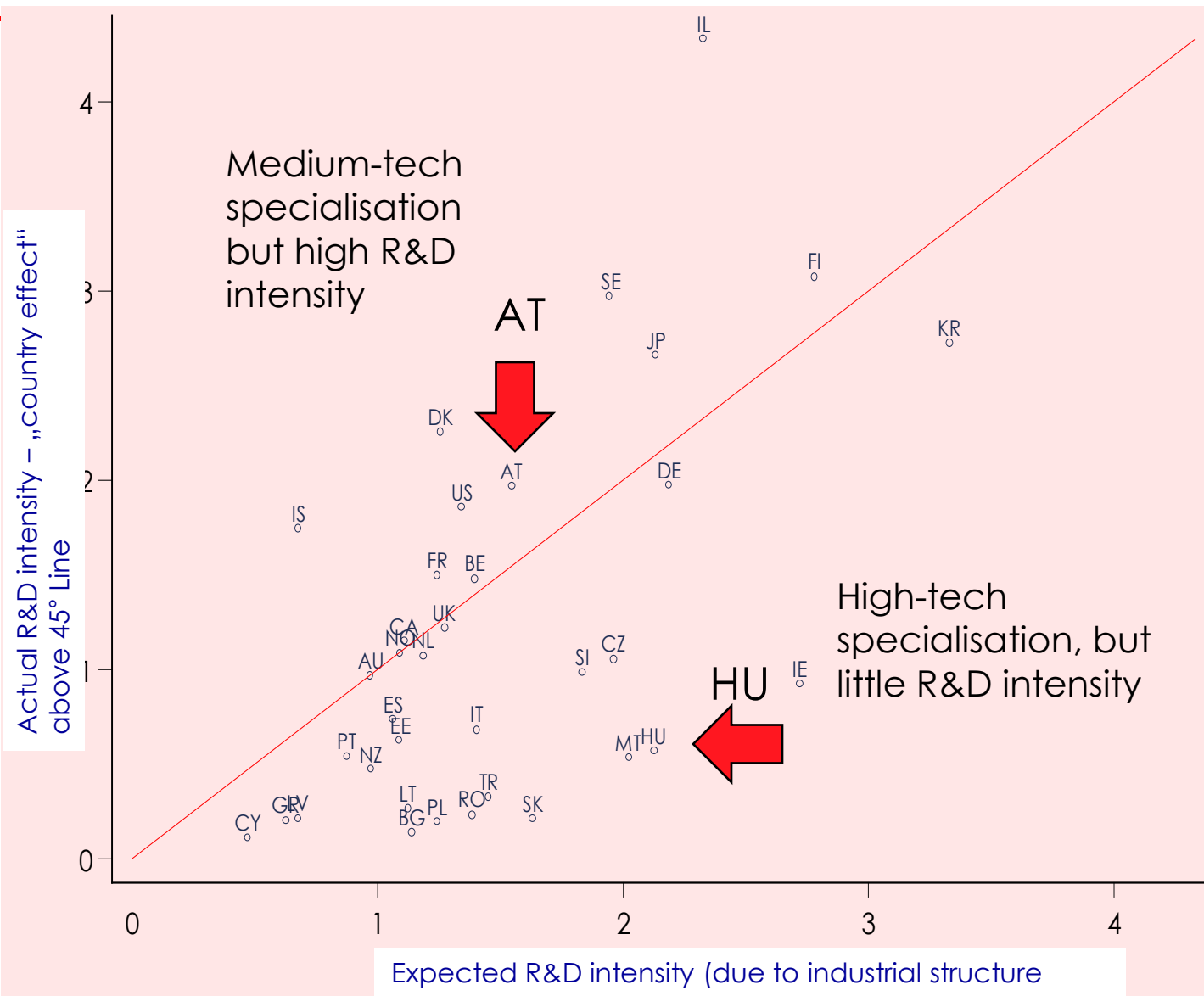
**The new output indicator only shows half (at best) of economic effects of innovation**

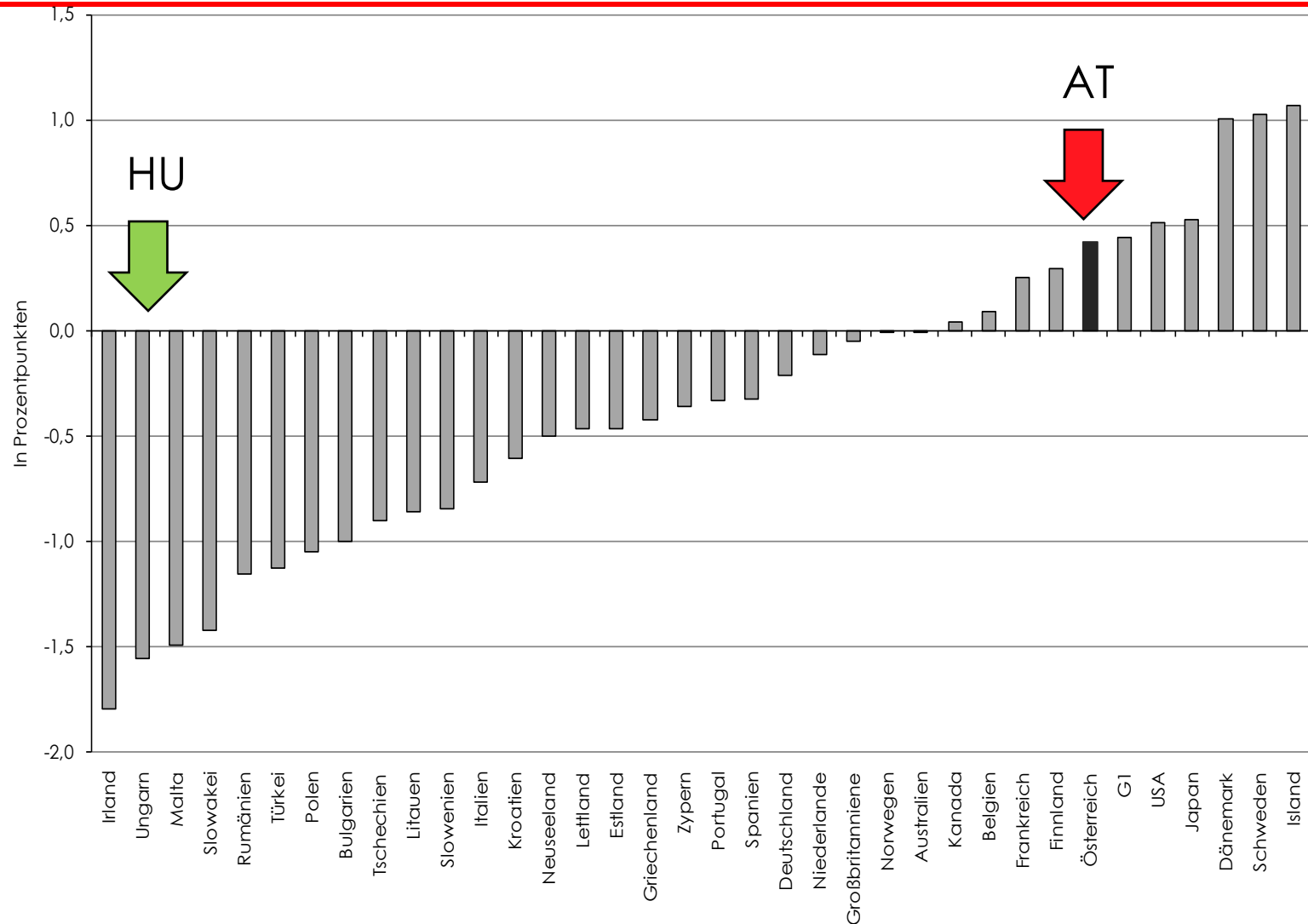


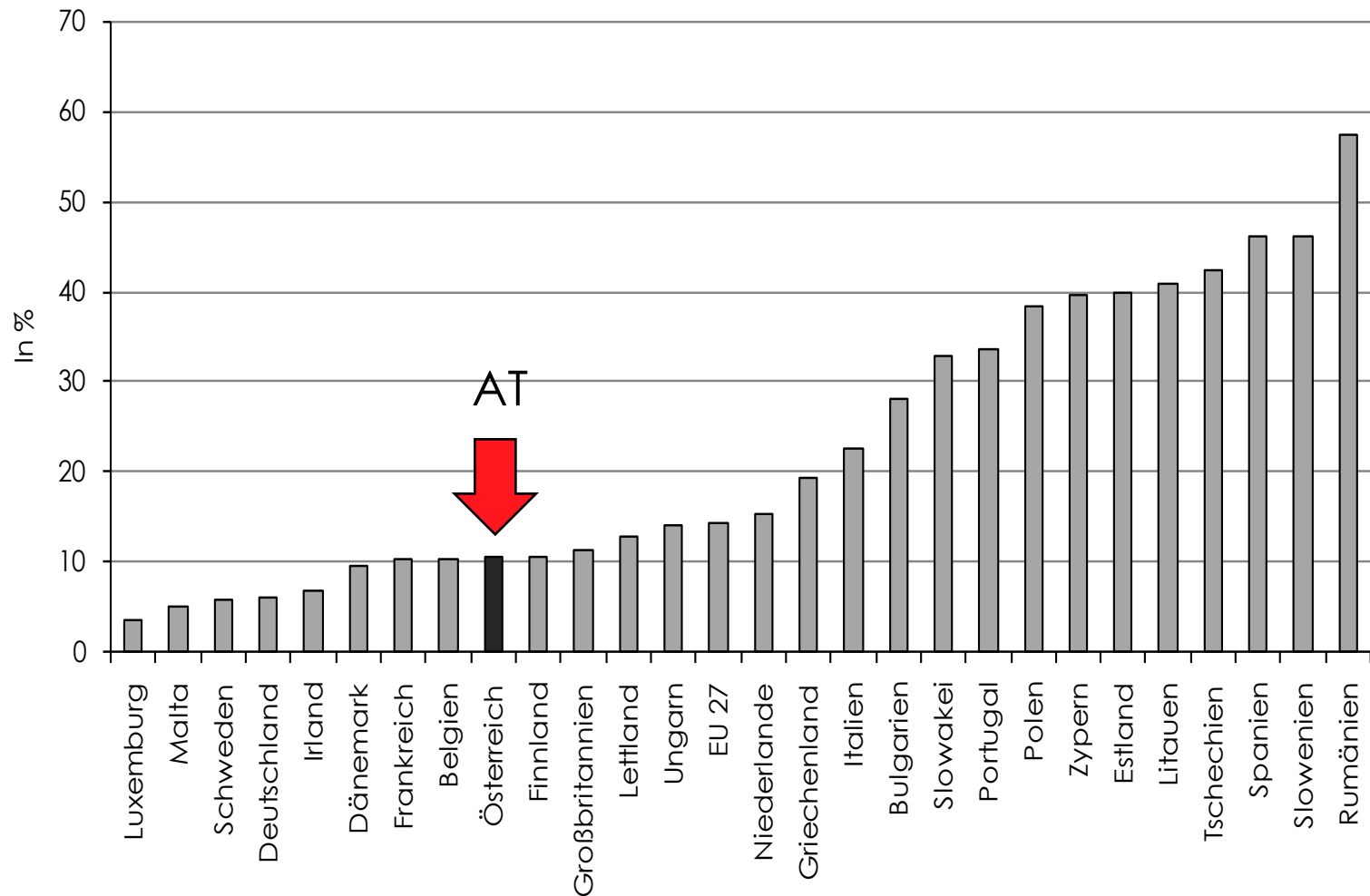
- **Innovation strategy might get it wrong:**
  - **Positive economic effects of structural upgrading underestimated**
  - **Structural change strategies risk becoming „picking the winner“-strategies - sectoral high-tech focus at expense of bottom-up funding of individual firm innovation projects**
  - **More focus on output/outcome in policy discussion – but problem, not adequately measured**

- **Indicators for structural upgrading**
  - **Quality-adjusted patent indicators**
  - **Correcting for effects of global value chains and for varying sectoral R&D intensities**
  - **Export quality**

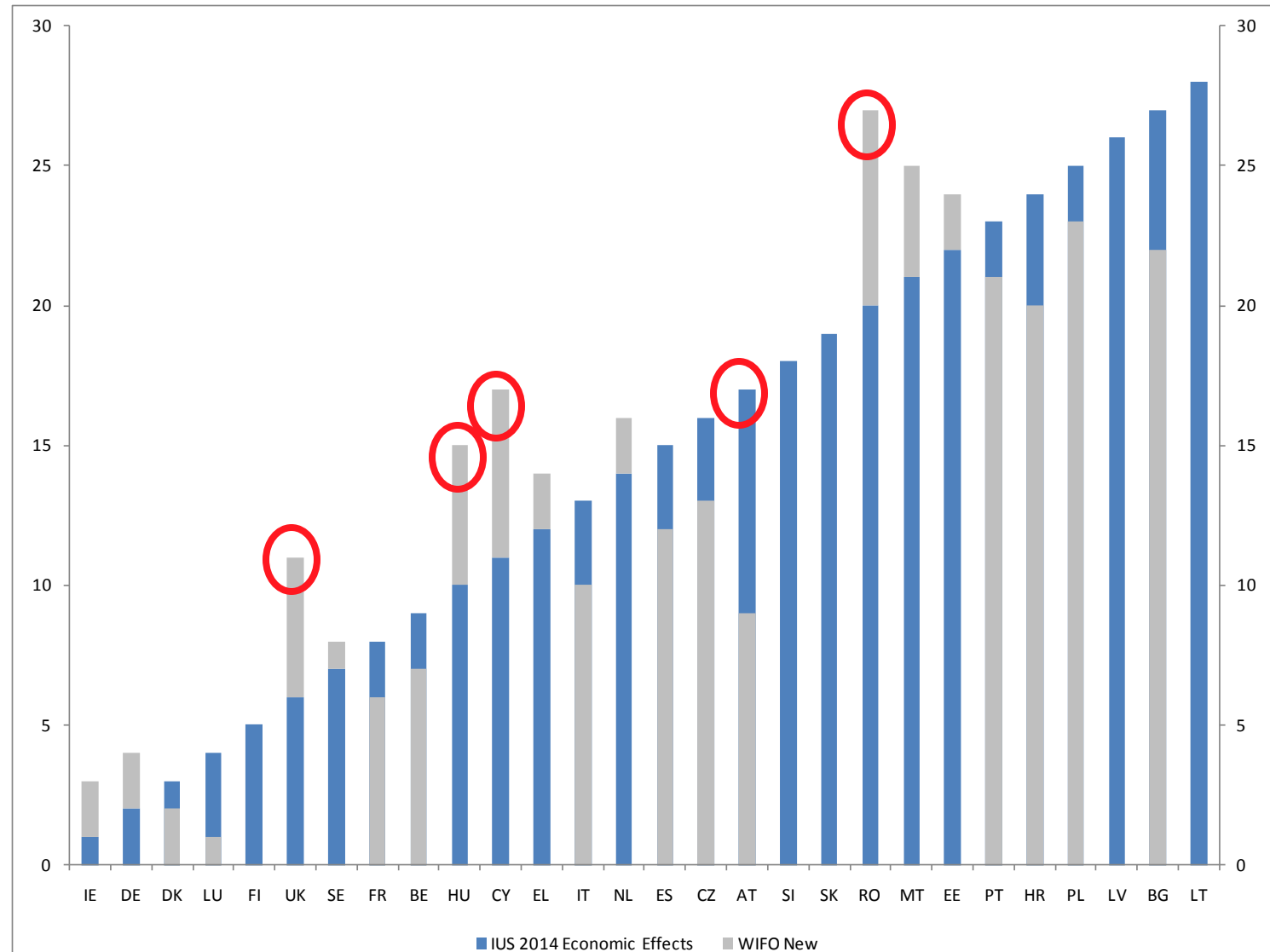
# Sectorally adjusted R&D intensity of business sector, 2009





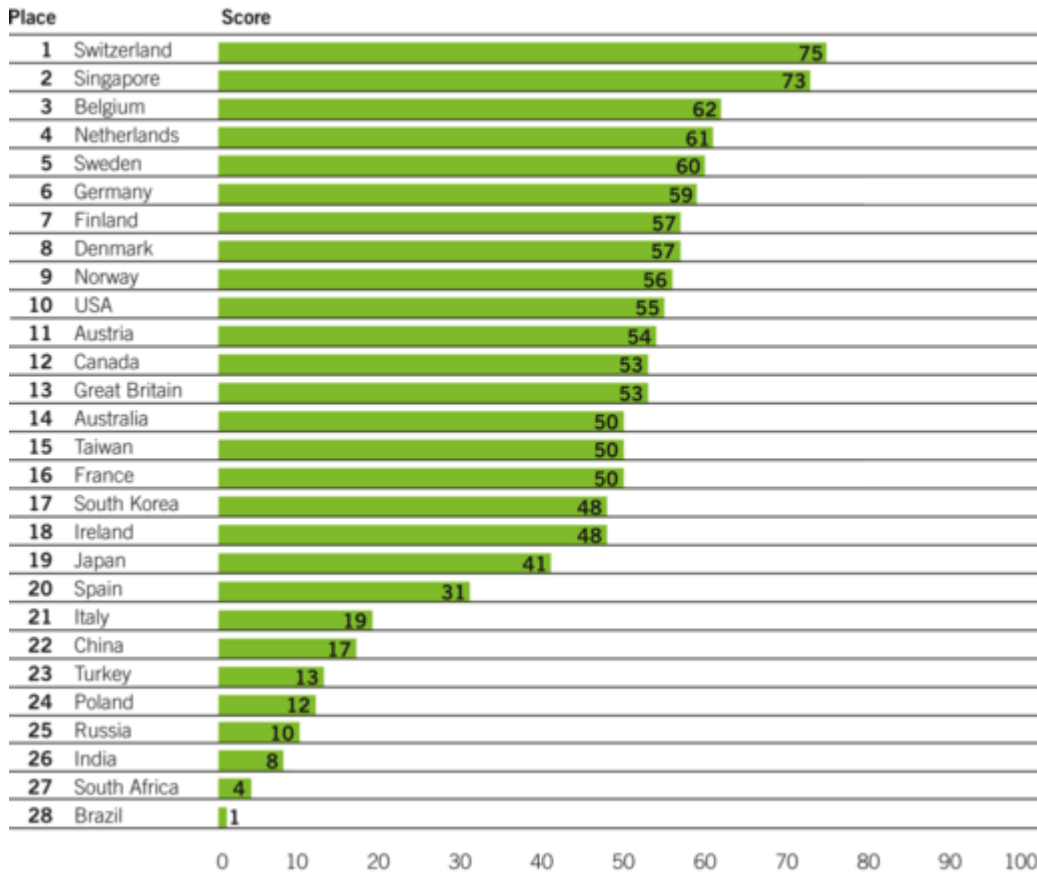


# New ranking in IUS economic effects



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- Innovation indicator de:  
<http://www.innovationsindikator.de/english.html>
  - <http://www.globalinnovationindex.org/content.aspx?page=GII-Home>
  - OECD – no composite indicator, only individual indicators (e.g. STI scoreboards) – can always use innovation model presented to group indicators per area and get picture of country strengths and weaknesses
  - WEF, IMD – manager-survey based as well as stats – little explanatory power

Overall result of the Innovation Indicator, 2012



- In principle, better analytic foundations than IUS (indicator inclusion criterion due to economic model)
- 38 indicators, by 5 sectors of activity
- But results doubtful: Belgium nl ahead of Sweden, Germany? Japan just before Spain and Italy?
- Some survey results from WEF used, other doubtful indicators

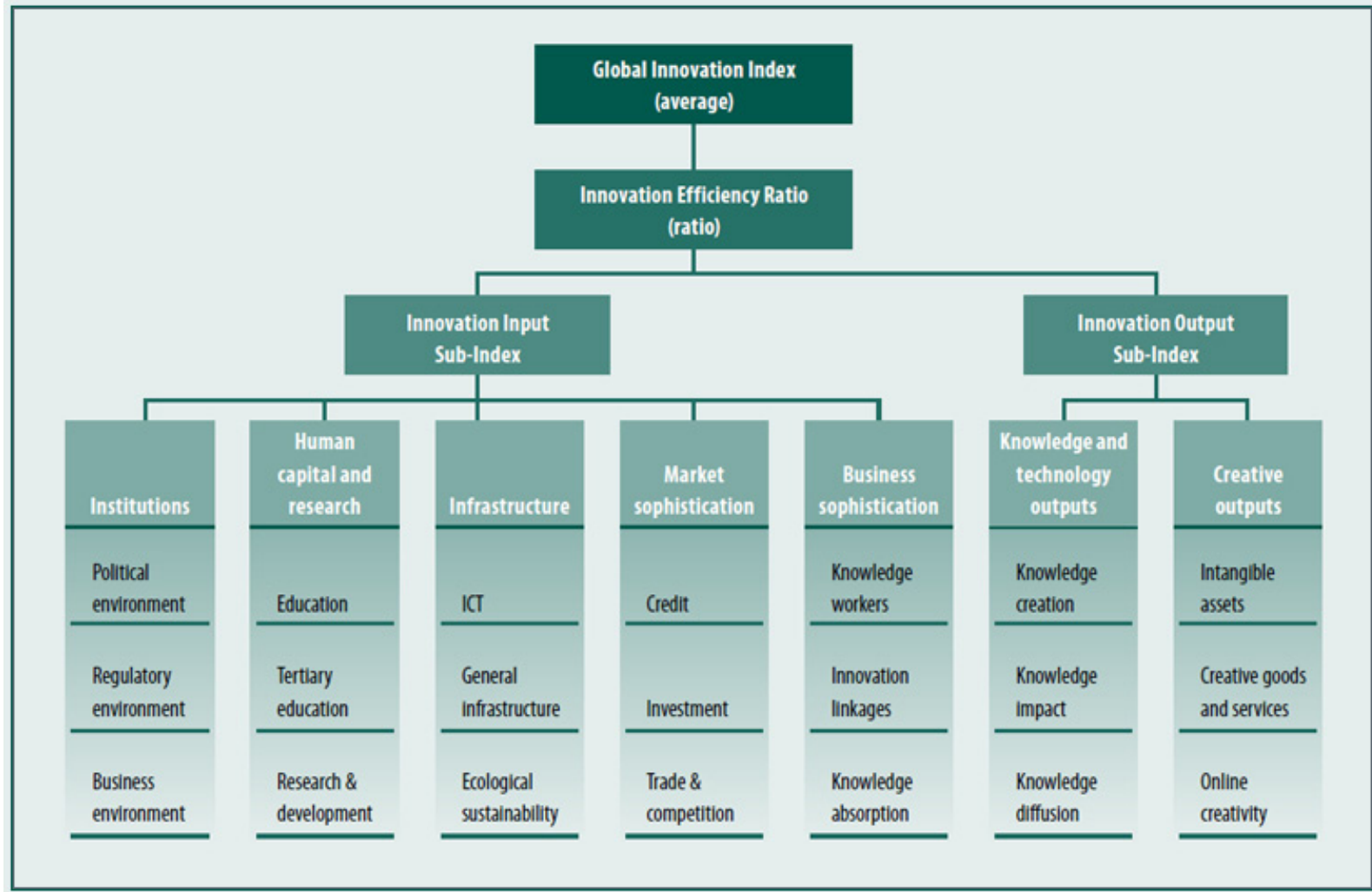


|     |                                                                                   |                       |
|-----|-----------------------------------------------------------------------------------|-----------------------|
| B1  | Foreign students as a percentage of all tertiary enrolment                        | Education             |
| B2  | Share of employees with at least secondary (non tertiary) education               | Education             |
| B3  | Population with ISCED 6 level education in mathematics, sciences, and engineering | Education             |
| B4  | Tertiary graduates per 55+ year old academic employees                            | Education             |
| B5  | Share of employees with tertiary education                                        | Education             |
| B6  | Annual education expenses per student                                             | Education/State       |
| B7  | Quality of education system                                                       | Education/State       |
| B8  | Quality of the mathematical and natural science education                         | Education/State       |
| B9  | Index of PISA results in sciences, reading, mathematics                           | Education/State       |
| G1  | E-readiness indicator                                                             | Society               |
| G2  | Risk-taking behavior                                                              | Society               |
| G3  | Number of PCs per 100 inhabitants                                                 | Society               |
| G4  | Share of post materialists                                                        | Society               |
| S1  | Public demand for advanced technologies                                           | State                 |
| W1  | Demand of companies for technological products                                    | Enterprises           |
| W2  | Early-stage venture capital relative to GDP                                       | Enterprises           |
| W3  | Importance of Marketing                                                           | Enterprises           |
| W4  | Share of international co-patents                                                 | Enterprises           |
| W5  | Share of value added in high-tech sectors in total value added                    | Enterprises           |
| W6  | Share of employees in knowledge intensive services                                | Enterprises           |
| W7  | Intensity of competition                                                          | Enterprises           |
| W8  | GDP per capita                                                                    | Enterprises           |
| W9  | Transnational patents per capita                                                  | Enterprises           |
| W10 | USPTO patent applications per capita                                              | Enterprises           |
| W11 | Value added per hour worked                                                       | Enterprises           |
| W12 | Trade balance in high-tech goods per capita                                       | Enterprises           |
| W13 | Share of university R&D financed by enterprises                                   | Enterprises           |
| W14 | Internal business R&D expenditures as share of GDP                                | Enterprises           |
| W15 | B-index for tax-based funding of business R&D                                     | Enterprises/State     |
| W16 | Publicly funded R&D in enterprises as a share of GDP                              | Enterprises/State     |
| F1  | Number of researchers in FTE per 1,000 employees                                  | Public Research       |
| F2  | Number of SCI publications relative to population                                 | Public Research       |
| F3  | Quality of research institutions                                                  | Public Research       |
| F4  | Field-specific expected impact rate of SCI-publications                           | Public Research       |
| F5  | Public science sector patents per inhabitant                                      | Public Research       |
| F6  | Share of international SCI co-publications                                        | Public Research       |
| F7  | R&D share in Public Research Institutions and Universities                        | Public Research/State |
| F8  | Country share among the top 10% of most highly cited publications                 | Public Research)      |

- 
- Innovation input sub-index with 5 areas, Innovation output sub-index with 2 areas
  - Wider (84 indicators) – e.g. rule of law, regulation, financial access, ICT infrastructure etc., more countries (142)
  - Linear weighting (simple average of all indicators in sub-indices); strong methodological changes each year (last year: 20 indicators changed) – problematic for performance over time
  - Problems with output indicators similar to IUS (licensing incomes etc.); some indicators really related to innovation performance?
  - Results sometimes also doubtful Japan; Germany; Belgium now 21st instead of 3rd in innovation indicator)

Table 1: Global Innovation Index rankings

| Country/Economy          | Score (0–100) | Rank |
|--------------------------|---------------|------|
| Switzerland              | 66.59         | 1    |
| Sweden                   | 61.36         | 2    |
| United Kingdom           | 61.25         | 3    |
| Netherlands              | 61.14         | 4    |
| United States of America | 60.31         | 5    |
| Finland                  | 59.51         | 6    |
| Hong Kong (China)        | 59.43         | 7    |
| Singapore                | 59.41         | 8    |
| Denmark                  | 58.34         | 9    |
| Ireland                  | 57.91         | 10   |
| Canada                   | 57.60         | 11   |
| Luxembourg               | 56.57         | 12   |
| Iceland                  | 56.40         | 13   |
| Israel                   | 55.98         | 14   |
| Germany                  | 55.83         | 15   |
| Norway                   | 55.64         | 16   |
| New Zealand              | 54.46         | 17   |
| Korea, Rep.              | 53.31         | 18   |
| Australia                | 53.07         | 19   |
| France                   | 52.83         | 20   |
| Belgium                  | 52.49         | 21   |
| Japan                    | 52.23         | 22   |
| Austria                  | 51.87         | 23   |
| Malta                    | 51.79         | 24   |
| Estonia                  | 50.60         | 25   |
| Spain                    | 49.41         | 26   |
| Cyprus                   | 49.32         | 27   |
| Czech Republic           | 48.36         | 28   |
| Italy                    | 47.85         | 29   |
| Slovenia                 | 47.32         | 30   |
| Hungary                  | 46.93         | 31   |



- Video uploads youtube
- ICT services exports in % total exports (as in IUS – knowledge-intensive services)
- Press freedom is crucial, but doesn't (yet) prevent china and Singapore from innovating
- Lots of World Economic Forum survey questions (very doubtful)
- Cost of redundancy dismissal can work both ways (as high cost is incentive for human capital training)
- QS university rankings not good (survey-based) – IUS Better
- Growth rate of GDP/capita – can be related to a myriad of factors

## ■ Conclusions

- To map innovation potential, need indicators on innovation ...
  - Inputs
  - Activities
  - Outputs
  - Outcomes
- These different areas are more or less difficult to measure: input better than output.
- Ongoing (Academic) work to improve indicators.
- Don't trust WEF, IMD survey indicators.

- 
- **Efficiency/effectiveness measures not admissible when components not appropriately measured (inputs, outputs, outcomes)**
  - **Correlation/weighting**
    - Different levels of development
  - **Output/outcome monitoring**
    - Sectoral indicators for manufacturing suffer from rise of global value chains (fragmentation of production across several countries)
  - **Given high correlation R&D spending with innovation/productivity – sometimes ok to look at more input-based indicators, because quality of measurement higher (but correct for sectoral R&D intensities)**



- 
- Strong policy use of input/process indicators, as well as of innovation summary indices (composite indicators)
  - Maybe rising policy use of outcome indicators due to new EU-indicator
  - Careful with simple efficiency/effectiveness observations based on IUS indicators
  - To interpret change in country ranking, have a close look at what caused the change:
    - New indicator, others rising faster, or we fall back? Need context-based interpretation, need information on economy and innovation system

- Innovation analysis cannot only rely on indicators – need detailed, context-based analysis
- But: IUS is not totally wrong – ranking of countries not completely wrong-footed – there is a correlation with economic performance
- For EU: Better than innovation indicator de and Global Innovation Index (but of course different countries etc.)

## ■ Glossary

- <http://stats.oecd.org/glossary/index.htm>
- [Oslo Manual](#)

<http://www.oecd.org/innovation/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm>

### **Frascati manual:**

<http://www.oecd.org/science/inno/frascaticmanualproposedstandardpracticeforsurveysonresearchandexperimentaldevelopment6thedition.htm>

- **Thank you for your attention!**
- [www.wifo.ac.at](http://www.wifo.ac.at)
- [Juergen.janger@wifo.ac.at](mailto:Juergen.janger@wifo.ac.at)

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