



The Relations between public subsidies, business R&D and innovativeness: A qualitative meta-analysis

Patricia van Hemert and Peter Nijkamp

vrije Universiteit

amsterdam



General aim of paper



- 1) Find evidence for the influence of different forms of (R&D) expenditures (direct or indirect) on innovation performance in the 27 EU member states by means of rough set analysis
- 2) Find out if specific forms of expenditure are more efficient and create higher output in specific countries and if there is a pattern recognizable
- 3) Implications for future innovation policies?

Overview presentation

- 1) Background
- 2) European Innovation Scoreboard
- 3) Limitation European Innovation Scoreboard: towards a new framework
- 4) Rough set analysis
 - 4.1 rough set analysis of expenditures and employment
 - 4.2 rough set analysis of overall innovation performance
- 5) Conclusions
- 6) Policy implications

1. Background

- In literature innovation often related to concept productivity (Romer, 1990; Lichtenberg, 1992)
- Econometric studies show large, positive and significant effect R&D on productivity (based on aggregate or industry level data) (Guellec and Van Pottelsberghe, 2001)
- R&D intensity focus point of Lisbon strategy and Barcelona target and many countries have taken steps to increase innovation efforts
- However many challenges in assessing R&D impacts related to causality, attribution, internationality, evaluation of time-scale and definition of appropriate indicators
- Many micro- and macro-econometric studies on spillovers and social rate return measuring positive effect R&D on productivity, but little studies on innovation process or non-economic impacts of R&D

R&D expenditures in literature

- Technological advances considered key component of innovation and economic growth (Grossman and Helpman, 1994)
- R&D plays crucial role in technological development and economic competitiveness country (Rosenberg and Birdzell, 1990; Fagerberg, 1994; Tijssen, 2002)
- Industry funded R&D expenditures considered most significant for innovation, public sector R&D smaller contribution and directed at making improvements in areas not directly related to growth (OECD, 1998)
- Public R&D supported by idea that market failure leads to underinvestment in R&D by private sector (Nadiri, 1993; Cameron, 1998)
- Public R&D more than private R&D has benefits for society like skill development, generation new knowledge, new scientific instruments, etc. (Salter and Martin, 2001), which relates to idea that in Europe nowadays production and diffusion of knowledge are central

R&D expenditures by sector as a share of total spending in EU member states, 1998, 2002 and 2006 (% of GDP)

	A Business		B Government		C Higher education		A+B+C		Real GDP growth rate (% change previous year)		
	1998	2006	1998	2006	1998	2006	1998	2006	1998	2002	2006
Austria	1.12	1.66	0.11	0.13	0.52	0.65	1.77	2.49	3.6	1.6	3.4
Belgium	1.32	1.24	0.11	0.16	0.4	0.41	1.86	1.83	1.7	1.5	2.8
Bulgaria	0.11	0.12	0.43	0.31	0.03	0.05	0.57	0.48	4.0	4.5	6.3
Cyprus	0.03	0.09	0.12	0.12	0.05	0.18	0.22	0.42	5.0	2.1	4.0
Czech Republic	0.74	1.02	0.29	0.27	0.11	0.25	1.15	1.54	-0.8	1.9	6.8
Denmark	1.32	1.62	0.29	0.16	0.41	0.63	2.04	2.43	2.2	0.5	3.9
Estonia	0.11	0.51	0.14	0.15	0.32	0.46	0.57	1.14	5.4	8.0	11.2
Finland	1.92	2.46	0.36	0.32	0.56	0.65	2.86	3.45	5.2	1.6	4.9
France	1.33	1.32	0.4	0.36	0.38	0.38	2.14	2.09	3.5	1.0	2.2
Germany	1.54	1.77	0.33	0.35	0.4	0.41	2.27	2.53	2.0	0.0	2.9
Greece	0.12(a)	0.17	0.11(a)	0.12	0.23(a)	0.27	0.45(a)	0.57	3.4	3.9	4.2
Hungary	0.26	0.48	0.18	0.25	0.17	0.24	0.68	1	4.8	4.4	3.9
Ireland	0.89	0.89	0.11	0.09	0.26	0.34	1.24	1.32	8.0	6.6	5.7
Italy	0.51	0.54	0.21	0.19	0.33	0.33(b)	1.05	1.09(b)	1.4	0.5	1.8
Latvia	0.08	0.35	0.13	0.11	0.19	0.24	0.4	0.7	4.7	6.5	12.2
Lithuania	0.01	0.22	0.32	0.18	0.21	0.4	0.55	0.81	7.5	6.9	7.7
Luxembourg	:	1.25	:	0.19	:	0.04	:	1.47	6.5	4.1	6.1
Malta	:	0.34	:	0.03	:	0.18	:	0.54	:	2.6	3.4
Netherlands	1.03	0.96	0.34	0.24	0.51	0.49(c)	1.9	1.67	3.9	0.1	3.0
Poland	0.28	0.18	0.21	0.21	0.18	0.17	0.67	0.56	5.0	1.4	6.2
Portugal	0.15	0.35	0.17	0.12(b)	0.26	0.29(b)	0.65	0.83	4.9	0.8	1.3
Romania	0.38	0.22	0.09	0.15	0.02	0.08	0.49	0.45	:	5.1	7.9
Slovakia	0.51	0.21	0.19	0.16	0.07	0.12	0.78	0.49	4.4	4.8	8.5
Slovenia	0.71	0.96	0.41	0.39	0.23	0.24	1.36	1.59	3.6	3.7	5.7
Spain	0.46	0.67	0.15	0.2	0.27	0.33	0.87	1.2	4.5	2.7	3.9
Sweden	2.6(a)	2.79	0.12(a)	0.17	0.74(a)	0.76	3.55	3.73	3.8	2.4	4.1
United Kingdom	1.17	1.1	0.24	0.18	0.35	0.46	1.79	1.78	3.4	2.1	2.9

Source: Eurostat

Main science and technology indicators 2006

	Gross domestic expenditures on R&D 2006						Total researchers 2006
	Million current PPP€	% of GERD financed by		% performed by			All sectors
		Industry	Government	Industry	Higher Education	Government	
Austria	257 294.5	45.6	36	1.66	0.65	0.13	44 127(c)
Belgium	316 622.0	59.7(a)	24.7(a)	1.24	0.41	0.16	48 757(a)
Bulgaria	25 238.2	27.8(a)	63.9(a)	0.12	0.05	0.31	11 920(a)
Cyprus	14 630.9	16.8(a)	67(a)	0.09	0.18	0.12	1 424(a)
Czech Republic	113 458.5	56.9	39	1.02	0.25	0.27	39 676
Denmark	220 069.4	59.5(a)	27.6(a)	1.62	0.63	0.16	43 460(a)
Estonia	13 233.6	38.1	44.6	0.51	0.46	0.15	6 411
Finland	16 7041.0	66.6	25.1	2.46	0.65	0.32	53 273
France	180 7462.0	52.2(a)	38.4(a)	1.32	0.38	0.36	252 994(a)
Germany	2 322 200.0	67.6(a)	28.4(a)	1.77	0.41	0.35	411 784(a)
Greece	213 985.0	31.1(a)	46.8(a)	0.17	0.27	0.12	33 396(a)
Hungary	90 045.1	43.3	44.8	0.48	0.24	0.25	32 786
Ireland	174 705.0	59.3	30.1	0.89	0.34	0.09	18 589
Italy	1 479 981.1	39.7(a)	50.7(a)	0.54	0.33(a)	0.19	125 534(a)
Latvia	16 046.7	32.7	58.2	0.35	0.24	0.11	7 200
Lithuania	23 721.4	26.2	53.6	0.22	0.4	0.18	11 918(a)
Luxembourg	33 853.6	26.2	16.6(a)	1.25	0.04	0.19	2 443(a)
Malta	5 075.1	52.1	34.4	0.34	0.18	0.03	977
Netherlands	534 324.0	51.1(b)	36.2(b)	0.96	0.49(d)	0.24	49 831(a)
Poland	272 130.7	33.1	57.5	0.18	0.17	0.21	96 374
Portugal	155 322.6	36.3	55.2(a)	0.35	0.29(a)	0.12(a)	37 769(a)
Romania	97 718.4	30.4	64.1	0.22	0.08	0.15	30 122
Slovakia	44 571.4	35	55.6	0.21	0.12	0.16	18 816
Slovenia	30 453.9	59.3	34.4	0.96	0.24	0.39	8 213
Spain	980 954.0	47.1	42.5	0.67	0.33	0.2	193 024
Sweden	313 327.0	65.7	23.5(a)	2.79	0.76	0.17	82 496(a)
United Kingdom	1 912 656.0	45.2	31.9	1.1	0.46	0.18	:

Source: Eurostat

2. European Innovation Scoreboard (EIS)

- In 2000 EIS developed at request Lisbon Council as statistical report belonging to Trend Chart on Innovation
- Innovation priority in all member states and European Commission, but framework conditions, cultural preferences and political priorities very diverse in EU countries
- European Commission keen to develop common and political framework for innovation policy in Europe (EC, 1996)
- Scoreboard focuses on high-tech innovation and provision of indicators for tracking EU's progress towards Lisbon goal
- EIS nowadays accumulated considerable quantities of information about innovation indicators

3. Limitations European Innovation Scoreboard: towards a new framework

- List and number of indicators undergone major changes over time (EIS, 2007), as result analysis of EIS data often concerned with incomplete knowledge, manipulation of data, and so on
- Relationships and patterns within data can provide new knowledge about innovation performance in the different EU countries (Zhong and Skowron, 2001; Cios et al. 1998)
- Intelligence techniques of data analysis often unable to derive conclusions from incomplete knowledge or inconsistent or manipulated pieces of information
- Rough set analysis useful as clarifying exploratory tool, especially for complex issues as innovation performance which is dependent on many different factors
- Advantages: 1) does not need preliminary or additional information about data; 2) inconsistencies in database not corrected, but instead produced classification rules are categorized in certain and possible

4. Rough set analysis with Rough Set Data Explorer (ROSE)

- Artificial intelligence technique
- Qualitative exploratory correlation analysis for small samples
- Rough set: set for which classification of group of certain objects is not certain
- Approach: 1) preprocessing with tasks like data completeness, attribute creation, selection and discretization; 2) processing by generation of preliminary knowledge such as derivation of rules and classification process
- Goal: generation of rules from information or decision system of innovation database



Information table

Object	Condition variable	Conditon variable	Decision variable
1	1	2	3
2	3	1	2
3	1	3	3

Overview of European Innovation Scoreboard dimensions and indicators used for our rough set analysis

European Innovation Scoreboard (2007)	1 st RSA	2 nd RSA
INPUT – Innovation Drivers		+
S&E graduates (per 1000 population aged 25-64)	+	
Population with tertiary education (per 100 population aged 25-64)	+	
Broadband penetration rate (number of broadband lines per 100 population)		
Participation in life-long learning (per 100 population aged 25-64)		
Youth education attainment level (% aged 20-24 with at least upper secondary education)		
INPUT-Knowledge Creation		+
Public R&D expenditures (% of GDP)	+	
Business R&D expenditures (% of GDP)	+	
Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditure)		
Share of enterprises receiving public funding for innovation (Community Innovation Survey)		
INPUT – Innovation & Entrepreneurship		+
SMEs innovating in-house (% of SMEs)		
Innovative SMEs co-operating with others (% of SMEs)		
Innovation expenditures (% of turnover)	+	
Early stage venture capital (% of GDP)		
ICT expenditures (% of GDP)	+	
SMEs using organizational innovation (% of SMEs)		
OUTPUT – Applications		+
Employment in high-tech services (% of total workforce)	+	
Exports of high technology products as a share of total exports		
Sales of new-to-market products (% of turnover)		
Sales of new-to-firm products (% of turnover)		
Employment in medium-high and high-tech manufacturing (% of total workforce)	+	
OUTPUT – Intellectual Property		+
EPO patents per million population		
USPTO patents per million population		
Triad patents per million population		
Community trademarks per million population		
Community industrial designs per million population		

4.1 Rough set analysis of expenditures and employment

Find out:

- Have R&D investments carried out by different sectors - private, public and higher education - different impacts on innovation output in the form of employment in high tech services and medium and high tech manufacturing? Which forms of expenditures influence differences in employment?

Dataset:

- 21 EU member states: Austria, Cyprus, Finland, Latvia, Slovenia, and UK were omitted due to missing data

Categories:

- (3) high, (2) medium, (1) low development

Rules for employment in high tech services

Conditions	Strength of rules	Number of countries*	Generalization
Rule 1. A1=1, A2=1, A3=2 / D=1	100%	2 (Romania, Slovakia)	IF public R&D expenditures = 0-0.33; business R&D expenditures = 0-0.80; and innovation expenditures = 0-1.14 THEN employment in high tech services = 0.1.82
Rule 2. A1=2, A2=1 / D=2	69.23%	9 (Bulgaria, Estonia, Greece, Hungary, Italy, Lithuania, Poland, Portugal, Spain)	IF public R&D expenditures = 0.34-0.66; business R&D expenditures = 0-0.80; innovation expenditures = 2.33-3.50; population with tertiary education = 13.33-26.66; and S&E graduates = 0-8.32 THEN employment in high tech services = 1.83-3.66
Rule 3. A6=1 / D=2	30.77%	4 (Czech Republic, Hungary, Luxembourg, Malta)	
Rule 4. A3=3, A5=2 / D=2	15.38%	2 (Germany, Greece)	
Rule 5. A2=2, A5=3 / D=3	66.67%	4 (Belgium, Denmark, Ireland, Netherlands)	
Rule 6. A2=3 / D=3	16.67%	1 (Sweden)	
Rule 7. A1=3, A6=3 / D=3	16.67%	1 (France)	
Rule 8. A1=3, A2=3 / D=3	16.67%	1 (France)	
Accuracy of classification	1.0000		
Quality of classification	1.0000		
Core set	A1 (public R&D expenditures), A5 (population with tertiary education)		
Quality of core	0.4762		
Strength of rules	Rule 1 (100%), including Romania and Slovakia Rule 2 (69.23%), including Bulgaria, Estonia, Greece, Hungary, Italy, Lithuania, Poland, Portugal, Spain Rule 5 (66.67%), including Belgium, Denmark, Ireland, Netherlands		

*N: 21

Summary of rough set results with decision variable: employment in high-tech services

	Public R&D expenditures	Business R&D expenditures	Innovation expenditures	ICT expenditures	Population with tertiary education	S&E graduates	Employment in high tech services
Belgium		0			+		+
Bulgaria	0	-					0
Czech Republic						-	0
Denmark		0			+		+
Estonia	0	-					0
France	+					+	+
Germany			+		0		0
Greece	0	-	+		0		0
Hungary	0	0				-	0
Ireland		0			+		+
Italy	0	0					0
Lithuania	0	-					0
Luxembourg						-	0
Malta						-	0
Netherlands		0			+		+
Poland	0	-					0
Portugal	0	-					0
Romania	-	-	0				-
Slovakia	-	-	0				-
Spain	0	-					0
Sweden		+					+

- (low development); 0 (medium development); + (high development)

Rules of employment in medium and high tech manufacturing

Conditions	Strength of rules	Number of countries*	Generalization
Rule 1. A4=2, A5=3, A6=3 / D=1	16.67%	1 (Lithuania)	IF public R&D expenditures = 0-0.33, 0.34-0.66 or 0.67-1; business R&D expenditures = 0-0.8 or 0.9-1.9; innovation expenditures = 1.15-2.32 or 2.33-3.5; ICT expenditures = 5.9-7.9 or 8-10; tertiary education = 26.67-40; and S&E graduates = 16.67-25 THEN employment in manufacturing = 0-4.14
Rule 2. A1=1, A2=2 / D=1	16.67%	1 (Luxembourg)	
Rule 3. A1=3, A3=2, A5=3 / D=1	16.67%	1 (Netherlands)	
Rule 4. A2=1, A3=3 / D=1	16.67%	1 (Greece)	
Rule 5. A1=2, A4=3, A5=3 / D=1	16.67%	1 (Estonia)	
Rule 6. A3=3, A5=3 / D=2	18.18%	2 (Denmark, Sweden)	
Rule 7. A3=1 / D=2	27.27%	3 (Bulgaria, Malta, Spain)	
Rule 8. A2=2, A6=3 / D=2	18.18%	2 (France, Ireland)	
Rule 9. A5=1 / D=2	27.27%	3 (Italy, Malta, Romania)	
Rule 10. A1=2, A2=2, A5=3 / D=2	18.18%	2 (Belgium, Ireland)	
Rule 11. A2=2, A3=3, A5=2 / D=3	25.00%	1 (Germany)	
Rule 12. A1=2, A6=1 / D=3	50.00%	2 (Czech Republic, Hungary)	
Rule 13. A1=1, A2=1, A4=2 / D=3	25.00%	1 (Slovakia)	
Approximate rules			
Rule 14. A1=2, A2=1, A4=2, A5=2 / D=1 OR D=2	100.00%	2 (Portugal (-), Poland (0))	IF public R&D = 0-0.33, 0.34-0.66 or 0.34-0.66; business R&D = 0-0.8 or 0.9-1.9; innovation expenditures = 2.33-3.5; ICT expenditures = 5.9-7.9; tertiary education = 13.33-26.66; and S&E graduates = 0-8.32 THEN employment in manufacturing = 8.33-12.5
Accuracy of classification	between 0.7143 and 1.0000		
Quality of classification	0.9048		
Core set	A1 (public R&D expenditures), A3 (innovation expenditure), A5 (tertiary education)		
Quality of core	0.5238		
Strength of rules	Rule 7 (27.27%), including Bulgaria, Malta, Spain Rule 9 (27.27%), including Italy, Malta, Romania Rule 12 (50.00%), including Czech Republic, Hungary		

Summary of rough set results with decision variable: employment in medium-tech/high-tech manufacturing

	Public R&D expenditures	Business R&D expenditures	Innovation expenditures	ICT expenditures	Population with tertiary education	S&E graduates	Employment medium and high-tech manufacturing
Belgium	0	0			+		0
Bulgaria			-				0
Czech Republic	0					-	+
Denmark			+		+		0
Estonia	0			+	+		-
France		0				+	0
Germany		0	+		0		+
Greece		-	+				-
Hungary	0					-	+
Ireland	0	0			+	+	0
Italy					-		0
Lithuania				0	+	+	-
Luxembourg	-	0					-
Malta			-		-		0
Netherlands	+		0		+		-
Poland	0	-		0	0		0
Portugal	0	-		0	0		-
Romania					-		0
Slovakia	-	-		0			+
Spain			-				0
Sweden			+		+		0

- (low development); 0 (medium development); + (high development)

Investigating relative importance of attributes on level employment for countries

N=21	Employment in high-tech services			Quality of classifications	Employment in med-tech/ high-tech manufacturing			Quality of classifications
	low	medium	high		low	medium	high	
With core attributes	2	15	6	1.000	5(1)	12(1)	4	0.905
With a temporarily reduced condition attribute								
Public R&D expenditures	1(1)	15(2)	7	0.857	3(3)	10(2)	2(2)	0.667
Business R&D expenditures	2	19	9	1.000	5(1)	12(1)	4	0.905
Innovation expenditures	2	14	6	1.000	4(2)	11(2)	4	0.810
ICT expenditures	2	15	6	1.000	5(1)	12(1)	4	0.905
Tertiary education	2	13(1)	5(1)	0.905	5(1)	11(2)	3(1)	0.810
S&E graduates	2	21	7	1.000	5(1)	11(1)	4	0.905

() Approximate rules

4.2 Rough set analysis of innovation performance

Find out:

- What is the role of the different factors on overall degree of innovativeness (based on 2007 Summary Innovation Index)?

Dataset:

- 26 EU member states: Slovenia was omitted due to missing data

Categories:

- (5) high degree of innovativeness between 1.00-0.81, (4) medium-high degree between 0.80-0.61, (3) medium degree between 0.60-0.41, (2) medium-low degree between 0.40-0.21, (1) low degree between 0.20-0.00

Rules overall innovation performance based on the Rough Set Analysis

Conditions	Strength of rules	Number of countries**	Generalization*
Rule 1. A1=2,A2=1,A3=2 / D1	100%	2 (Latvia, Romania)	IF Innovation drivers = 0,21-0,40; Knowledge creation = 0,00-0,20; and Innovation & entrepreneurship = 0,21-0,40 THEN overall innovation performance=0,00-0,20
Rule 2. A2=2 / D2	53.85%	7 (Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Poland, Spain)	IF Innovation drivers = 0,00-0,20 or 0,41-0,60; Knowledge creation = 0,21-0,40; Innovation & entrepreneurship = 0,00-0,20 or 0,21-0,40; and Intellectual property = 0,00-0,21 or 0,21-0,40 THEN overall innovation performance = 0,21-0,40
Rule 3. A1=3, A5=1 / D2	23.08%	3 (Estonia, Lithuania, Spain)	
Rule 4. A1=1 / D2	15.38%	2 (Malta, Portugal)	
Rule 5. A3=1 / D2	7.69%	1 (Slovakia)	
Rule 6. A3=2, A5=2 / D2	7.69%	1 (Italy)	
Rule 7. A4=3, A5=2 / D3	50.00%	4 (Belgium, France, Ireland, UK)	IF Applications = 0,21-0,40 or 0,41-0,60; and Intellectual property = 0,21-0,40 or 0,41-0,60 or 0,61-0,80 THEN overall innovation performance 0,41-0,60
Rule 8. A4=2, A5=3 / D3	25.00%	2 (Austria, Netherlands)	
Rule 9. A5=4 / D=3	25.00%	2 (Germany, Luxembourg)	
Rule 10. A4=3, A5=3/ D4	100.00%	3 (Denmark, Finland, Sweden)	IF Applications = 0,41-0,60; and Intellectual property = 0,41-0,60 THEN overall innovation = 0,61-0,80
Accuracy of classification	1.0000		
Quality of classification	1.0000		
Core set	A1 (Innovation drivers), A2 (Knowledge creation)		
Quality of core	0.8077		
Strength of rules	Rule 1 (100%), including Latvia, Romania Rule 2 (53.85%), including Bulgaria, Cyprus, Czech Republic, Greece, Hungary, Poland, Spain Rule 10 (100%), including Denmark, Finland, Sweden		

** For calculating the dimensions, the indicator data of the EIS are re-scaled (see <http://www.proinno-europe.eu/> for more detail). The maximum re-scaled score is equal to 1 and the minimum value is equal to 0.

*N=26

Summary of rough set results with decision variable: overall innovation performance

	Innovation drivers	Knowledge creation	Innovation & entrepreneurship	Applications	Intellectual property	Innovation performance
Austria				-	0	0
Belgium				0	-	0
Bulgaria		-				-
Cyprus		-				-
Czech Republic		-				-
Denmark				0	0	+
Estonia	0				--	-
Finland				0	0	+
France				0	-	0
Germany					+	0
Greece		-				-
Hungary		-				-
Ireland				0	-	0
Italy			-		-	-
Latvia	-	--	-			--
Lithuania	0				--	-
Luxembourg					+	0
Malta	--					-
Netherlands				-	0	0
Poland		-				-
Portugal	--					-
Romania	-	--	-			--
Slovakia			--			-
Spain	0	-			--	-
Sweden				0	0	+
UK				0	-	0

-- (0,00-0,20); - (0,21-0,40); 0 (0,41-0,60); + (0,61-0,80); ++ (0,81-1,00)

	MCA
Austria	20
Belgium	17
Bulgaria	2
Cyprus	13
Czech Republic	12
Denmark	24
Estonia	11
Finland	26
France	18
Germany	25
Greece	7
Hungary	9
Ireland	21
Italy	16
Latvia	4
Lithuania	5
Luxembourg	22
Malta	8
Netherlands	19
Poland	6
Portugal	10
Romania	1
Slovakia	3
Slovenia	14
Spain	15
Sweden	27
UK	23

Investigating relative importance attributes on innovativeness of countries

N=26	Overall innovation performance					Quality of classifications
	low	medium-low	medium	medium-high	high	
With core attributes	2	13	8	3	0	1.0000
With a temporarily reduced condition attribute						
Innovation drivers	1(1)	13(1)	8	3	0	0.9231
Knowledge creation	1(1)	13(2)	9	3	0	0.8846
Innovation & entrepreneurship	2	14	8	3	0	1.0000
Applications	2	14	9	3	0	1.0000
Intellectual property	2	13	9	3	0	1.0000

() Approximate rules

5. Conclusions

- Measuring innovation performance should be done with care
- Innovation performance different per culture, per level of development, per sector and basically per country
- Results of different exploratory analyses however show consistency and overlap
- Countries with lower innovativeness should focus on improving their input factors, whereas higher growth countries should concentrate on output factors to achieve more innovativeness
- With regards to countries with low innovativeness distinction should be made between new member states and southern European countries
- Difference between Scandinavian and other high growth countries is mainly lack of intellectual property of latter group
- Further research into effect innovation output factors for these countries necessary in order to validate results

6. Policy implications

- New member states benefit especially from public R&D expenditures (i.e. strengthening of public institutions), whereas for southern European countries investments in business R&D expenditures seems important
- For countries with high level of innovativeness, business R&D expenditures and innovation expenditures on firm level are most effective
- Level of population with tertiary education considerable effect on innovation performance
- Support for human capital as important push factor of economic growth, especially in light of production of highest share of high-tech employment in Europe by service sectors
- Especially for developed countries public R&D expenditures should consist mainly of expenditures on education



THANK YOU