R&D, spillovers, innovation systems and the genesis of regional growth in Europe

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Rural Development Conference
Edinburgh, 19 October 2006

Approaches to the analysis of innovation

- **How can innovation and growth be generated in the periphery of Europe?**
- **3 traditional approaches:**
  1. **The 'linear model'**
     - Analysis of the link between R&D, patents and growth
       - Fundamentally quantitative (econometric analysis)
       - Conducted mainly by 'mainstream' economists
  2. **The 'systems of innovation' approach**
     - Analysis of the 'territorially-embedded' institutional networks that favour the generation of innovation
     - The capacity to set these networks depends in turn, on a series of social and structural conditions ('the social filter')
       - Fundamentally qualitative
       - Conducted mainly by geographers, evolutionary economists, and some economic sociologists
  3. **Knowledge spillovers**
     - Look at the diffusion and assimilation of innovation
       - Quantitative and qualitative
       - Economists and geographers

Aim of the paper

- **Little interaction and/or cross-fertilization**
  1. Different methods
  2. Difficulties in operationalizing institutional networks
  3. Huge gap in the literature
- **To contribute to fill this gap by:**
  1. Including in a simple model
     - Linear R&D approaches
     - Innovation systems (proxied by the 'social filter')
     - Spillovers
  2. For all regions in the EU-25
  3. Between 1995-2003

Structure of the presentation

- Theoretical background
- Model
- Dataset
- Empirical results
- Conclusions

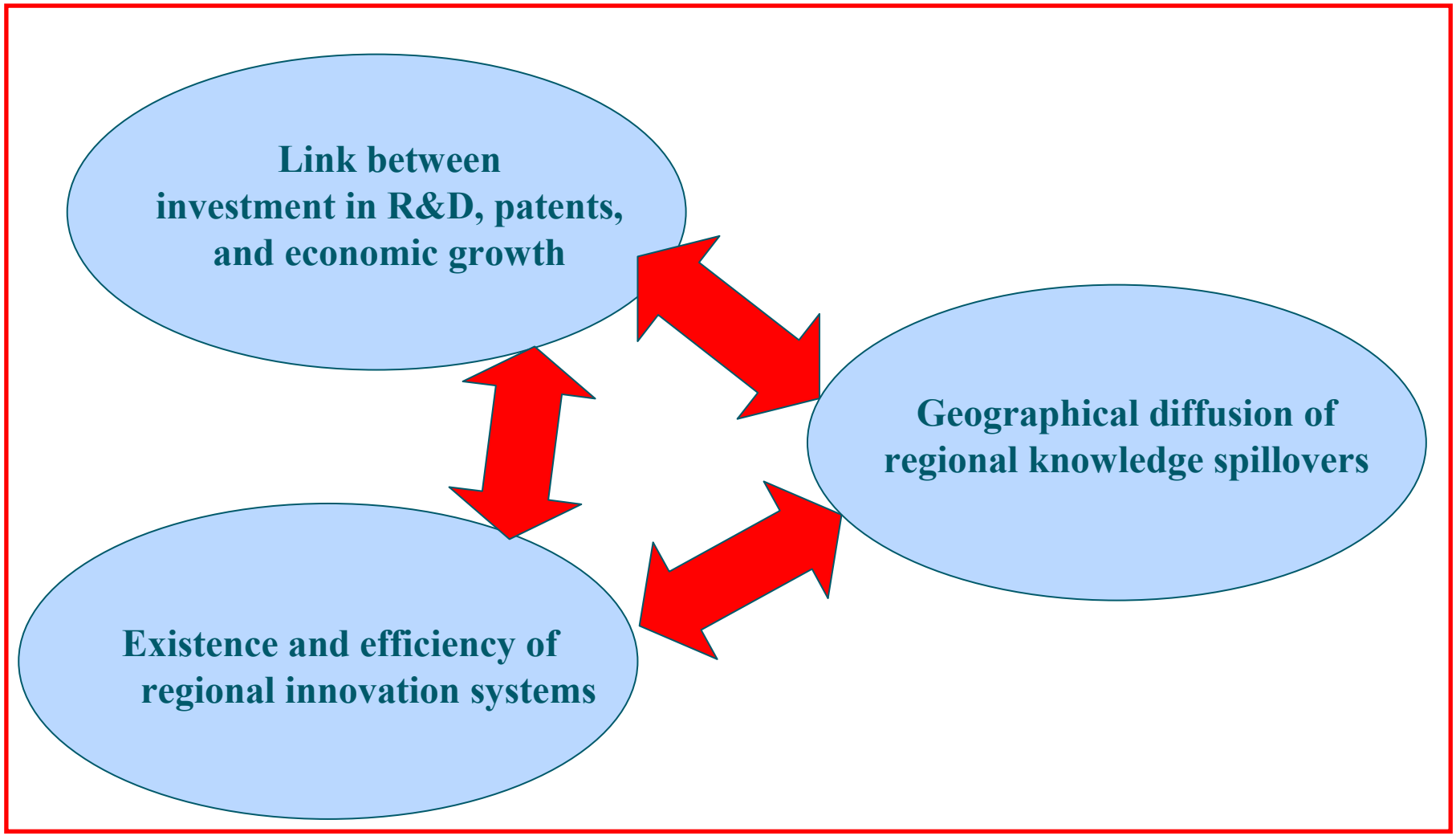
Theoretical background

Link between investment in R&D, patents, and economic growth.
(Fagerberg 1988, 1994 and 1997; Grossman and Helpman 1991;Maurseth and Verspagen 1999)

Geographical diffusion of regional knowledge spillovers;
(Anselin et al. 1997, Adams and Jaffe 2002; Audretsch and Feldman 2003, Leamer and Storper 2001, Storper and Venables 2004, Sonn and Storper 2005)

Existence and efficiency of regional innovation systems.
(Camagni 1995, Becattini 1987, Morgan 1997 and 2004, Cooke et al. 1997, Iammarino 2005, Rodriguez-Pose 1999)

Theoretical background



The model

	Endogenous	**Spillovers**
R&D	Investment in R&D in the region	Investment in R&D in neighbouring regions
Regional systems of innovation	Regional system of innovation	Regional system of innovation in neighbouring regions
GDP per capita	As a proxy for initial conditions and potential	Initial conditions in neighbouring regions
National effect	Controlled for by a set of National Dummies	

The model II

$$\frac{1}{J}\ln\left(\frac{Y_{i,t}}{Y_{i,t-J}}\right)=\alpha+\beta_1\ln(y_{i,t-J})+\beta_2 RD_{i,t-j}+\beta_3 SocFilter_{i,t-J}+\beta_4 Spillov_{i,t-j}+\beta_5 ExtSocFilter_{i,t-J}+\beta_6 ExtGDPcap_{i,t-J}+\beta_7 D+\varepsilon$$

where:

$\frac{1}{J}\ln\left(\frac{Y_{i,t}}{Y_{i,t-J}}\right)$ is the usual logarithmic transformation of the ratio of regional per capita GDP in region *i* at the two extremes of the period of analysis (t-J,t);

α is a constant;

$\ln(y_{i,t-J})$ is the log of the GDP per capita of region *i* at the beginning of the period of analysis (t-J);

RD_{t-j} is expenditure in R&D as a % of GDP in region *i* at time (t-J);

$SocFilter_{i,t-J}$ is a proxy for the socio-economic conditions of region *i* representing its "social filter";

$Spillov_{i,t-j}$ is a measure of accessibility to extra-regional sources of innovation;

$ExtSocFilter_{i,t-J}$ is a measure of the "social filter" of neighbouring regions;

$ExtGDPcap_{i,t-J}$ is a measure of the GDP per capita in neighbouring regions

D is a set of national dummy variables;

ε is the error term.

Dataset

- **EUROSTAT New Cronos-Regio data.**
- **Regional division**
  1. NUTS1 regions for Germany, Belgium and the UK
  2. NUTS2 for all other countries (Spain, France, Italy, the Netherlands, Greece, Austria, Portugal, Finland, Czech Republic, Hungary, Poland, Slovakia).
  3. Uniregional countries (Denmark, Ireland, Luxemburg, Estonia, Latvia, Lithuania, Slovenia, Malta and Cyprus) excluded
  4. Regional data on R&D expenditure are not available in the Eurostat databank for Sweden.
  5. Total of 166 regions
- **Time span: 1995-2003**

Empirical results (I)

Table 3 - H-C OLS estimation of the empirical model. R&D, social filter and knowledge spillovers

	1	2	3	4	5	6	7	8	9	10	11	12
Constant	0.12284***	0.09406***	0.12182***	0.1126***	0.10707***	0.09655***	0.08491***	0.08989***	0.10777***	0.12054***	0.12187***	0.12059***
	(0.02814)	*(0.02572)*	*(0.02796)*	*(0.02563)*	*(0.02561)*	*(0.02671)*	*(0.03019)*	*(0.0292)*	*(0.02709)*	*(0.02802)*	*(0.02805)*	*(0.02809)*
Log GDP 95	-0,005756	-0,003098	-0.00663*	-0.00574*	-0,005112	-0,003359	-0,00196	-0,002733	-0,004345	-0.006577*	-0.006349*	-0.007705*
	(0.00353)	*(0.003255)*	*(0.003543)*	*(0.003267)*	*(0.003268)*	*(0.003346)*	*(0.003803)*	*(0.003478)*	*(0.003339)*	*(0.003571)*	*(0.003668)*	*(0.003929)*
R&D expenditure	0,1424	0.2682**	0,1791	0,1366	0,166	0.2556**	0.2664**	0.2653**	0.2548**	0,1883	0,177	0,1909
	(0.1207)	*(0.1174)*	*(0.1218)*	*(0.1212)*	*(0.1208)*	*(0.1229)*	*(0.1177)*	*(0.1182)*	*(0.1172)*	*(0.1213)*	*(0.1223)*	*(0.1234)*
Social Filter Index	0.01052**		0.010787**								0.010538**	0.011422**
	(0.004626)		*(0.004598)*								*(0.004682)*	*(0.004713)*
Accessibility to ExtraRegional Innovation		0,013236	0.01387*	0.013157*	0.013733*	0.012717*	0,012262	0,013353	0.013807*	0.014184*	0.013936*	0.014229*
		(0.008148)	*(0.008031)*	*(0.007908)*	*(0.007975)*	*(0.0083)*	*(0.008336)*	*(0.008182)*	*(0.008119)*	*(0.008052)*	*(0.008059)*	*(0.008067)*
National Dummies	x	x	x	x	x	x	x	x	x	x	x	x
Social Filter Individual Components:												
Education Population				0.017003***								
				(0.005341)								
Education Labour Force					0.019224***							
					(0.006986)							
Life-Long Learning						0,00385						
						(0.01076)						
Agricultural Labour Force							0,003802					
							(0.006528)					
Long Term Unemployment								0,001892				
								(0.006205)				
Young People									-0,009089			
									(0.005882)			
Extra-Regional Social Filter												
Total accessibility to innovation prone space										0.012617***		
										(0.005656)		
Accessibility to Innovation Prone Extra-Regional areas											-0,00808	
											(0.0261)	
Accessibility to wealth neighbouring regions												0,00000088
												(0.00000138)
R-Sq	0,665	0,659	0,672	0,681	0,676	0,66	0,66	0,659	0,665	0,67	0,672	0,672
R-Sq (adj)	0,626	0,62	0,631	0,642	0,636	0,618	0,618	0,618	0,624	0,63	0,629	0,63
F	17,27	16,84	16,7	17,45	17,03	15,82	15,85	15,81	16,19	16,61	15,72	15,77
Moran's I	-0,0185667	-0,0193012	-0,0189041	-0,0194612	-0,0198153	-0,0193265	-0,0198503	-0,0195195	-0,0199182	-0,0188243	-0,0188376	-0,0189403

*, ** and *** denote significance a ta 10%,5% and 1% level respectively. SE in parantheses

Empirical results (II)

Table 4 - H-C OLS estimation of the empirical model: accessibility to innovation

	1	2	3	4	5	6	7	8	9	10	11	12
Constant	0.12182***	0.134***	0.12317***	0.12551***	0.12107***	0.12176***	0.1216***	0.12116***	0.09082***	0.09202***	0.08063***	0.09103***
	(0.02796)	*(0.02838)*	*(0.02822)*	*(0.02844)*	*(0.028)*	*(0.02799)*	*(0.02799)*	*(0.028)*	*(0.02532)*	*(0.02533)*	*(0.02512)*	*(0.02533)*
Log GDP 95	-0.00663	-0.007635**	-0.006016*	-0,005813	-0,005554	-0,005661	-0,005642	-0,005572	-0,001745	-0,001913	-0,000093	-0,001779
	(0.003543)	*(0.003612)*	*(0.003571)*	*(0.003537)*	*(0.003506)*	*(0.003506)*	*(0.003505)*	*(0.003506)*	*(0.003166)*	*(0.003168)*	*(0.003078)*	*(0.003168)*
R&D expenditure	0,1791	0,1486	0,1458	0,1475								
	(0.1218)	*(0.1194)*	*(0.1211)*	*(0.1211)*								
Social Filter Index	0.010787**	0.01074**	0.01101**	0.010379**	0.01081**	0.010656**	0.010685**	0.010782**				
	(0.004598)	*(0.004579)*	*(0.004724)*	*(0.004638)*	*(0.00455)*	*(0.004538)*	*(0.004538)*	*(0.00455)*				
Accessibility to ExtraRegional Innovation												
Continous Space	0.01387*											
	(0.008031)											
180 minutes cutoff		0.00983**										
		(0.00481)										
300 minutes cutoff			0,002556									
			(0.004712)									
600 minutes cutoff				-0,005154								
				(0.007263)								
Total accessibility to Innovation (Extra+Intra regional)												
Continous Space					0,005349				0.008264*			
					(0.004505)				*(0.004401)*			
180 minutes cutoff						0,006191				0.009091**		
						(0.004619)				*(0.004518)*		
300 minutes cutoff							0,006103				-0,000643	
							(0.004628)				*(0.004707)*	
600 minutes cutoff								0,005447				0.00836*
								(0.004506)				*(0.004402)*
National Dummies	x	x	x	x	x	x	x	x	x	x	x	x
R-Sq	0,672	0,674	0,666	0,666	0,665	0,666	0,666	0,665	0,652	0,653	0,644	0,652
R-Sq (adj)	0,631	0,634	0,625	0,625	0,626	0,627	0,627	0,627	0,615	0,616	0,606	0,615
F	16,7	16,89	16,25	16,28	17,27	17,34	17,33	17,28	17,46	17,55	16,84	17,47
Moran's I	-0,018904	-0,019629	-0,018612	-0,019055	-0,018991	-0,01924	-0,01919	-0,018993	-0,018867	-0,01915	-0,016545	-0,01886

*, ** and *** denote significance a ta 10%,5% and 1% level respectively. SE in parentheses

R&D, social filter, and spillovers

Investment in R&D positive and statistically significant

Relying on your own investment, better than hoping for a free-ride

H-C OLS estimation o[illegible]he empirical model. R&D, social filter and l[illegible]w

	2	
Constant	0.09406***	0[illegible]182***
	(0.02572)	*(0.02796)*
Log GDP 95	-0.0030[illegible]	-0.00663*
	(0.003255)	*(0.003543)*
R&D expenditure	0.2682**	0.1791
	(0.1174)	*(0.1218)*
Social Filter Index		0.010787**
		(0.004598)
Accessibility to ExtraRegional Innovation	0.013236	0.01387*
	(0.008148)	*(0.008031)*

*, ** and *** denote significance at a 10%,5% and 1% level respectively. SE in parantheses

But its impact is conditioned by the 'social filter'

The 'social filter' enhances the capacity to assimilate knowledge spillovers

Full table

The role of "Social Filter"

H-C OLS estimation of the empirical model. R&D, social filter and knowledge spillovers

	3	4	5	11
Constant	0.12182***	0.1126***	0.10707***	0.12187***
	(0.02796)	*(0.02563)*	*(0.02561)*	*(0.02805)*
Log GDP 95	-0.00663*	-0.00574*	-0.005112	[illegible]9*
	(0.003543)	*(0.003267)*	*(0.003[illegible]*	*(0.003668)*
R&D expenditure	0.1791	0.1366	[illegible]166	0.177
	(0.1218)	*(0.1[illegible]*	*(0.1208)*	*(0.1223)*
Social Filter Index	0.010787**			0.010538**
	(0.004598)			*(0.004682)*
Accessibility to ExtraRegional Innovation	0.01387*	0.013157*	0.013733*	0.013936*
	(0.008031)	*(0.007908)*	*(0.007975)*	*(0.008059)*
Social Filter Individual Components:				
Education Population		0.017003***		
		(0.005341)		
Education Labour Force			0.019224***	
			(0.006986)	
Extra-Regional Social Filter				
Accessibility to Innovation Prone Extra-Regional areas				-0.00808
				(0.0261)

The social filter index is always significant

But the significance comes down to education

The socio-economic conditions of neighbouring regions do NOT influence local performance

Knowledge spillovers

$$\frac{1}{J}\ln\left(\frac{Y_{i,t}}{Y_{i,t-J}}\right) = \alpha + \beta_1 \ln(y_{i,t-J}) + \beta_2 RD_{i,t-j} + \beta_3 SocFilter_{i,t-J} + \beta_4 Spillov_{i,t-j} + \beta_5 ExtSocFilter_{i,t-J} + \beta_6 ExtGDPcap_{i,t-J} + \beta_7 D + \varepsilon$$

Accessibility to ExtraRegional Innovation

Continous Space	0.01387* *(0.008031)*
180 minutes cutoff	0.00983** *(0.00481)*
300 minutes cutoff	0,002556 *(0.004712)*
600 minutes cutoff	-0,005154 *(0.007263)*

Knowledge spillovers are significant in explaining regional growth performance

But strong distance decay effects

Full table

Social Filter: a definition

- **A complex set of economic, social, political and institutional features that determine the capacity of every society to translate innovation into economic activity**

- **The 'social filter' contributes to make regions 'innovation prone' and others innovation averse'**

- **The "social filter" is a assumed as a proxy for the set of "conditions that render some courses of action easier than others" (Morgan 2004) thus making "innovation prone" interactions and institutions more likely in certain localities than in others.**

Social Filter Index: PC analysis

Principal Component Analysis

Tab.2a - Principal Component Analysis: Eigenanalysis of the Correlation Matrix

	PC1	*PC2*	*PC3*	*PC4*	*PC5*	*PC6*
Eigenvalue	2.5886	1.2723	0.9083	0.6418	0.5661	0.0229
Proportion	0.431	0.212	0.151	0.107	0.094	0.004
Cumulative	0.431	0.643	0.795	0.902	0.996	1

Tab2b - Principal Component Analysis: Principal Components's Coefficients

Variable	*PC1*	*PC2*
Education Population	0.576	-0.224
Education Labour Force	0.554	-0.313
Life-Long Learning	0.395	0.26
Agricultural Labour Force	-0.43	-0.285
Long Term Unemployment	-0.14	-0.459
Young People	0.019	0.701

Our measure for regional spillovers

The index is a potential measure of the "innovative activities" (in terms of nationally weighted millions of Euros invested in R&D activities) that can be "reached" from each region at a "cost" which increases with distance.

$$A_i = \sum_j g(r_j) f(c_{ij})$$

Where A_i is the accessibility of region i, r_j is the activity R to be reached in region j, c_{ij} is the generalised cost of reaching region j from region I and g(·) and f(·) are "activity" function (i.e. the activities/resources to be reached) and "impedance" function (i.e the effort, cost/opportunity to reach the specific activity) respectively.

$$f(c_{ij}) = w_{ij} = \frac{\frac{1}{d_{ij}}}{\sum_j \frac{1}{d_{ij}}}$$

where d_{ij} is the average trip-length (in minutes) between region *i* and *j*.

Conclusions

- **R&D investment helps explain differential regional growth patterns;**

HOWEVER

- **A variety of socio-economic factors influence the capacity of a regional space to "translate" innovation into economic growth;**
- **Knowledge flowing from neighbouring regions improves regional growth performance;**
- **Spillovers are geographically bounded and they decay with distance;**
- **Policy implications:**
  1. Innovation policies with human capital policies are mutually reinforcing
  2. Regions with good endowments of human capital, but weak R&D investment can achieve innovation
  3. The opposite case is less likely
  4. In cases of areas well below the technological threshold, human capital policies are the best way to assimilate innovation and reap technological spillovers