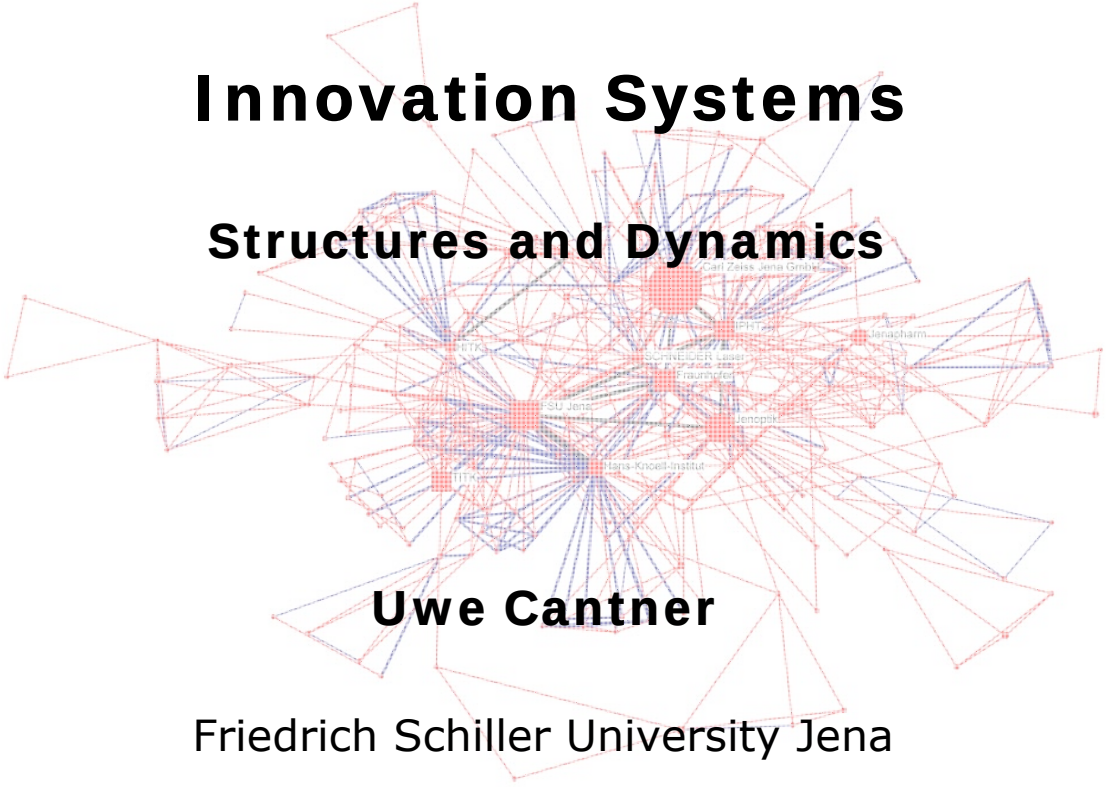
Innovation Systems

Structures and Dynamics



Uwe Cantner

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Alessandria, January 28, 2010

Introduction

- Schumpeter and systemic innovation
  - Schumpeter I&II
  - Schumpeter J (Imai/Yamazaki 1994)

- Collective invention (Allen 1983, von Hippel 1987)

- Systemic Innovation Approach
  - national innovation systems (Freeman et al. 1988, Lundvall 1992, Nelson 1992)
  - technological systems (Carlsson & Stankiewicz 1991)
  - sectoral innovation systems (Malerba & Orsenigo 1997)
  - regional innovation systems (Cooke 1992)
  - local innovation systems (Breschi & Lissoni 2001)
  - urban innovation systems (Fischer et al. 2001)

- Examples
  - Silicon Valley, Japan, Wissenschaftsstadt Ulm, Sophia Antipolis, Science City Jena

THEORY

Knowledge transmission I

- Character as an economic good
  - public (Arrow 1962)
  - latent public (Nelson 1990)
  - private / tacit knowledge (Polany 1967)

- Knowledge dissemination and transfer

  - Mode of transmission
    - market
    - hierarchy
    - network

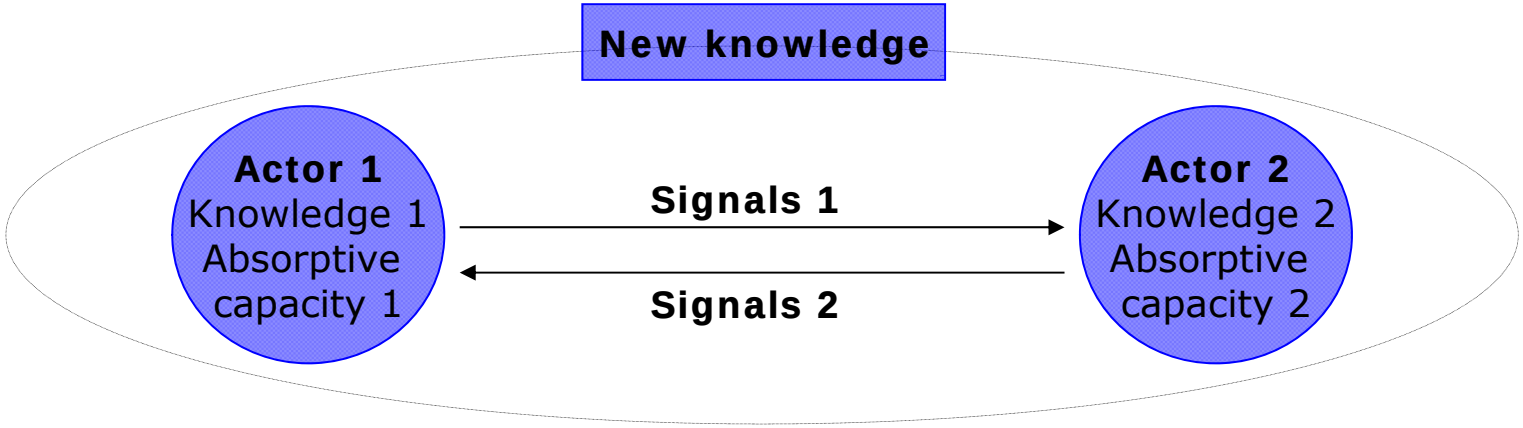
  - "Quantity" of transmission
    - sender (outgoing spillovers): willingness and abilities to communicate/codify
    - recipient (incoming spillovers): absorptive capacities (Cohen/Levinthal 1989)

  - Proximity concepts (Boschma 2005)

Knowledge transmission II

- Innovative actors and collective invention – cooperative innovation
  - bounded rational (Simon 1957) ➔ trial-and-error
  - resource based view of the firm (Penrose 1959, Wernerfeld 1984, Barney 1991) and extensions (Teece et al. 1992)
  - get access to external knowledge
    - external R&D
    - integration of innovative activities by M&A
    - collective invention/ cooperative innovation
      - reducing risk and sharing R&D costs (Deeds & Hill 1996, Baum et al. 2000)
      - combining complementary assets (Teece 1986, Nooteboom 1999)
      - internalizing spillovers (Griliches 1992), knowledge exchange, interactive learning

Knowledge transmission III



- Conditions for interactive learning and collective invention/innovation
  - Getting into contact
    - Who?
  - Generic potential
    - How endowed?
    - Understanding?
  - Control of the relationship
    - Control and / or trust
    - Tacit knowledge components and face-to-face

Proximity concepts

Boschma (2005)

Knowledge transmission IV

- Cognitive or technological proximity
  - Common understanding
    - Technological overlap and absorptive capacities
    - Generic potential
  - Horizontal structures, vertical structures, Jacobs structures

- Organizational proximity
  - Mode of know-how transfer
    - Market
    - Network
    - Hierarchy

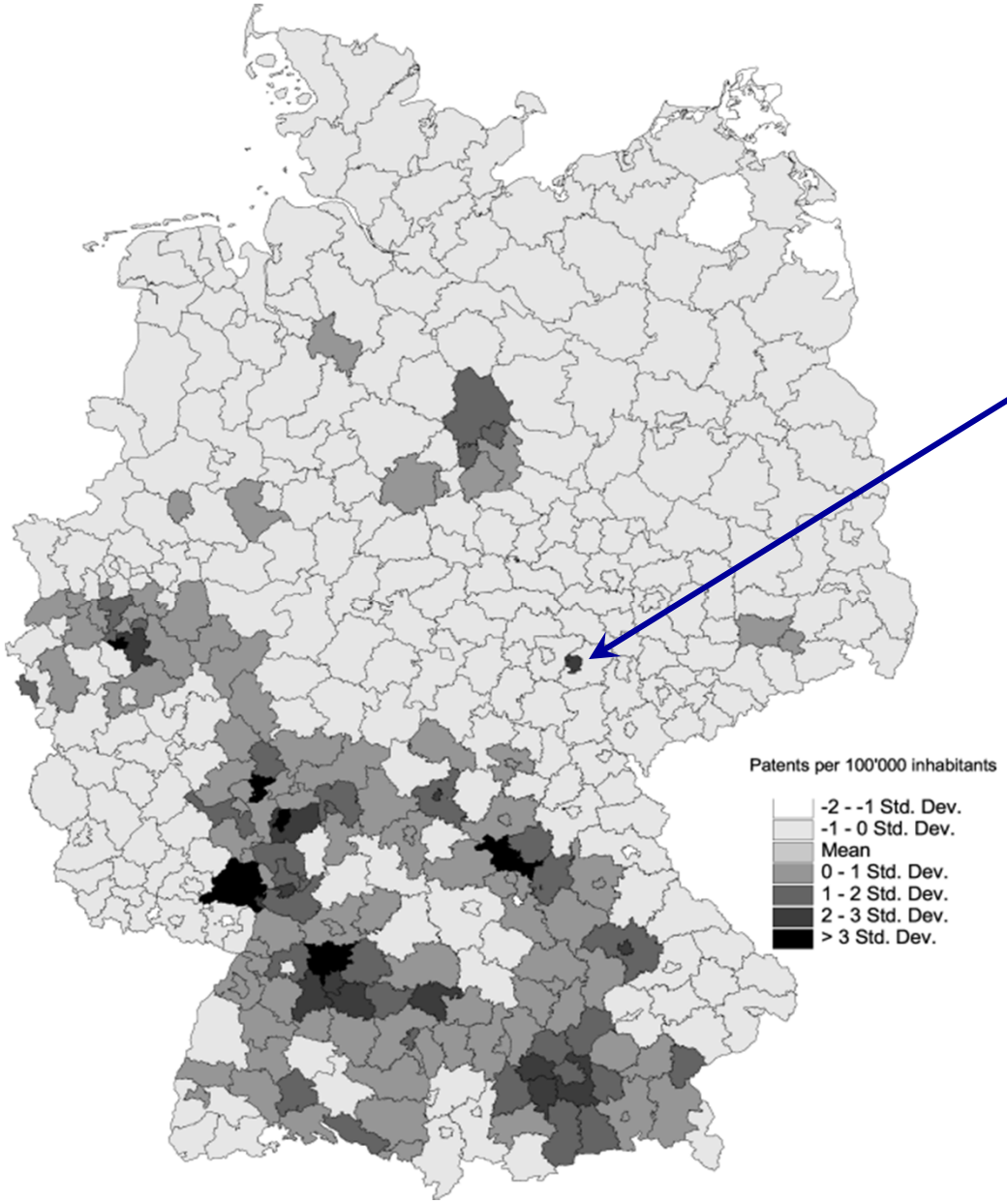
- Institutional proximity
  - Trust based on general habits and attitudes (macro)

- Social proximity
  - Trust based on social relationships (micro)

- Geographical or spatial proximity
  - Location in space

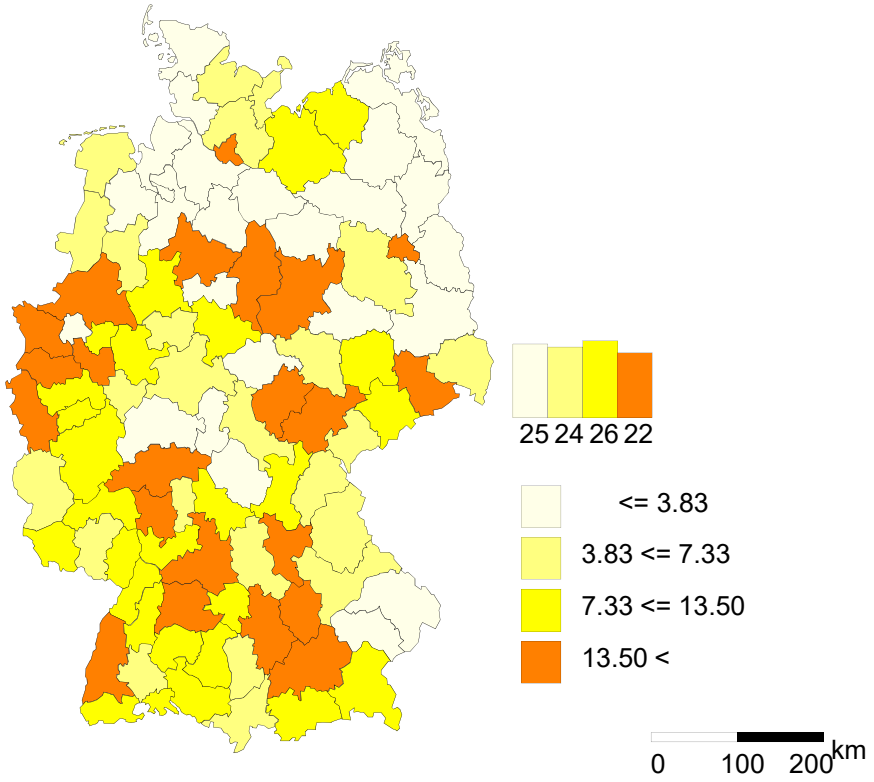
- Source of ideas and innovation
- Control of cooperative ventures
- Facilitating function

EMPIRICS

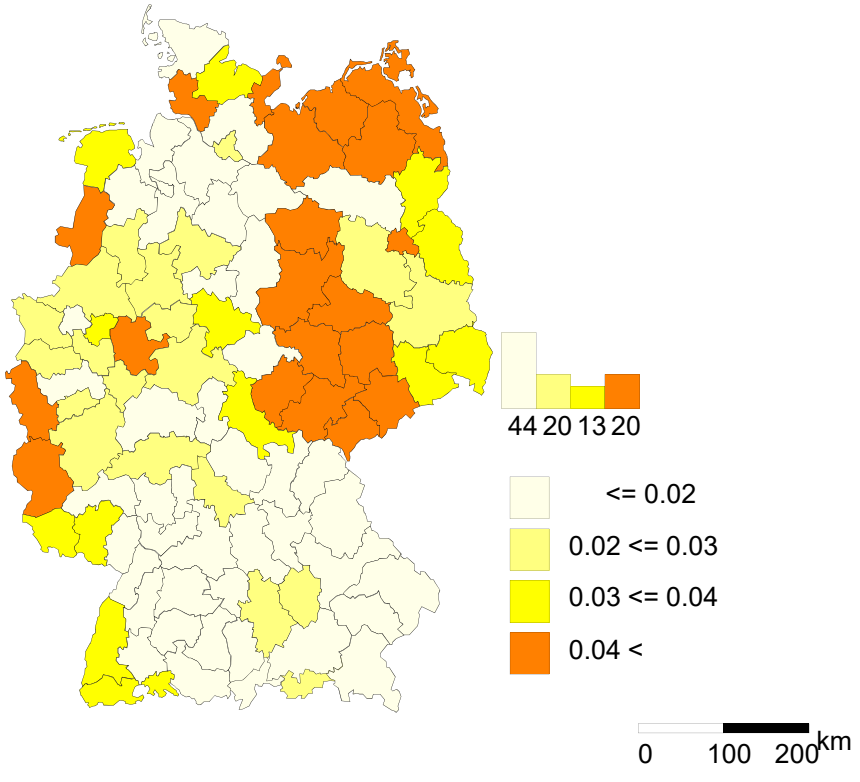


Source: Cantner/Graf 2003

Accounting for collective invention and cooperative innovation



Observed Co-applications
2002 - 2003



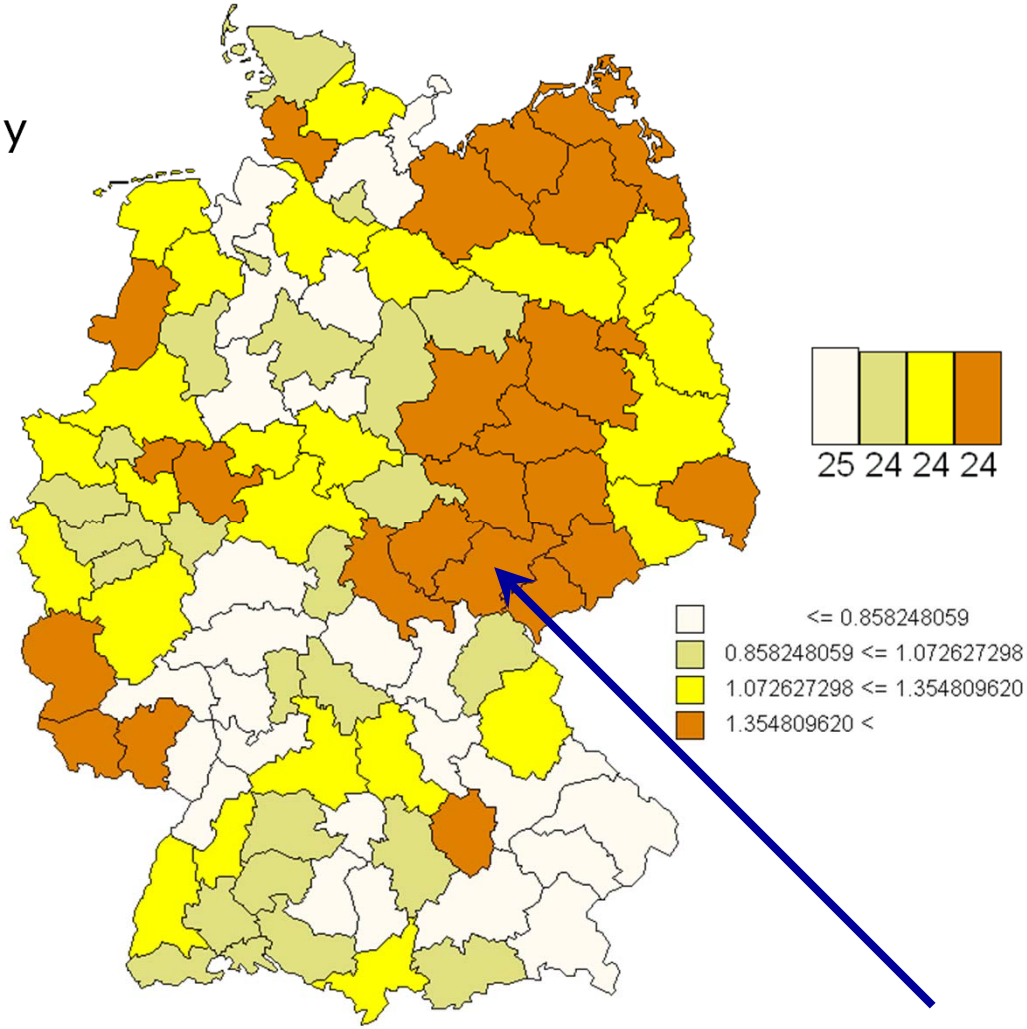
Co-application propensity
2002 - 2003

Source: Cantner/Meder 2008

- Are these results being the effect of a specific constellation of industries (which show a relatively high degree of cooperative patents)?

- index measuring the relative regional effect on cooperative patenting (RRI) (Cantner/Meder 2008)
  - Share-shift analysis
  - RRI <(>) 1 observed cooperation below (above) expected cooperation

R1: East-West effect
R2: North-South effect



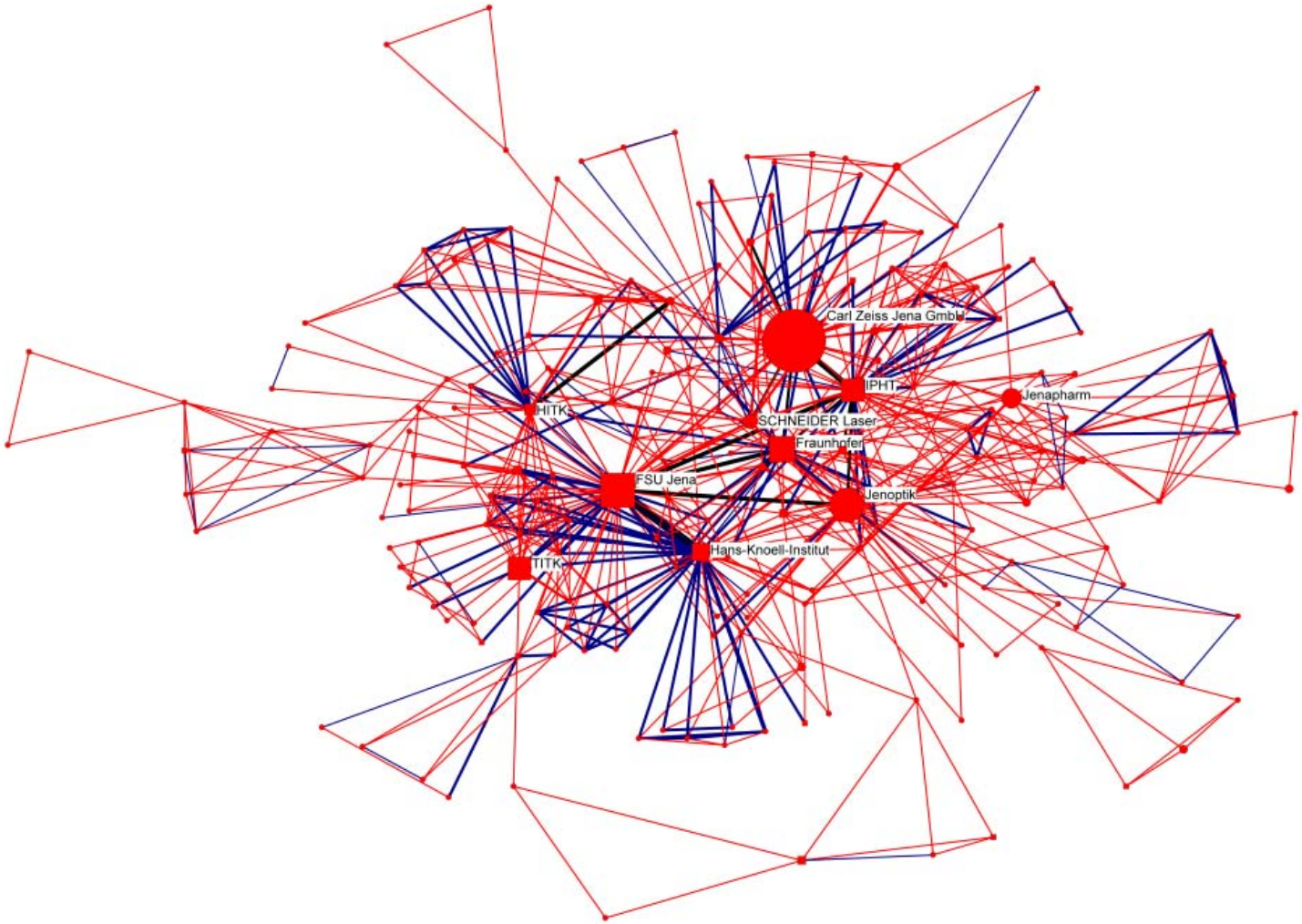
Source: Cantner/Meder 2008

- Question

- Results
  - **R1**: persistency
  - **R2**: dependence on knowledge
    - qualitatively
    - quantitatively
    - inverted-**u** relationship

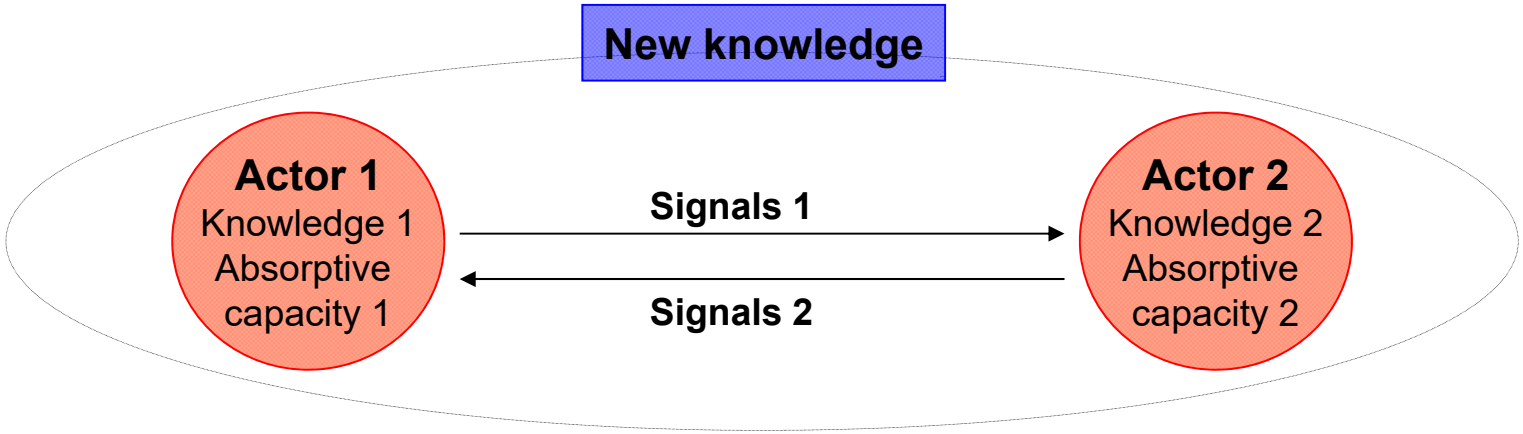
Model Method dep. Variable	M1 System GMM **regional effect$_t$**	M2 System GMM **regional effect$_t$**
regional effect$_{t-1}$	**0.155**** (0.029)	**0.155**** (0.033)
relatedness$_{t-1}$	**9.012**** (0.029)	
(relatedness$_{t-1}$)^2	**-24.85*** (0.067)	
knowledgebase$_{t-1}$		**1.319*** (0.053)
(knowledgebase$_{t-1}$)^2		**-0.521**** (0.037)
Pop. density$_t$	-0.001* (0.057)	-0.001** (0.025)
GDP$_t$	-0.007 (0.65)	0.001 (0.97)
D$_{2002}$	0.063 (0.25)	0.062 (0.25)
Sargan test serial auto-correlation AR(1) AR(2)	0.504 0.000 0.881	0.442 0.000 0.810
# of observations	383	383
# of ror regions	97	97
p values in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%		

Source: Cantner/Meder 2008



Jena network of innovators 1995-2001

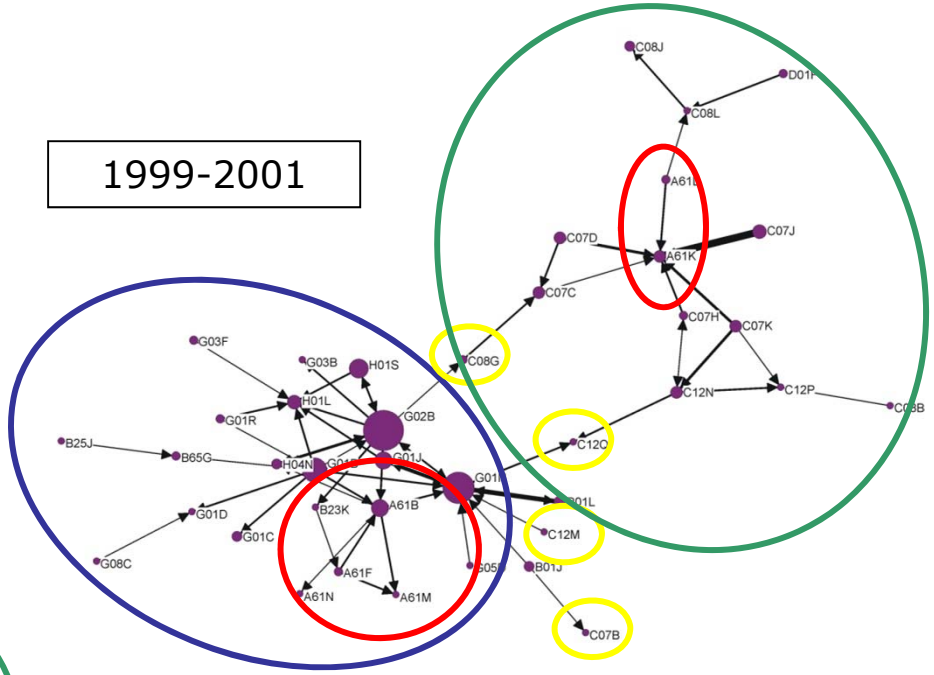
Availability/Awareness and Compatibility

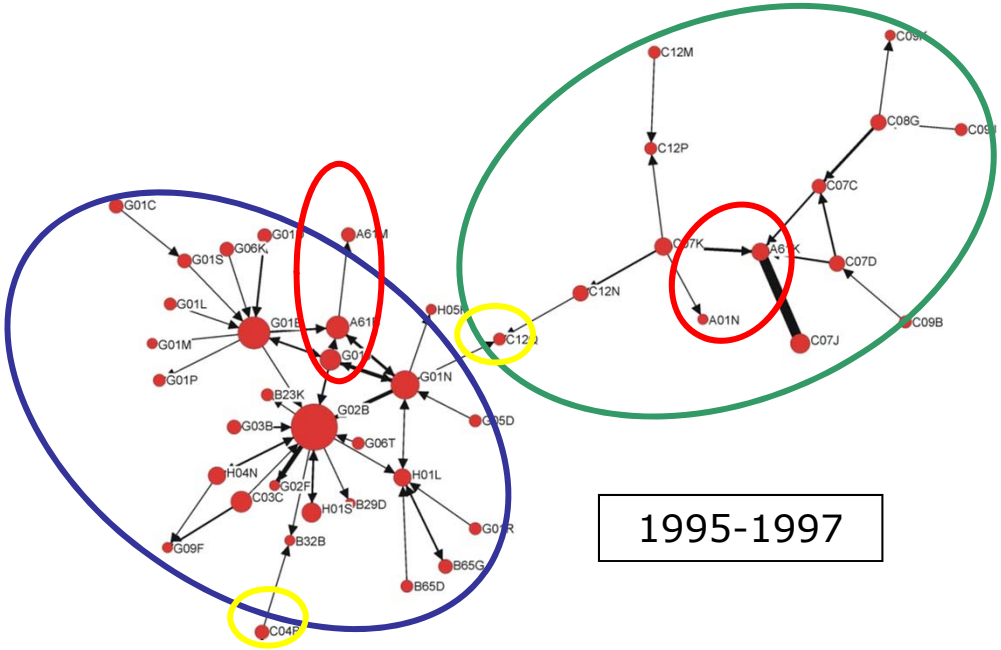


- Issue 1:
  Finding cooperation partner(s) and compatibility of actors / knowledge
  - Technological relatedness, absorptive capacity and cross-fertilization
  - Costs of search and transfer institutions
  - Policy actors
  - Research Institutes

Technological basis and relatedness

1999-2001



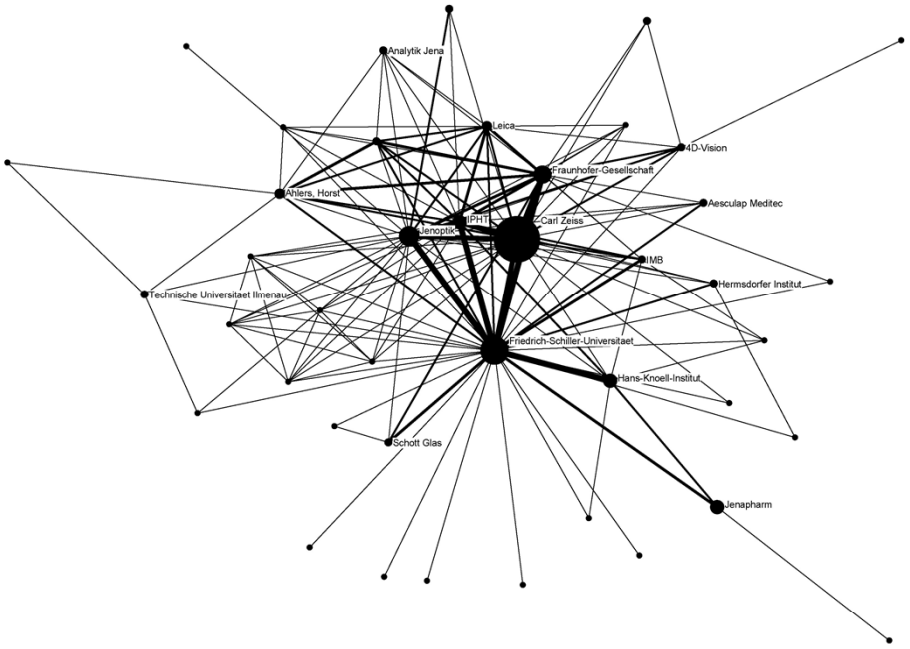


1995-1997

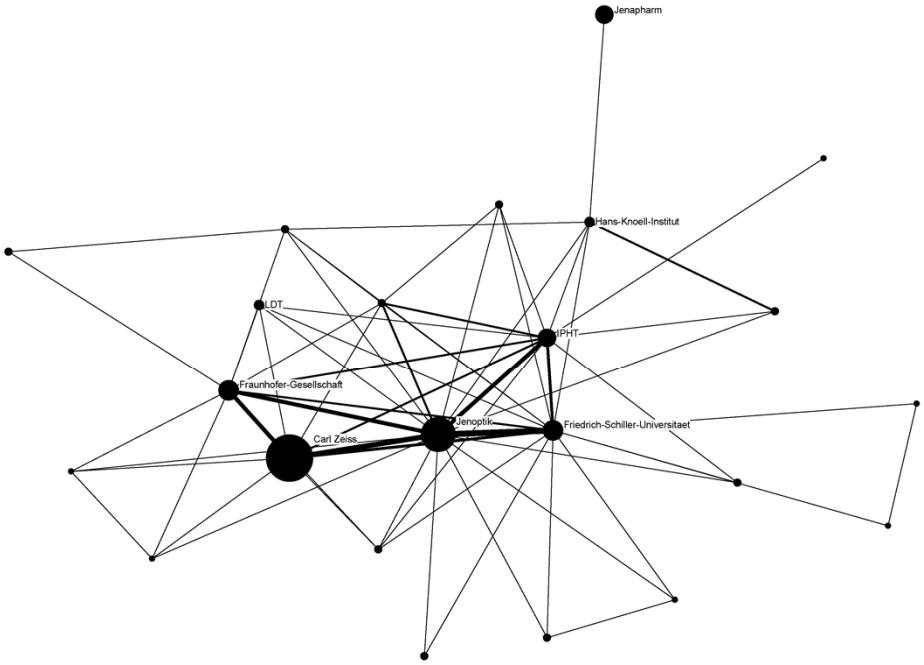
rank	field
1	Optics
2	Biotechnology
3	Medical instruments
4	Measuring instruments
5	Pharmaceuticals

Source: Cantner/Graf 2003
Cantner/Meder/ter Wal 2008

Potentials for cooperation



1999-2001

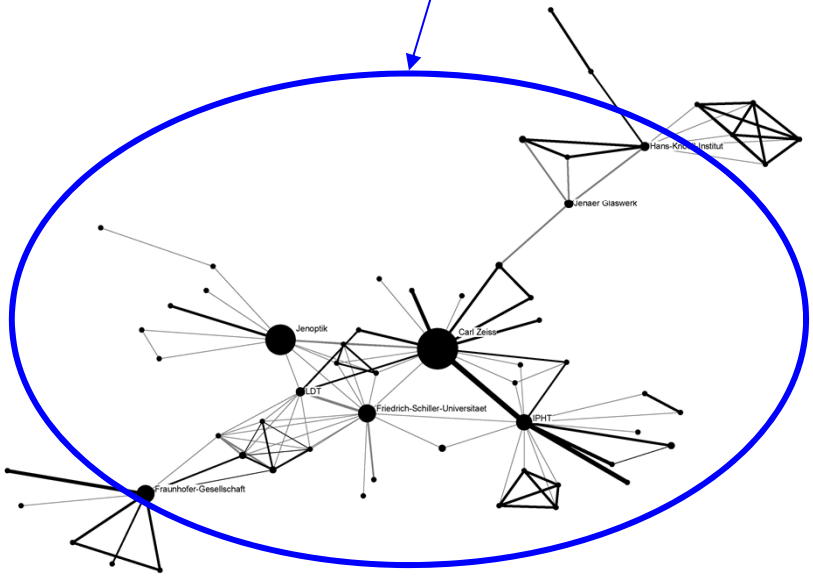


1995-1997

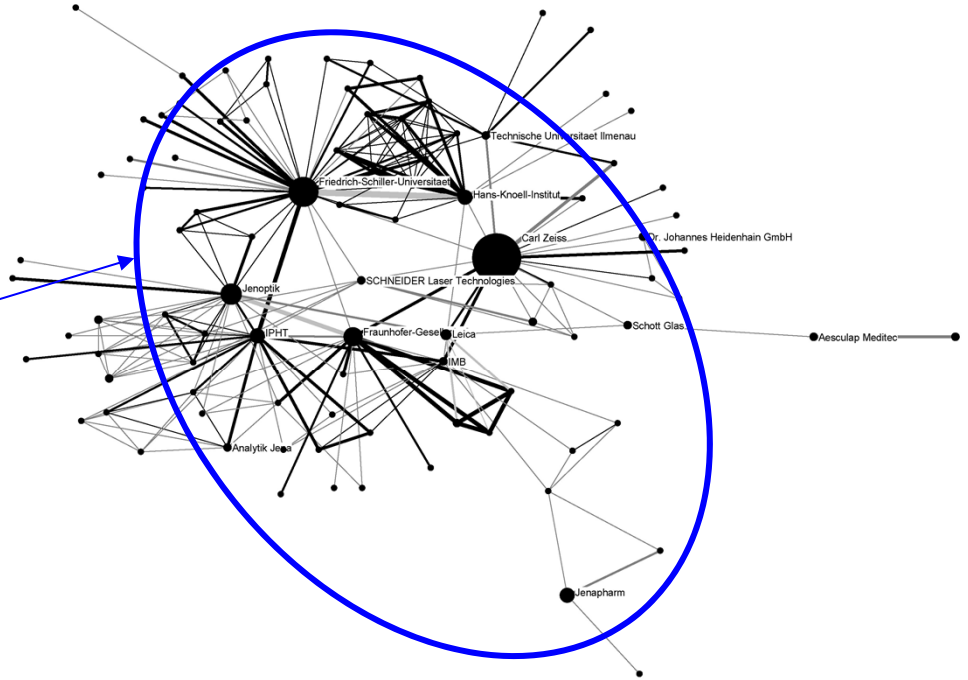
Source: Cantner/Graf 2006

Realized cooperation

32 persistent innovators



1995-1997



1999-2001

cooperation, scientist mobility

Source: Cantner/Graf 2006
equiv. on a local basis: Joel 2008

- What is the influence of the perceived importance of **intermediation actors** on cooperation success?

- Results
  - **R1**: intermediation actors are considered important by actors running a successful cooperation project
  - **R2**: For Jena this relationship does not hold, contrary to Northern Hesse and Sophia Antipolis

- Interpretation
  - the Jena spin-off agglomeration does not require intermediation as the actors know each other already

Model Method dep. Variable	M1 Logit **coop-success**	M2 Logit **coop-success**
int-imp	**0,732***** (3,09)	
int-imp * jena		**0,461** (1,41)
int-imp * northern hesse		**0,926***** (3,01)
int-imp * sophia antipolis		**1,670**** (2,36)
firm size	0,352*** (4,40)	0,34*** (4,15)
firm age	-0,005 (-1,39)	-0,007* (-1,79)
group member	0,495** (2,04)	0,52** (2,17)
higly educated researchers	1,529*** (4,17)	1,413*** (4,07)
Constant	-2,903*** (-8,54)	-2,768*** (-8,50)
Observations	659	659
Robust z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%		

Source: Cantner/Meder/Wolf 2009

- How are **political actors, research institutes and network partners** related to a firm's innovative capacity?

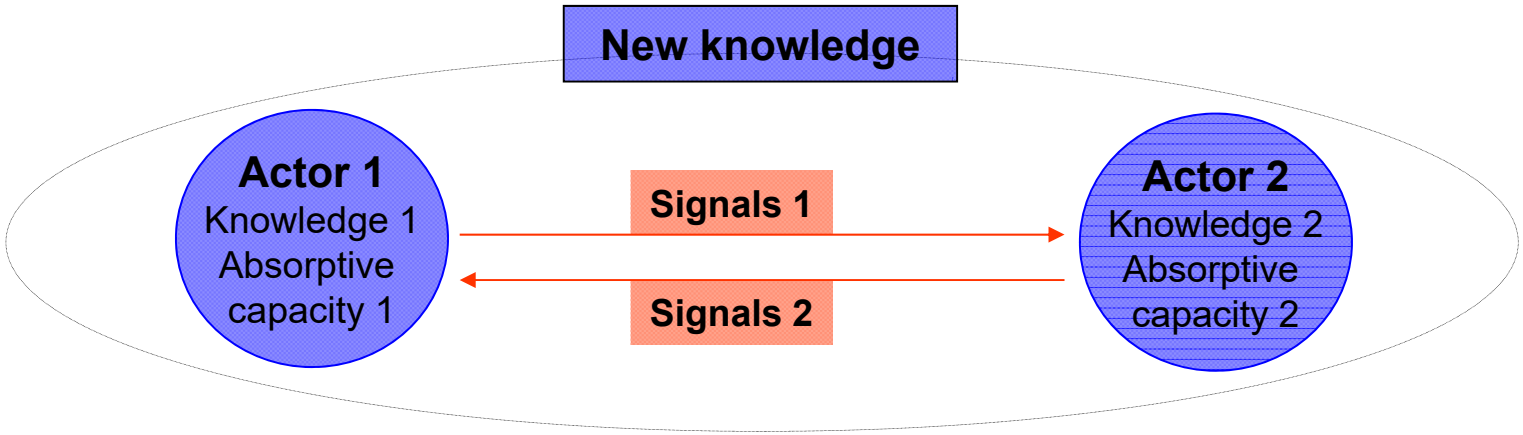
- Results
  - **R1**: political actors are not significantly related to innovative capacity
  - **R2**: research institutes are positively related to innovative capacity
  - **R3**: size of the own network is significantly related to innovative capacity; inverted-**u**

- Interpretation
  - the Jena spin-off agglomeration does not benefit from policy contact
  - but from public research and own network

MODEL method dep. Variable	M1 OLS **Innovative capacity**	M2 Poisson **Innovative capacity**	M3 Negbin **Innovative capacity**
rel. to pol. actors	**0,022** (0,172)	**0,029** (0,988)	**0,049** (0,795)
rel. to res. institutes	**0,482**** (2,392)	**0,100**** (2,081)	**0,022** (0,226)
coop. netw.	**0,780***** (4,430)	**0,200***** (5,868)	**0,298***** (3,739)
(coop. netw.)^2	**-0,026***** (-3,132)	**-0,007***** (-4,573)	**-0,011***** (-3,130)
coop. netw. X optic	**-0,350*** (-1,884)	**-0,109***** (-3,160)	**-0,190**** (-2,306)
log(employment)	1,108*** (3,195)	0,096 (0,987)	0,088 (0,498)
optic industrie	-0,056 (-0,073)	-0,266 (-1,499)	-0,281 (-0,813)
service sector	-0,27 (-0,613)	-0,023 (-0,197)	-0,073 (-0,344)
R&D staff	3,444*** (4,803)	0,020*** (3,032)	0,044** (2,114)
exp. future dev.	0,426** (2,169)	0,243*** (4,226)	0,272*** (2,773)
Intercept	-1,186 (-1,49)	-0,357 (-1,332)	-0,581 (-1,306)
Adjusted R^2 Pseudo R2 observations	0,49 153	 0,346 153	 -1.79 153
in parentheses t-tests (OLS) or z-test (Poisson, Negbin); * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level			

Source: Cantner/Conti/Meder 2009
similar Cantner/Joel 2008

Reciprocity and Trust



- Issue 2:
  Flexibility for exchanging knowledge ←→ Controlling these processes
  - Knowledge exchange and networking
  - Direct versus indirect reciprocity

- What role does **trust** play for the failure / success of cooperation projects?

- Results
  - **R1**: the higher the level of ex-post trust, the less likely a cooperation will fail
  - **R2**: this is more pronounced in Jena compared to Northern Hesse and Sophia Antipolis

- Interpretation
  - the Jena spin-off agglomeration enjoys a trust heritage from the Kombinate and VEB times

Model Method dep. Variable	M1 Logit **coop-failed**	M2 Logit **coop-failed**
ex-post-trust	**-1,130***** (-2,71)	
ex-post-trust*jena		**-1,454***** (-3,54)
ex-post-trust*northern hesse		**-1,114***** (-2,87)
ex-post-trust*sophia-antipolis		**-0,985** (-1,62)
firms size	-0,072 (-0,29)	
firm age	-0,004 (-0,62)	
group member	0,586 (0,89)	
highly educated researchers	-0,784 (-0,69)	
Constant	1,458 (1,01)	
Observations	279	279
Robust z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%		

Source: Cantner/Meder/Wolf 2009

- How do network incumbents **interact and build linkages**? Can we identify a time persistent **pattern of linkages**?

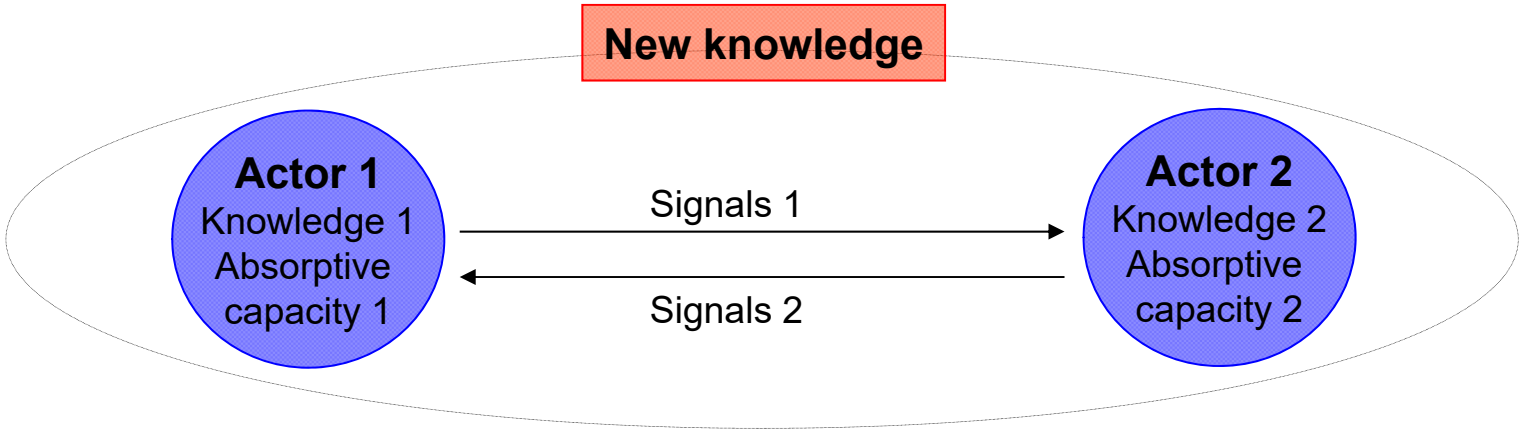
- Results
  - **R1**: linkages do not seem to be persistent but rather short term
  - **R2**: linkages in 99-01 are best explained by mobility of researchers in the same period
  - **R3**: technological overlap is a necessary condition for building a linkage

- Interpretation
  - in a spin-off agglomeration, flexibility in linkages may indicate a high degree of trust among the network actors

Model Method dep. Variable	M1 network regression **cooperation$^{99\text{-}01}$**		
		$Pr(\geq\|t\|)$	$Pr(\geq b)$
cooperation$^{95\text{-}97}$	**-0,082*****	0,154	1,000
scientist mobility$^{95\text{-}97}$	**-0,136****	0,43	0,989
scientist mobility$^{99\text{-}01}$	**0,410*****	0	0,004
tech. overlap$^{95\text{-}97}$	**0,075***	0,361	0,072
(tech. overlap95-97)^2	**0,038****	0,014	0,014
public linkages	0,277*	0,051	0,077
private linkages	-0,109	0,178	0,842
intercept	0,051	0,431	0,894
mult. R2 (adj.) # of obs. (nodes)	0,153 496		(0,141) (32)
significance-levels according to QAP: ***≤0.01, **≤0.05, *≤0.1; significance is the minimum of Pr(>b) (which is documented) and Pr(<b); # of permutations: 1000			

Source: Cantner/Graf 2006

Generic Potential and Lock-in



- Issue 3:
  Sustaining the generic potential
  - Technological lock-in
    - Internal density of a local network increases specific knowledge-stock
      ➔ BUT: risk of lock-in
    - Local 'buzz' and global 'pipelines' (Storper/Venables 2004; Bathelt et al. 2004)
  - Gate-keepers (Giuliani 2005) serve two functions:
    - external knowledge sourcing and
    - diffusion within the local system

- How are **innovators, entering the system, connected** compared to those exiting?
  How does the **connectedness of the permanent innovators** develop over time?

- Results
  - **R1**: entering innovators are significantly better connected to permanent innovators than exiters
  - **R2**: exiting innovators are significantly better connected among themselves than entering innovators
  - **R3**: over time permanent innovators become significantly more connected among themselves

- Interpretation
  - Jena network core is attractive for entry
  - network core increases its internal connectedness

method variable	network analysis **mean degree in cooperation**	
	within	to permanent
1995-1997 exit	**3,084** (5,207)	**0,710** (1,873)
1999-2001 entry	**2,242** (4,424)	**1,516** (2,623)
difference p-value	0,066	0,003
1995-1997 permanent	**2,563** (5,346)	
1999-2001 permanent	**3,938** (6,710)	
difference p-value	0,1	
standard deviation in parentheses		

Source: Cantner/Graf 2006

- How do the Jena innovators draw on **Jena external cooperation partners**?

- Results
  - **R1**: concerning all actors (persistent and temporary innovators) we find the share of external linkages to decrease over time
  - **R2**: concerning the persistent actors we find a drastic decrease in the share of external linkages

- Interpretation
  - in the Jena system there is a tendency towards stronger internal orientation
  - esp. public research institutes do not seem to provide an antenna function

variable		**ratio of external to internal linkages**	
all innovators		**1995-1997**	**1999-2001**
private actors	cooperation	**1,65**	**1,59**
	scientist mobility	**2,09**	**1,74**
public actors	cooperation	**1,86**	**1,52**
	scientist mobility	**1,77**	**1,27**
only persistent innovators			
private actors	cooperation	**0,50**	**0,13**
	scientist mobility	**2,25**	**0,69**
public actors	cooperation	**1,25**	**0,08**
	scientist mobility	**1,25**	**0,33**

Source: Cantner/Graf 2006

- How does a relationship to the Jena **innovator network** affect the **survival of newly founded firms**?

- Results
  - **R1**: for all new firms, the ATT of those surviving 6 and 7 years is significantly positive
  - **R2**: for all new firms in closer geogr. proximity, the ATT of those surviving 5-8 years is significantly positive and higher than in R1
  - **R3**: for spin-offs, the ATT of those surviving 4-8 years is significantly positive and higher than in R1 / R2

- Interpretation
  - being integrated in the Jena system provides better survival probabilities to new firms that are spin-offs and that are closer to Jena geographically

Matching algorithm	NN radius caliper (0,05)			Bootstrap results (200)	
	ATT	std. err.	T-stat	z	P>|z|
all new start-ups and spin-offs in Thuringia					
survival4	0,0048	0,0365	0,13	0,13	0,90
survival5	0,0688	0,0386	1,78	1,61	0,11
survival6	**0,0727***	0,0388	1,87	1,86	0,06
survival7	**0,0775***	0,0380	2,04	1,90	0,06
survival8	0,0362	0,0352	1,03	0,98	0,33
# of obs.	treated untreated	188 4412			
all start-ups and spin-offs within East Thuringia					
survival4	0,0275	0,0510	0,54	0,54	0,589
survival5	**0,1568*** **	0,0532	2,95	2,84	0,005
survival6	**0,1590*** **	0,0538	2,95	2,87	0,004
survival7	**0,1457*** **	0,0531	2,74	2,62	0,009
survival8	**0,0949***	0,4949	1,92	1,77	0,077
# of obs.	treated untreated	105 980			
only spin-offs in Thuringia					
survival4	**0,2056** **	0,0759	2,71	2,28	0,02
survival5	**0,3375*** **	0,0837	4,03	3,51	0,00
survival6	**0,3735*** **	0,0852	4,38	4,23	0,00
survival7	**0,3683*** **	0,0860	4,28	3,95	0,00
survival8	**0,1930** **	0,0800	2,40	2,40	0,02
# of obs.	treated untreated	45 198			

Source: Cantner/Wolf 2009

FINAL REMARKS

- Some features of network structures and dynamics are already taken into account
- A even more actor based analysis is required (patents don‘t do it alone)
- Disentangeling relationships (market, hierarchy, network)
- Longer times series
- Broader span of cases – more general results
- Better connection of birds-eye analysis and case studies

The End !

CONCLUSIONS FOR THE JENA CASE

Conclusions: History




Tradition of Carl Zeiss, Ernst Abbe and Otto Schott **(from 1866 to 1905)**

- cooperation between two large manufacturing firms (Zeiss optics and Schott glass) and the university (Abbe) (also von Schleiden)
- First innovation system?

"Kombinate" in the economic system of the GDR **(after world war II)**

- large, divisional firms ("Kombinate" and "VEBs")
- dedicated to certain technologies; politically decided on (glass, optics, pharmaceutics)
- "intrapreneurship" (and politically guided internal selection)

System of innovation **(since ~1990)**

- network of innovators with core firms and institutions dedicated to traditional high-tech (glass, optics, pharmaceutics) as well as new high-tech (electronics, bio-tech, medi-tech, IT, laser)
- **spin-offs** from former Kombinate/VEBs
- **start-ups** in other technologies/sectors (Cantner/Fornahl/Graf 2003)

➔ Jena: (1) a **spin-off agglomeration** and (2) an **entrepreneurial site**

- from hierarchy to markets and networks?
- from "intrapreneurship" to "entrepreneurship"?

Conclusions (cont.)

- High technological opportunities (also created during the Kombinat years in the former GDR) have been mainly exploited after 1990 by
  - an agglomeration of spin-offs (from the Kombinate and VEBs)
  - which quite easily and fast, but also with not much of alternative options, built up a network of innovators
  - where the influence of policy actors is negligible

- Over time this network of innovators
  - has become attractive for other actors trying to integrate close to the core
  - has influenced the performance especially of spin-offs and new firm founding nearby
  - but it has shown also an inward orientation especially by the core actors risking a lock-in

- The Jena case is not typical for economic transformation
  - e.g. Leuna (chemistry site close to Halle with heavy political support to attract external entrepreneurs)
  - But Berlin-Adlerhorst with similar pattern

Conclusions (cont.)

- The question is whether Jena "is able to manage"
  - being a spin-off agglomeration with a Zeiss and Schott heritage and
  - being at the same time an open entrepreneurial site

- And the answer to this question has to do with the problem of how to reconcile different attitudes or role models

- "Leitbilder" (role models) in the Jena System of Innovation
  - cooperation between university and firm by Zeiss, Schott, Abbe, von Schleiden
    - "Leitbild" ⇒ "cooperate!"
  - "Zeissianertum": certain attitude towards the usage of technique and tech. change
    - "Leitbild" ⇒ "be highly precise and better than others!"
    - but also with a "smell" of exclusiveness
  - "Schambach-Leitbild": Intershop (software development)
    - "Leitbild" ⇒ "be different!" or "we´ll make it!"
    - with a strong Jena external orientation

The End II

Thank you to

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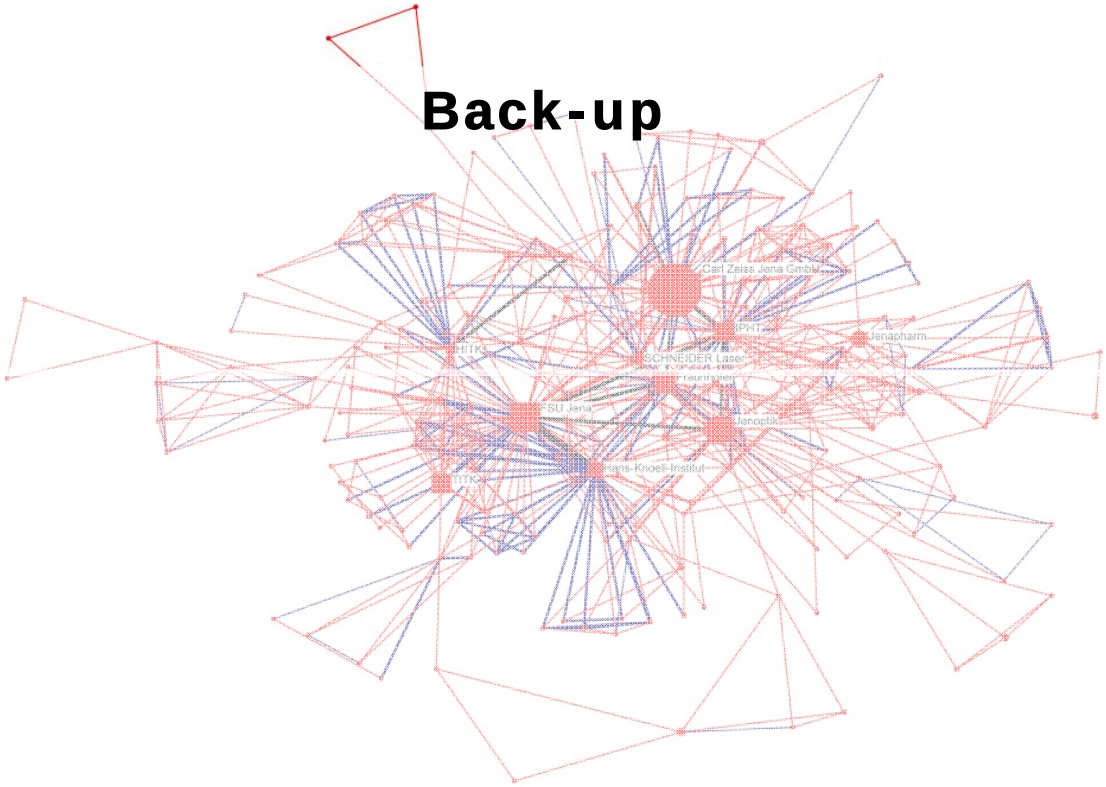
Back-up


Carl Zeiss Jena GmbH
IPHT
Jenapharm
BIITKA
SCHNEIDER Laser
FSU Jena
Jenoptik
Hans-Knoell-Institut
ITKA

- Jena's patenting pattern compared to other German regions

patent intensity	➔ above average
cooperative patents	➔ above average (as other regions in East Germany)
cooperative patents with region internal partners	➔ far above average
cooperative patents with research institutes	➔ above average (as other regions in East Germany)

- Are these results being the effect of a specific constellation of industries (which show a relatively high degree of cooperative patents)?
  - index measuring the relative regional effect on cooperative patenting (Cantner/Meder 2008)
  - Jena shows a rather high relative regional effect which
    - is persistent over time and
    - depends on the coherence of the underlying knowledgebase of the actors involved (inverted-**u** relationship)

Knowledge transmission II

	Market	Hierarchy	Network
Normative basis	contract and property rights	contractual relations	complementary strengths
Type of communication	prices	routines	relationships
Conflict management	legal system	controlling	reciprocity, reputation
Flexibility	high	low	medium to high
Relationship between actors	independent	hierarchical	mutually dependent

(source: TEP 1992, 78)

Spots on Jena I

“Boomtown Jena“ (2000)

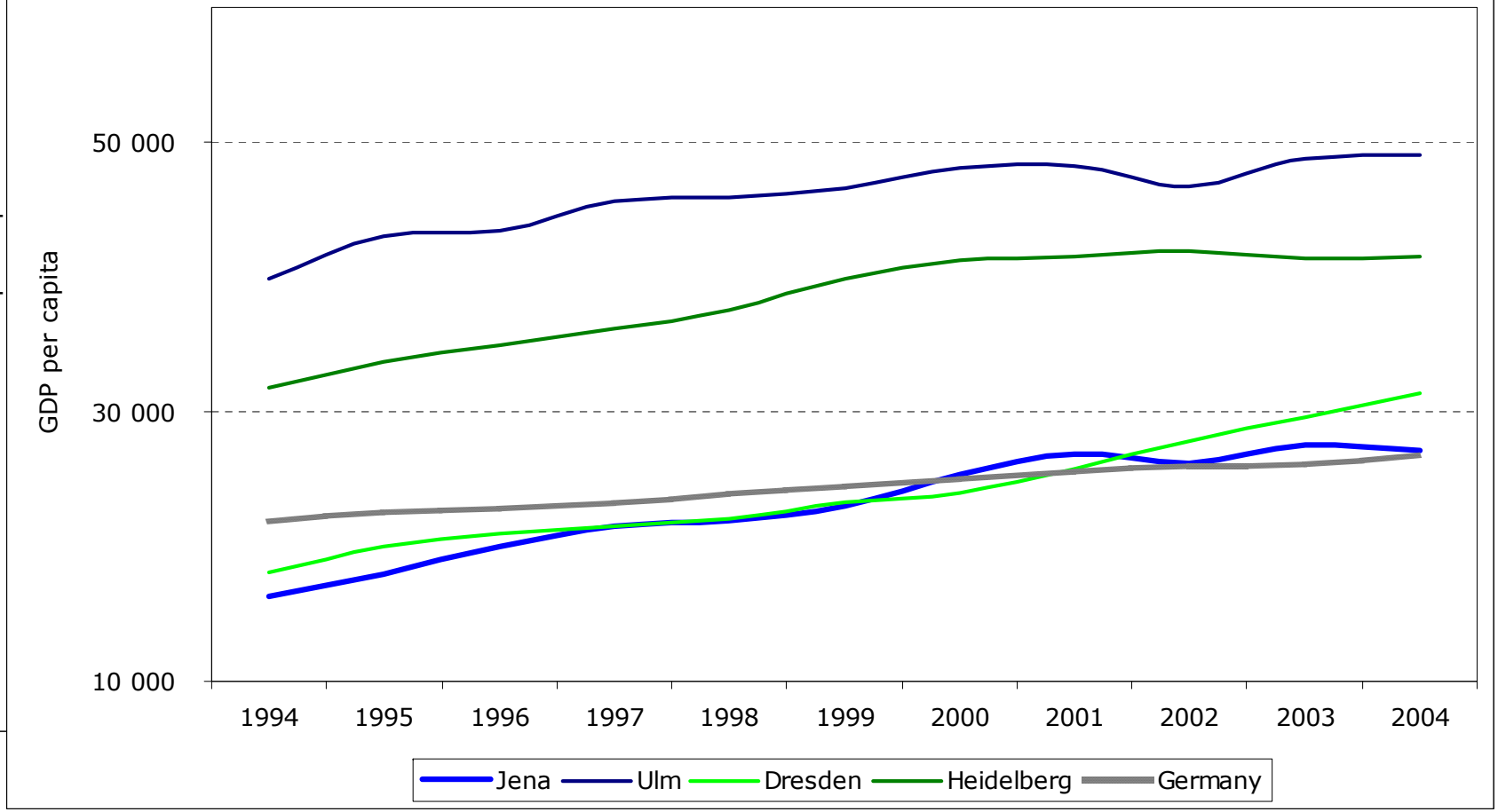
“Hidden Star“ (2004)

Jena‘s economic development

Jena in Thuringia

Jena in the "Neue Bundesländer"

Jena in Germany



Spots on Jena II

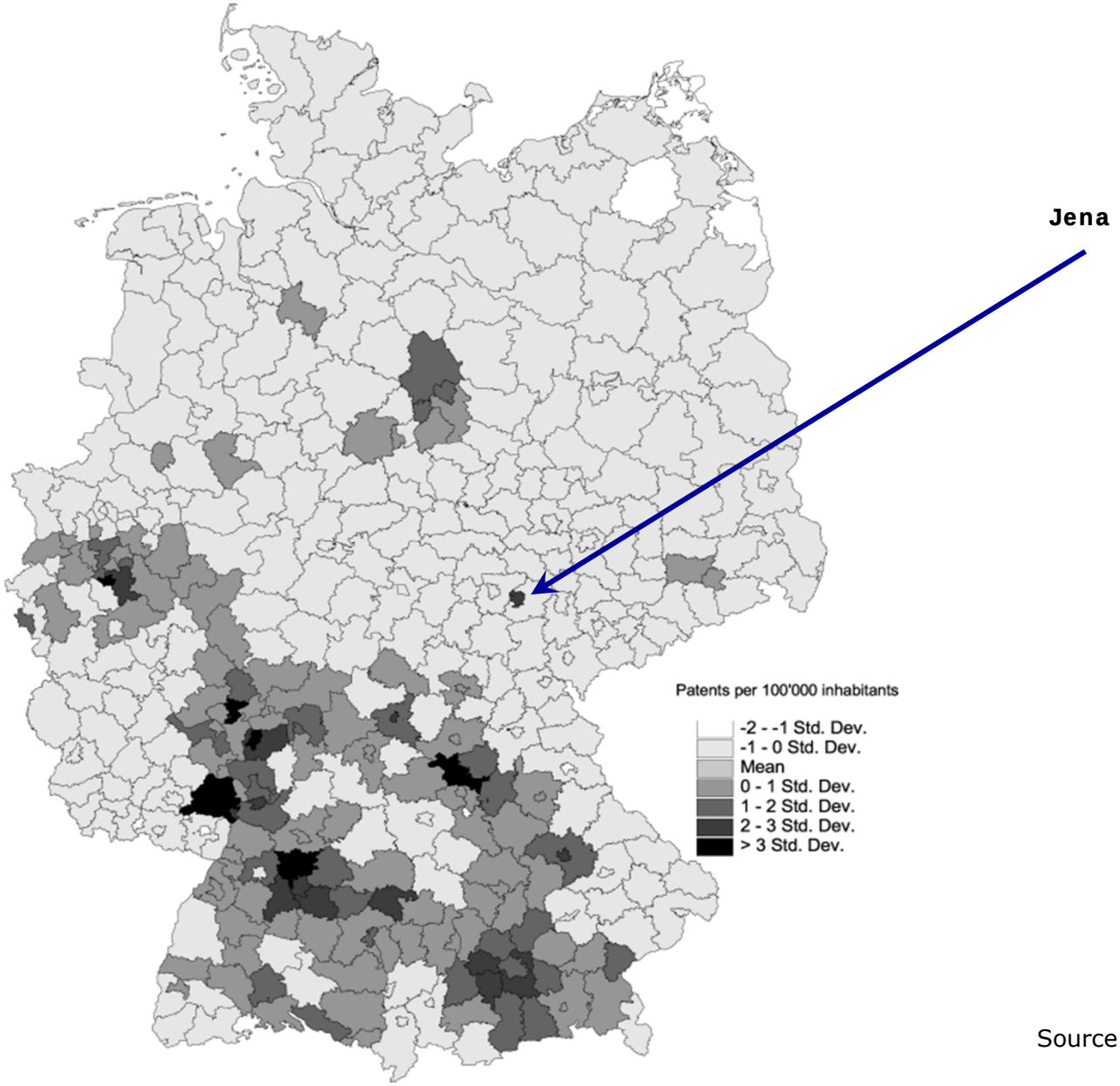
“Silicon Valley of the East“ (2000)

“The spirit in the air“ (2003)

“Learning City“ (2004)

“Science City” (2008)

1. Introduction and Motivation
2. Innovation and Collaboration
3. Actors and Technology
4. Internal mechanisms
5. External dimensions
6. Impact on firm founding



Source: Cantner/Graf 2003

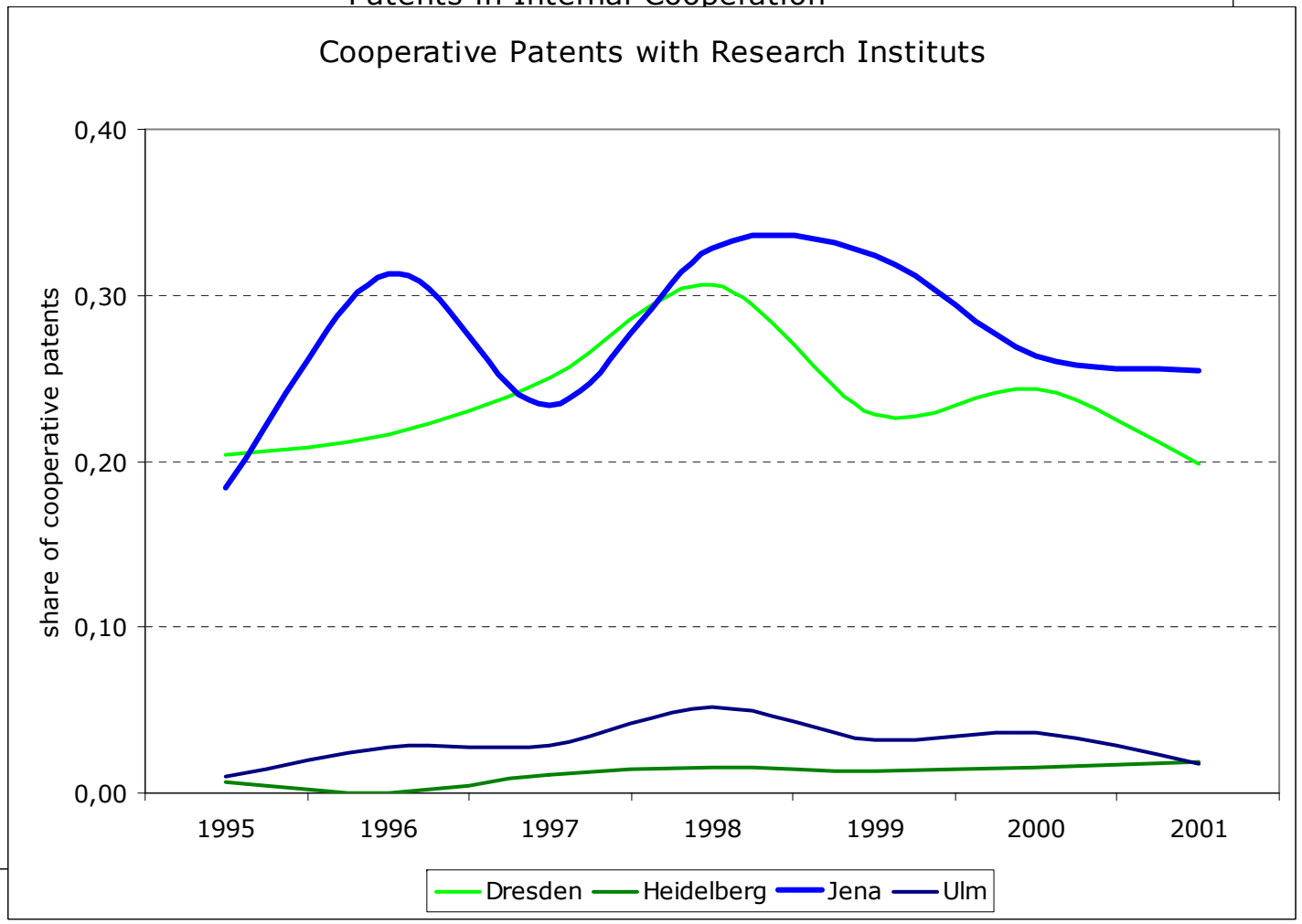
Patents

Patent Intensity

Cooperative Patents

Patents in Internal Cooperation

Cooperative Patents with Research Instituts



total no. of patents

patents per 100.000 inhabitants

share of patents in cooperation

share of patents in internal cooperation