EXPLORING THE EVOLUTION OF TECHNOLOGY SPACE THROUGH GEOGRAPHY, COMPLEXITY AND COLLABORATION

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HOW TECHNOLOGICAL DEVELOPMENT HAPPENS?

INNOVATION

COMBINING TECHNOLOGIES

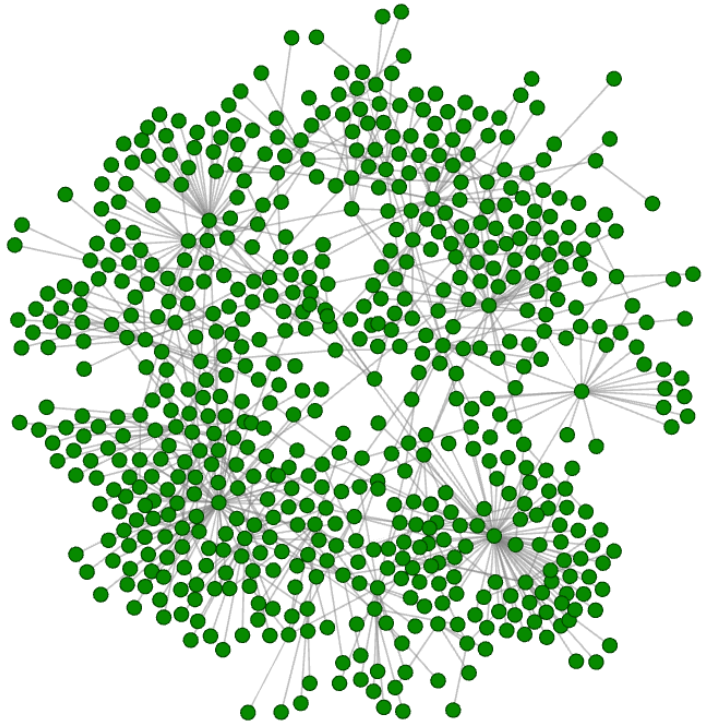
+

COMBINATION OF TECHNOLOGIES IS NOT ENTIRELY RANDOM

?

TECHNOLOGY SPACE

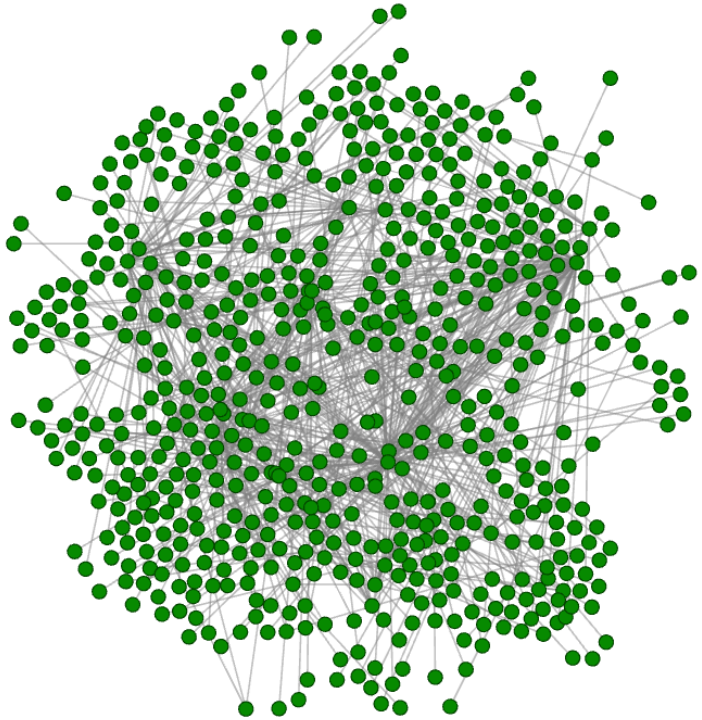
The network representation of technological combinations
Based on the co-occurrence / combination of technologies on **patents**



Technology space in 1980

TECHNOLOGY SPACE

The frequency 2 technologies are combined should change due to technological development
OUR AIM – explain the evolution of the technology space



Technology space in 2010

THE EVOLUTION OF TECHNOLOGY SPACE IS INFLUENCED BY…?

THE EVOLUTION OF TECHNOLOGY SPACE IS INFLUENCED BY…?

1) GEOGRAPHY

1) GEOGRAPHY

SPATIAL CO-CONCENTRATION OF TECHNOLOGIES

Whether 2 technologies tend to be co-concentrated frequently at the same place

High spatial co-concentration – high chance for combination

[measure := z-score of the correlation of location quotient values of techs in regions in the given period]

THE EVOLUTION OF TECHNOLOGY SPACE IS INFLUENCED BY…?

THE EVOLUTION OF TECHNOLOGY SPACE IS INFLUENCED BY…?

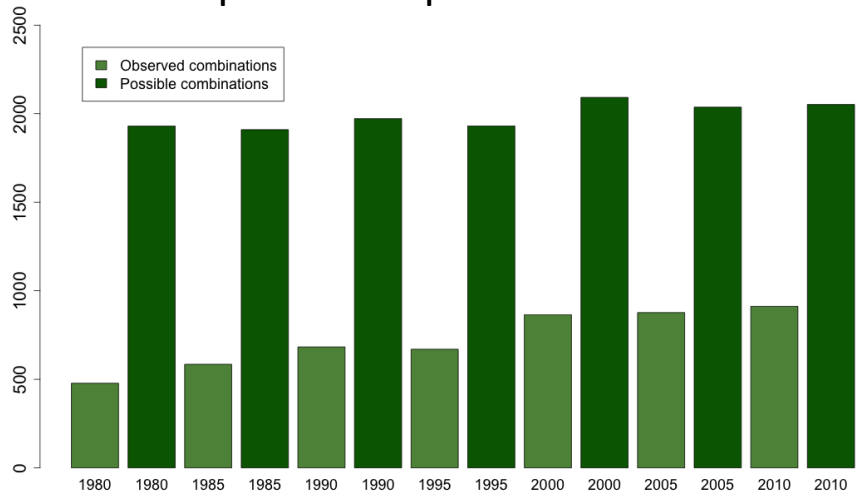
2) COMPLEXITY

2) COMPLEXITY OF COMBINED TECHNOLOGIES

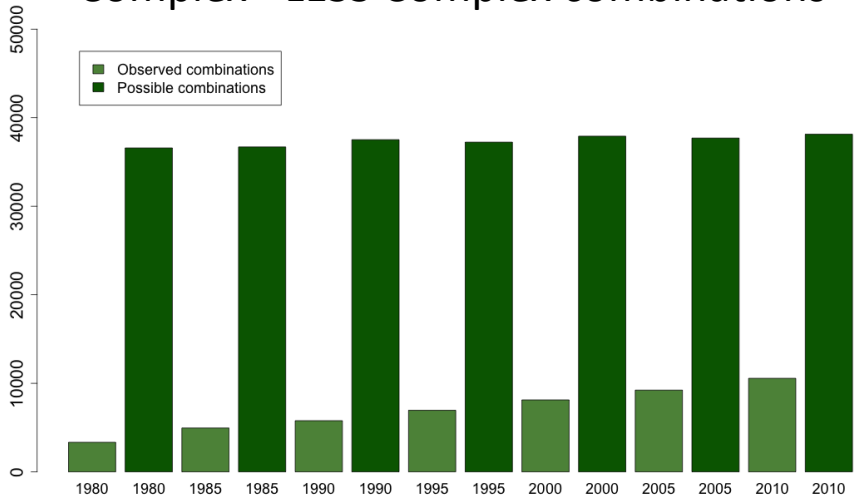
Complexity of technologies = structural diversity
around 10-digit CPC subclasses [Broekel 2018]

It might require more effort to combine 2 complex technologies than 2 simple technologies

Complex - Complex combinations



Complex - LESS Complex combinations

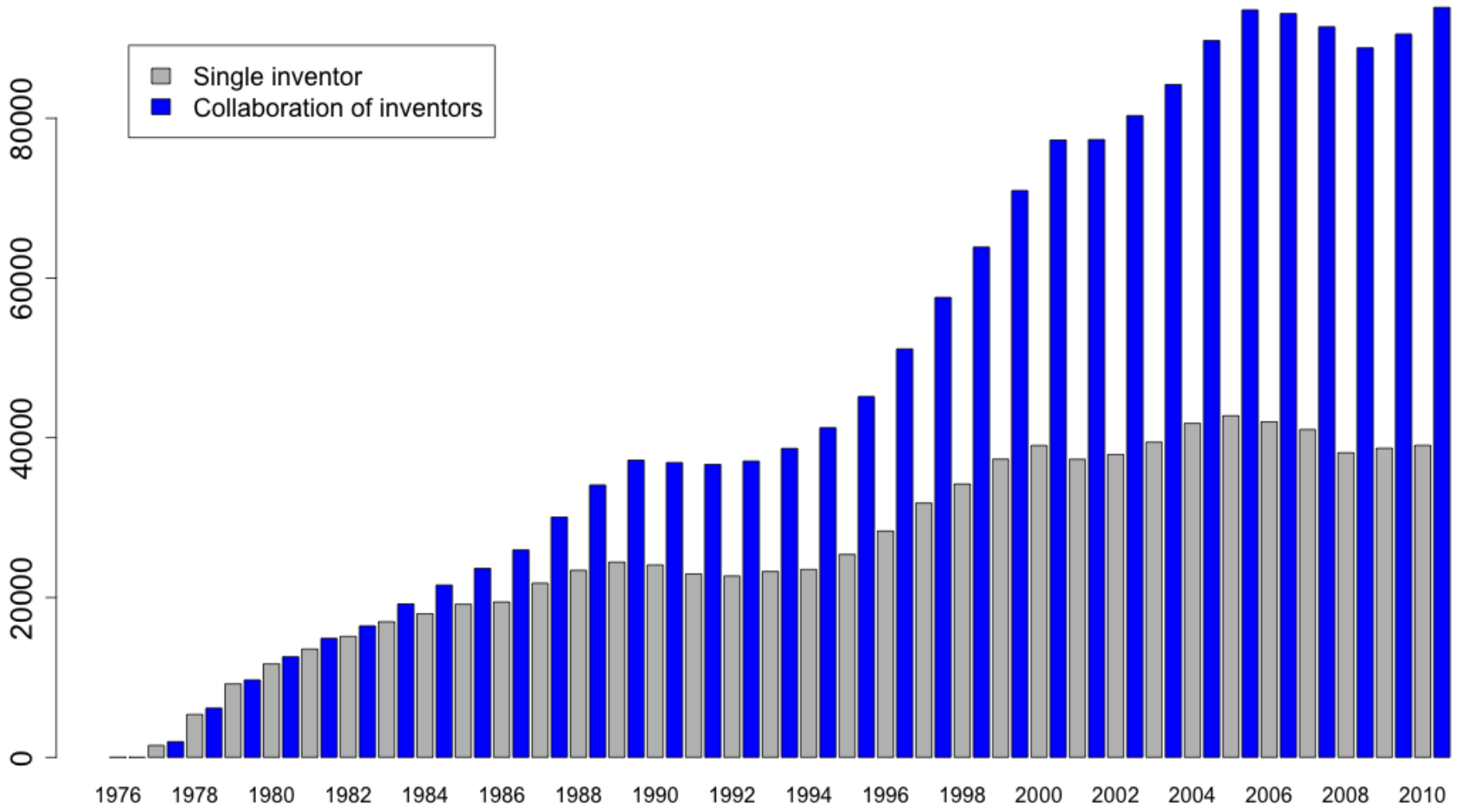


Complex := above the 0.1 percentile of complexity value in the given period

THE IMPORTANCE OF GEOGRAPHY / COMPLEXITY CAN BE DIFFERENT ON THE BASIS OF

3) WHO COMBINES TECHNOLOGIES?

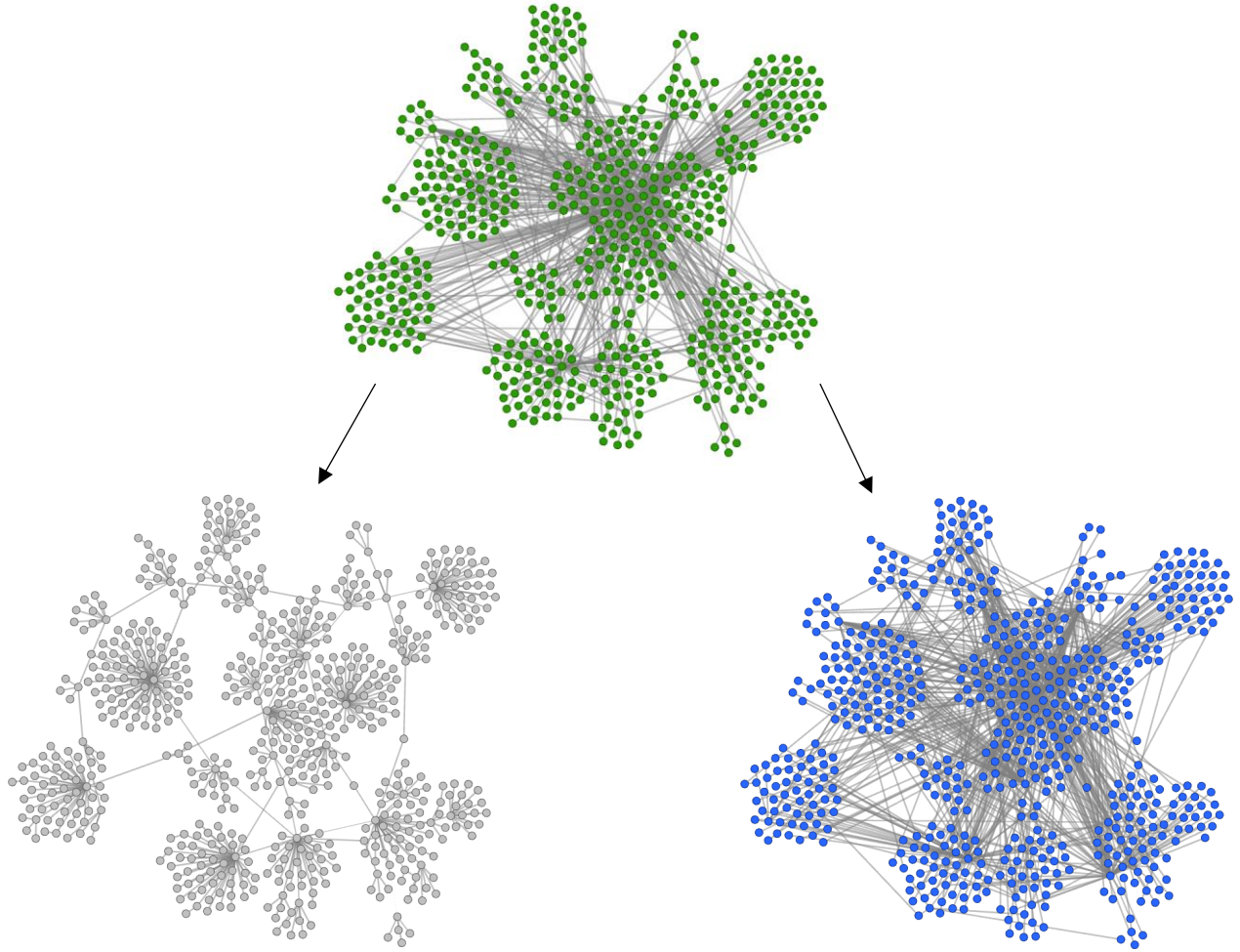
3) COLLABORATION OF HUMANS



Number of patents by individual inventors and collaboration teams, 1976-2010

OUR IDEA – DECOMPOSE THE TECHNOLOGY SPACE

FULL / Entire technology space

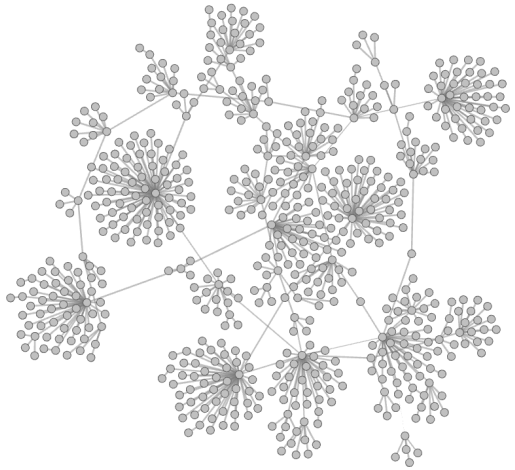


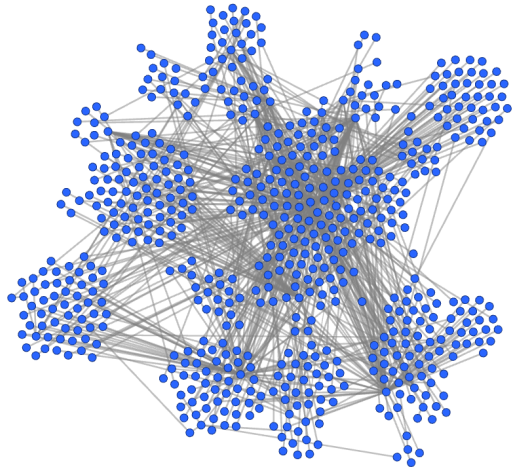
SINGLE / Technology space based on patents by single inventors

COLLAB / Technology space based on patents by collaboration teams

DIFFERENCE IN THE EFFECT OF GEOGRAPHY / COMPLEXITY?

SINGLE / Technology space
based on patents
by single inventors





COLLAB / Technology space
based on patents
by collaboration teams

GEOGRAPHY
Colocation of techs is more important for single inventors

COMPLEXITY
Single geniuses combine complex technologies
less frequently

GEOGRAPHY
Colocation of techs matters less for collective invention

COMPLEXITY
Teams can combine complex technologies
more frequently

DATA

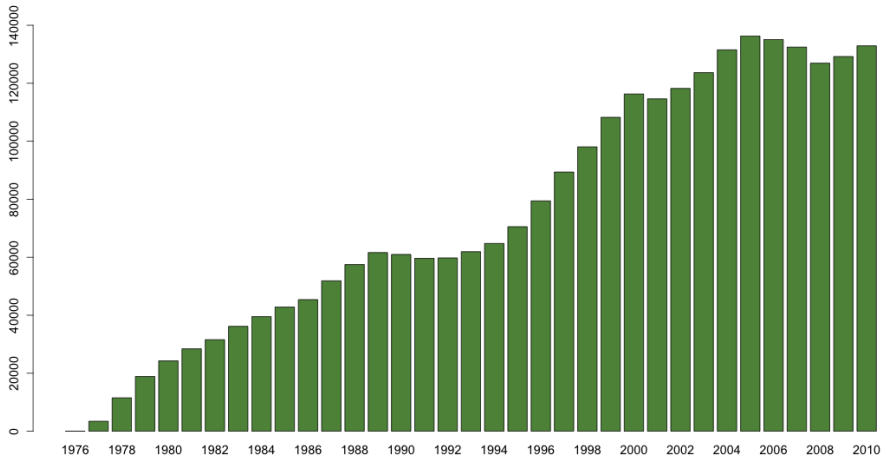
- OECD REGPAT data (2018)

2.602.978 patents in 1976-2010

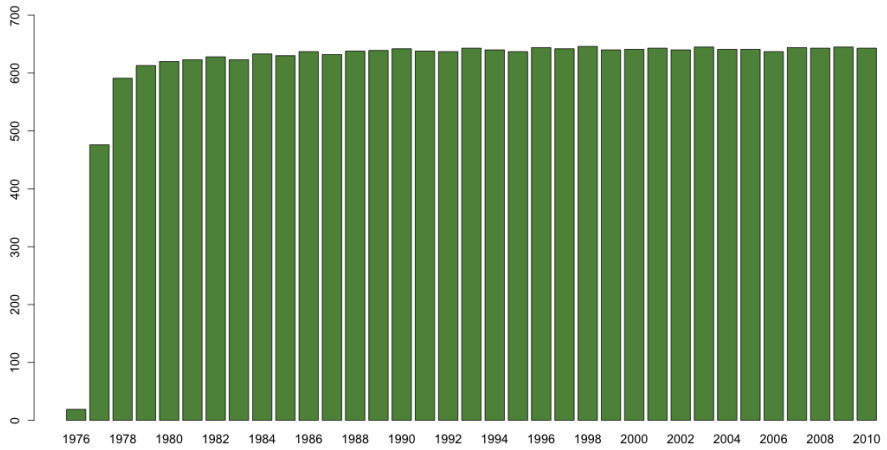
- 4-digit CPC technology classes

655 CPC classes

214.185 possible CPC combinations



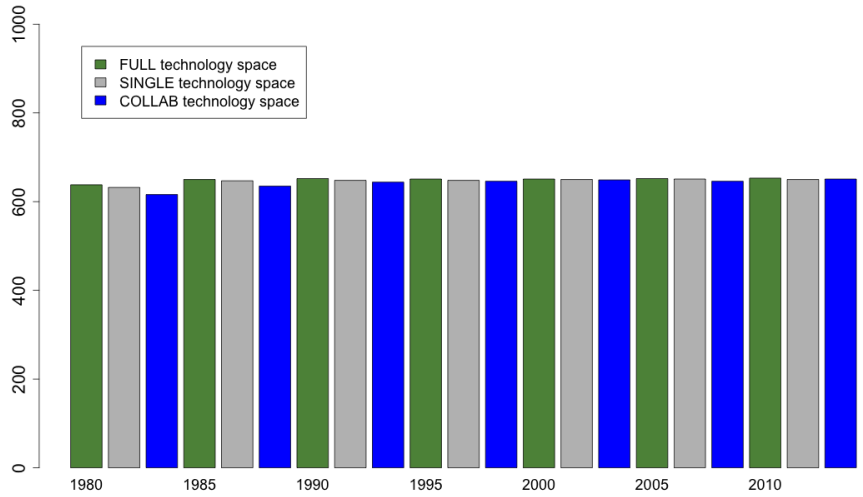
Nr patents per year, 1976-2010



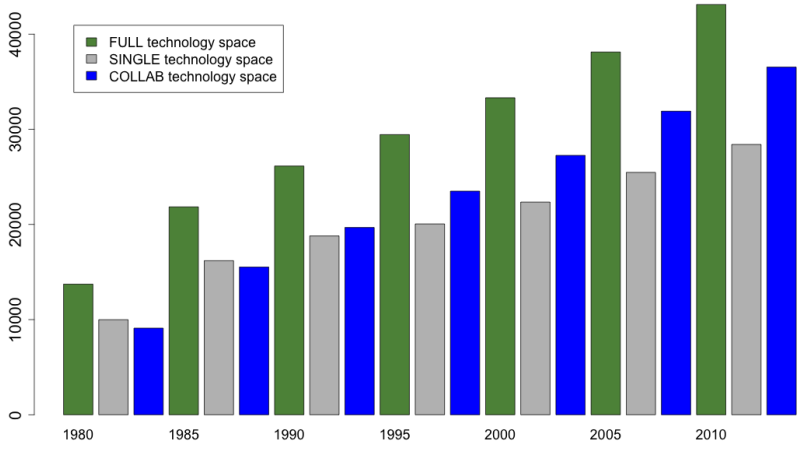
Nr CPC classes present in years, 1976-2010

TECHNOLOGY SPACE CREATION

- Non-overlapping FULL / SINGLE / COLLAB technology spaces for 1980-2010 by 5-year long periods = seq(1980, 2010, 5)
- **Node**: technology class (CPC 4-digit)
- **Edge**: the number of co-occurrences of 2 technologies on patents in the given period



Number of **nodes** in technology spaces



Number of **edges** in technology spaces

ESTIMATION STRATEGY

Estimation in 2 steps

Linear probability models on tie existence

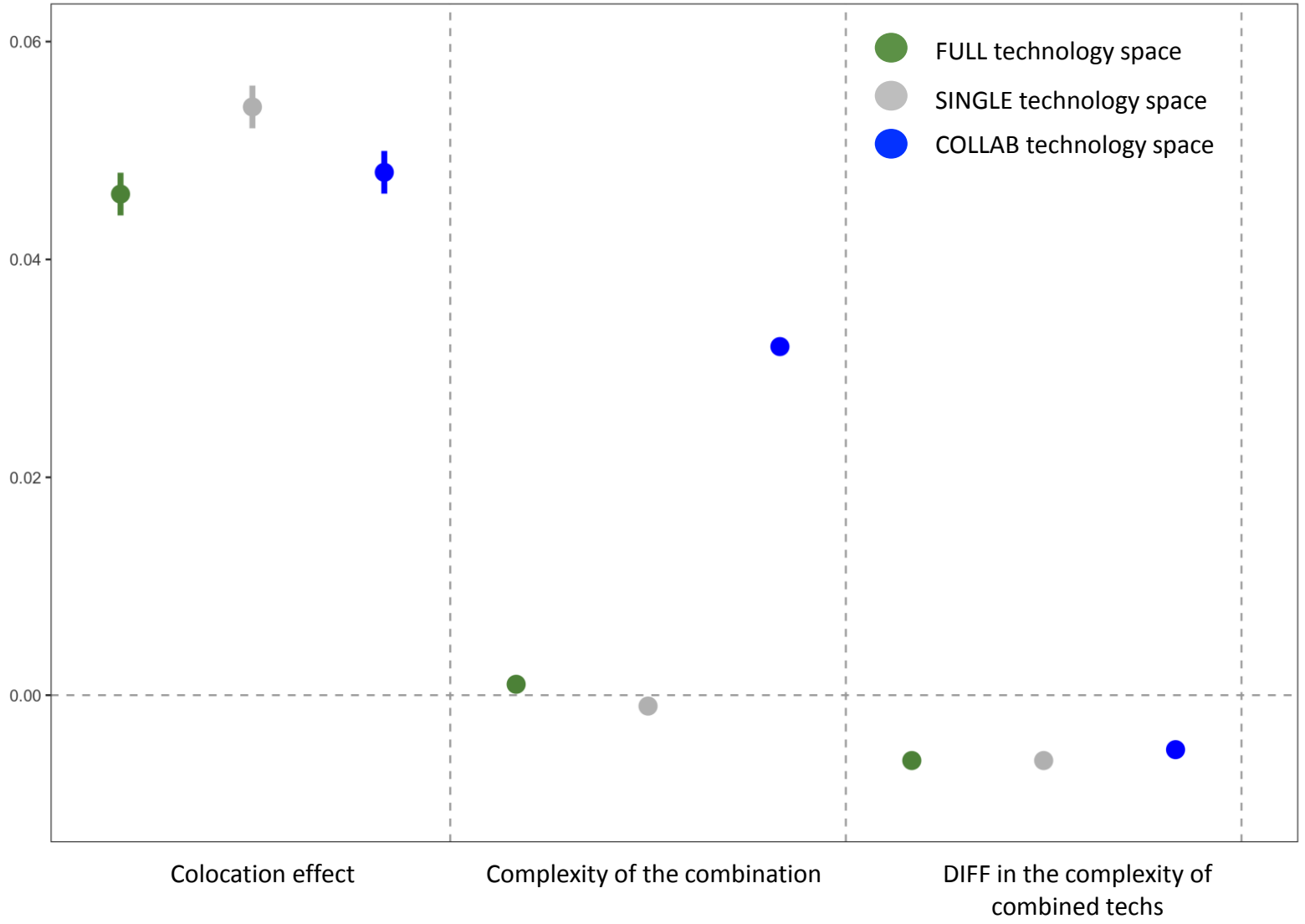
- Only ties that existed in at least one period
- Influence of colocation and complexity in different setups (full / single / collab)

Zero inflated negative binomial models with time FE

- How number of co-occurences depend on colocation and complexity in different setups (full / single / collab)

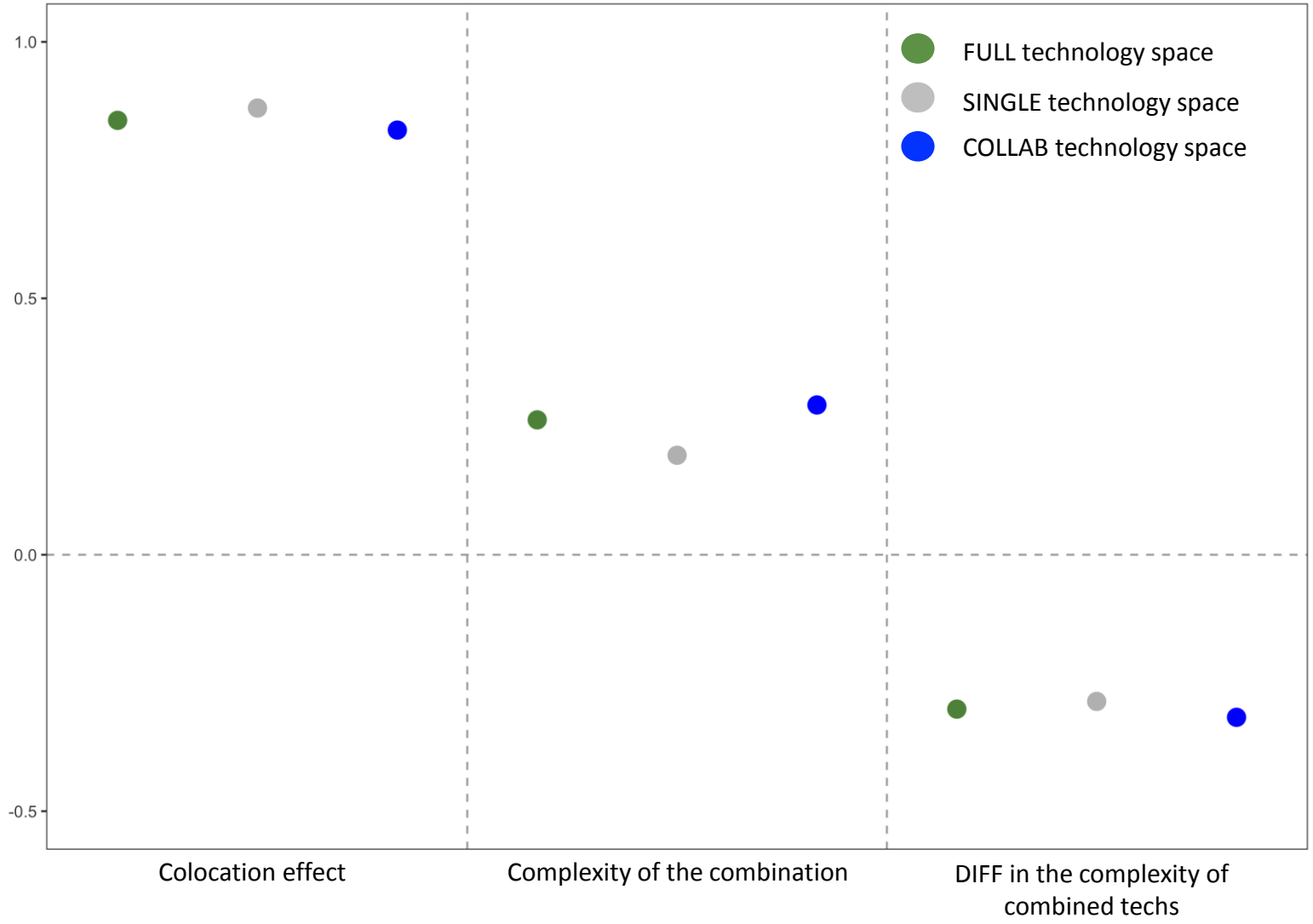
FINDINGS (1)

Linear probability model coefficients on the existence of ties (0/1)



FINDINGS (2)

Zero inflated negative binomial model coefficients on the number of co-occurences of technologies



CONCLUSION | DISCUSSION

2 main aims of the study

- 1) explain technological development through the evolution of the technology space
- 2) show that geography and complexity are important and have different effect on how single inventors and teams work on tech development

Important conclusions for regional economic development strategies

- Technology space -or- Knowledge space is used to create diversification strategies
- As the complexity of technologies increase human collaboration potential becomes key for technological development and diversification

THANKS!

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FINDINGS (1)

Linear probability models on the existence of ties (0/1)

	Dependent variable:	
	Existence of tie in FULL technology space 0/1	
	(1)	(2)
tie presence full lag1	0.335***	0.335***
	(0.002)	(0.002)
SUM complexities lag1	0.027***	0.031***
	(0.003)	(0.003)
ABSDIFF complexities lag1	0.010***	0.014***
	(0.002)	(0.003)
SUM X ABSDIFF complexities lag1		-0.031***
		(0.007)
colocation z-score lag1	0.047***	0.047***
	(0.001)	(0.001)
log nr patents CPC1 full lag1	0.042***	0.042***
	(0.001)	(0.001)
log nr patents CPC2 full lag1	0.040***	0.040***
	(0.001)	(0.001)
log clustering CPC1 full lag1	-0.069***	-0.069***
	(0.010)	(0.010)
log clustering CPC2 full lag1	-0.182***	-0.181***
	(0.010)	(0.010)
Period FE	Yes	Yes
Observations	380,484	380,484
R^2	0.180	0.180
Adjusted R^2	0.180	0.180
F Statistic	10,425.170*** (df = 8; 380470)	9,269.349*** (df = 9; 380469)
Note:		*p<0.1; **p<0.05; ***p<0.01

	Dependent variable:	
	Existence of tie in SINGLE technology space 0/1	
	(1)	(2)
tie presence single lag1	0.418***	0.418***
	(0.002)	(0.002)
SUM complexities lag1	0.021***	0.024***
	(0.002)	(0.002)
ABSDIFF complexities lag1	0.012***	0.014***
	(0.002)	(0.002)
SUM X ABSDIFF complexities lag1		-0.019***
		(0.007)
colocation z-score lag1	0.055***	0.055***
	(0.001)	(0.001)
log nr patents CPC1 single lag1	0.037***	0.037***
	(0.001)	(0.001)
log nr patents CPC2 single lag1	0.035***	0.035***
	(0.001)	(0.001)
log clustering CPC1 single lag1	-0.044***	-0.044***
	(0.008)	(0.008)
log clustering CPC2 single lag1	-0.157***	-0.157***
	(0.008)	(0.008)
Period FE	Yes	Yes
Observations	380,484	380,484
R^2	0.230	0.230
Adjusted R^2	0.230	0.230
F Statistic	14,213.870*** (df = 8; 380470)	12,635.620*** (df = 9; 380469)
Note:		*p<0.1; **p<0.05; ***p<0.01

	Dependent variable:	
	Existence of tie in COLLAB technology space 0/1	
	(1)	(2)
tie presence collab lag1	0.389***	0.389***
	(0.002)	(0.002)
SUM complexities lag1	0.028***	0.032***
	(0.002)	(0.003)
ABSDIFF complexities lag1	0.010***	0.014***
	(0.002)	(0.002)
SUM X ABSDIFF complexities lag1		-0.034***
		(0.007)
colocation z-score lag1	0.049***	0.049***
	(0.001)	(0.001)
log nr patents CPC1 collab lag1	0.042***	0.042***
	(0.001)	(0.001)
log nr patents CPC2 collab lag1	0.043***	0.043***
	(0.001)	(0.001)
log clustering CPC1 collab lag1	-0.039***	-0.039***
	(0.007)	(0.007)
log clustering CPC2 collab lag1	-0.075***	-0.075***
	(0.008)	(0.008)
Period FE	Yes	Yes
Observations	380,484	380,484
R^2	0.231	0.231
Adjusted R^2	0.231	0.231
F Statistic	14,314.060*** (df = 8; 380470)	12,727.230*** (df = 9; 380469)
Note:		*p<0.1; **p<0.05; ***p<0.01

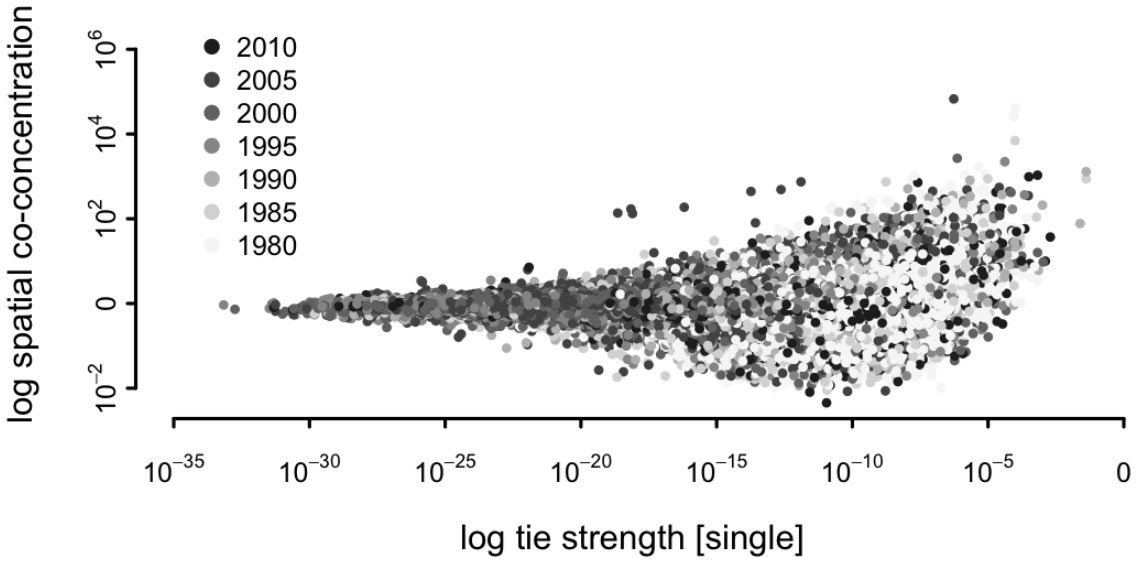
FINDINGS (2)

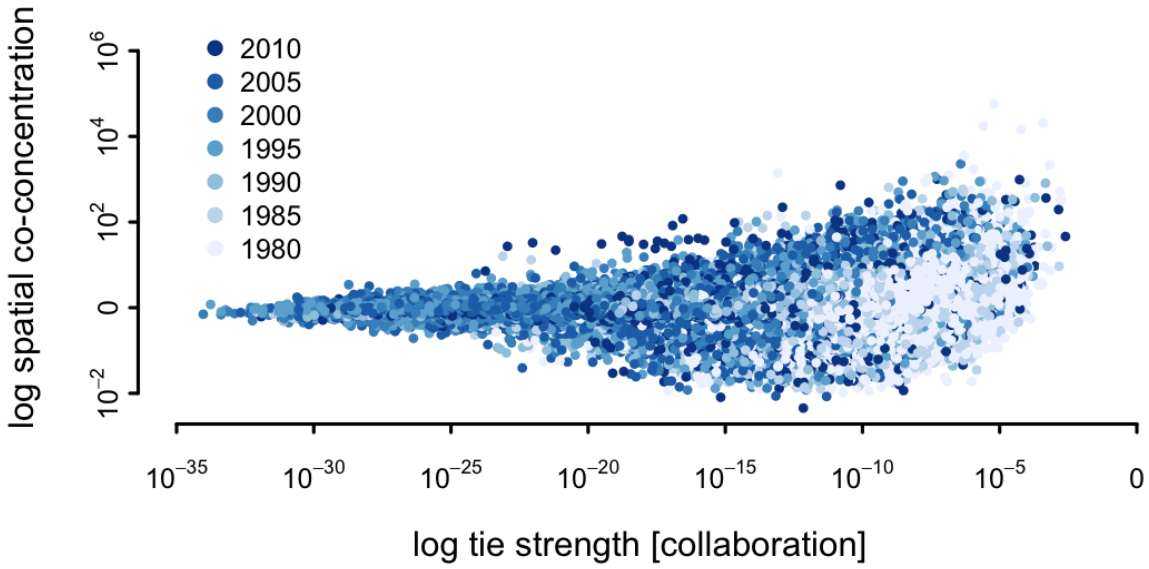
Zero inflated negative binomial models on the number of co-occurences of technologies

	Tie strength FULL technology space	Tie strength SINGLE technology space	Tie strength COLLAB technology space
Count model			
Colocation (z-score) lag1	0.836***	0.841***	0.833***
	(0.007)	(0.008)	(0.008)
SUM complexities lag1	1.351***	0.197***	0.289***
	(0.012)	(0.001)	(0.001)
ABSDIFF complexities lag1	0.641***	-0.241***	-0.277***
	(0.014)	(0.002)	(0.002)
SUM X ABSDIFF lag1	-0.441***	-0.434***	-0.376***
	(0.033)	(0.030)	(0.029)
Period FE	YES	YES	YES
Zero-inflation model			
Nr patents CPC1	-0.001***	-0.003***	-0.001***
FULL/SINGLE/COLLAB lag1	(0.000)	(0.037)	(0.000)
Nr patents CPC2	-0.000***	-0.001***	-0.000***
FULL/SINGLE/COLLAB lag1	(0.000)	(0.000)	(0.000)
Weighted local clustering CPC1	4.351***	3.454***	3.826***
FULL/SINGLE/COLLAB lag1	(0.035)	(0.037)	(0.036)
Weighted local clustering CPC2	5.198***	4.355***	4.251***
FULL/SINGLE/COLLAB lag1	(0.036)	(0.037)	(0.037)

FINDINGS

In relation to GEOGRAPHY



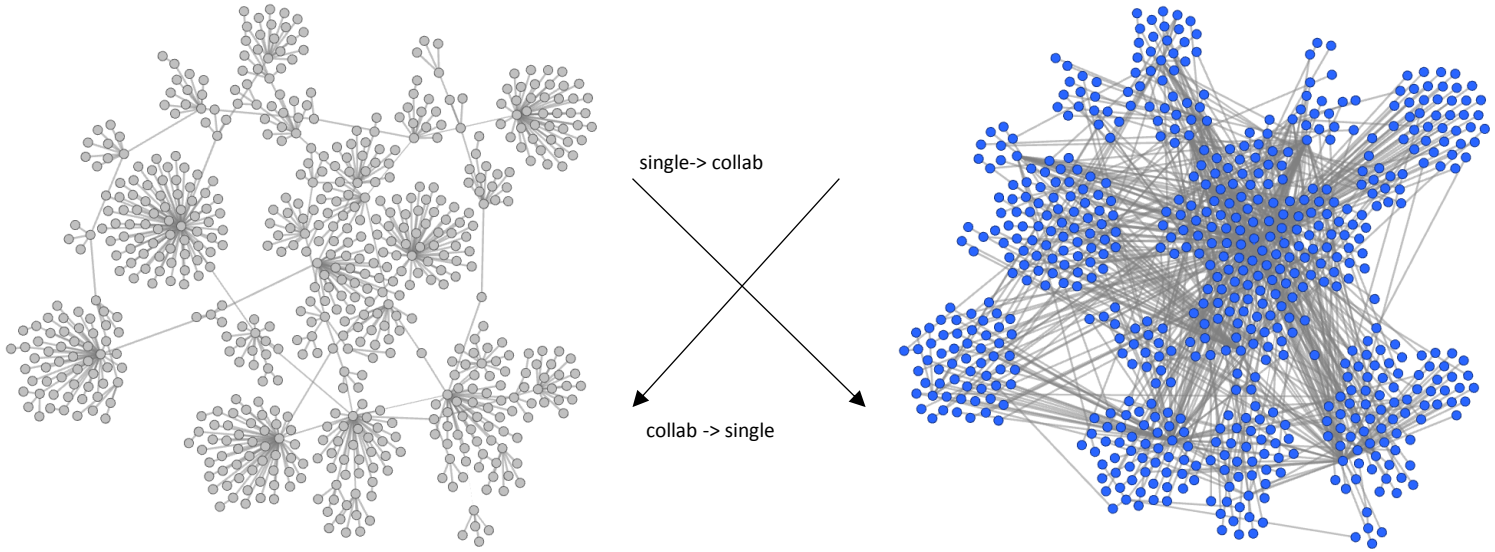


FUTURE OF THE PROJECT

(actually the past of the project)

CO-EVOLUTION OF SINGLE / COLLAB technology spaces

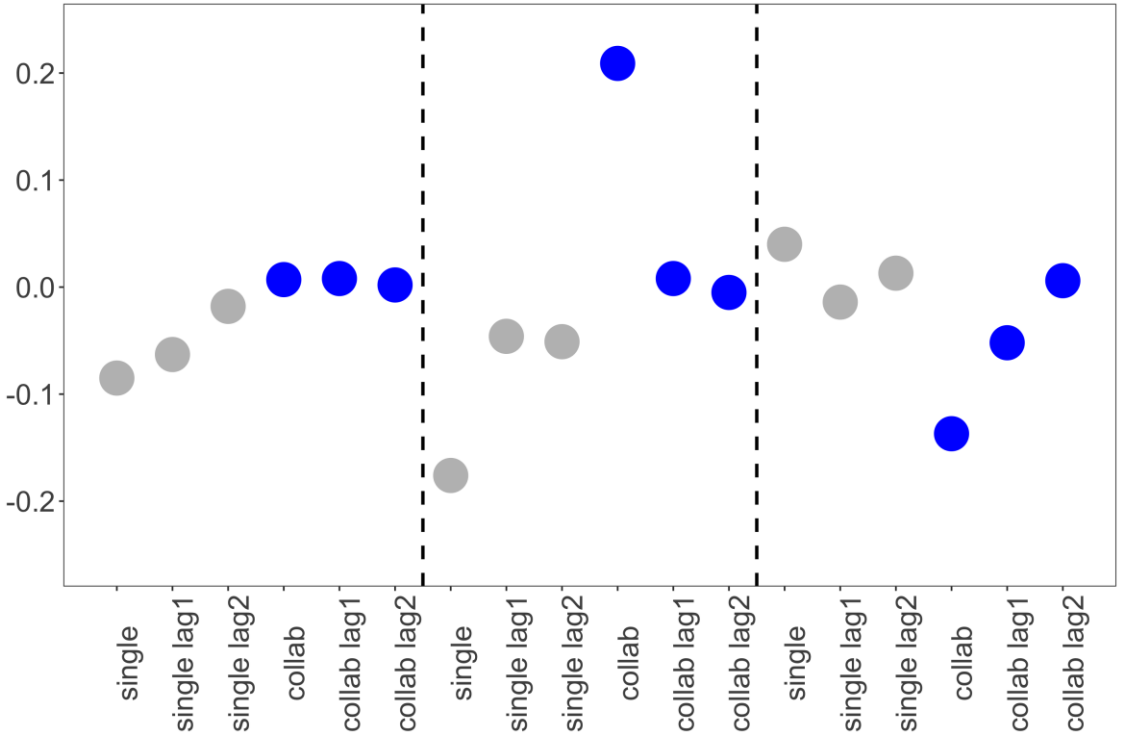
Hypothesis: Teams establish ties first – individuals will only combine technologies later in time



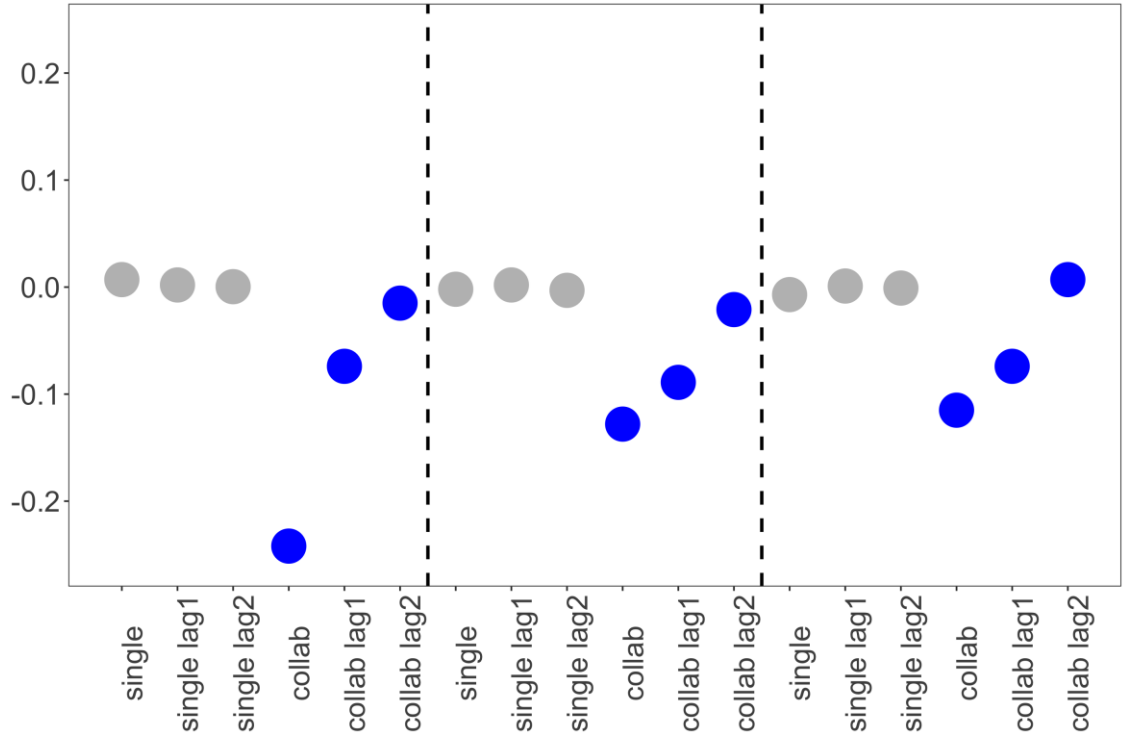
CO-EVOLUTION

(actually the past of the project)

DEP lead tie strength SINGLE



DEP lead tie strength COLLAB



Lead-Lag regression // Controls: weighted local clustering of node IPC1 / IPC2, Nr patents IPC1 / IPC2

CO-EVOLUTION

(actually the past of the project)