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Co-inventions and the evolution of incremental innovations in the European ICT patenting: evidence from 1990 to 2019

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Motivation and background 1/2

- ICT patenting has been pivotal in transforming socio-economic systems (Hall, Lotti, and Mairesse, 2013);
- ICT has proven instrumental to develop Industry 4.0 (Nuvolari, 2019) and green technologies (Corrocher and Ozman, 2020);
- Relevance of digital and green transition in European industrial policies (Reischauer, 2018; Crnec, Penca and Lovec, 2023);
- Recent debate on technology sovereignty have shed light on building competences and capacities to sustain both national competitiveness and transformative processes (Edler et al., 2023).

RQ: Does the European Union have the ICT knowledge and capacities to foster digital and green transition?

Motivation and background 2/2

- Patented inventions have different technological and economic value which are measured by patent quality indicators (Squicciarini, Dernis and Criscuolo, 2013);
- Patent quality indicators are implemented through a theory-driven approach, and highly sensitive to both the observable outcome selected and the technology type (Higham, de Rassenfosse, and Jaffe, 2021);
- Co-inventions are more complex and human capital-intensive than inventions developed singularly (Agostini and Caviggioli, 2015), while inventions that rely on a large number of diverse knowledge sources are supposed to lead to original results (Trajtenberg et al., 1997).

RQ1: Does originality predict co-inventions?

- Backward citations have been found to be positively related to the value of a patent (Harhoff et al., 2003), large numbers of backward citations may signal the innovation to be more incremental in nature (Lanjouw and Schankerman, 2001).

RQ2: Does ICT have become more and more incremental? Which variables explain the number of backward citations?

Methodology

RQ1: Does originality predict co-inventions?

- Classification ─ Logistic regressions

RQ2: Does ICT have become more and more incremental? Which variables explain the number of backward citations?

- Smoothing and cross-validation
- Ridge and LASSO

Data sources

- ICT-related patents applied at the European Patent Office (EPO) by EU-28 applicants during the period 1990-2019;

- ICT-related patents retrieved by ICT taxonomy based on International Patent Classification (IPC) proposed by Inaba and Squicciarini (2017);

- Aggregation of several data sources:
  1. OECD REGPAT Database,
  2. OECD Patent Quality Indicators Database,
  3. OECD Citations Database,
  4. OECD HAN database.

Variables 1/2

Dataset: 6620 patents, 33 variables

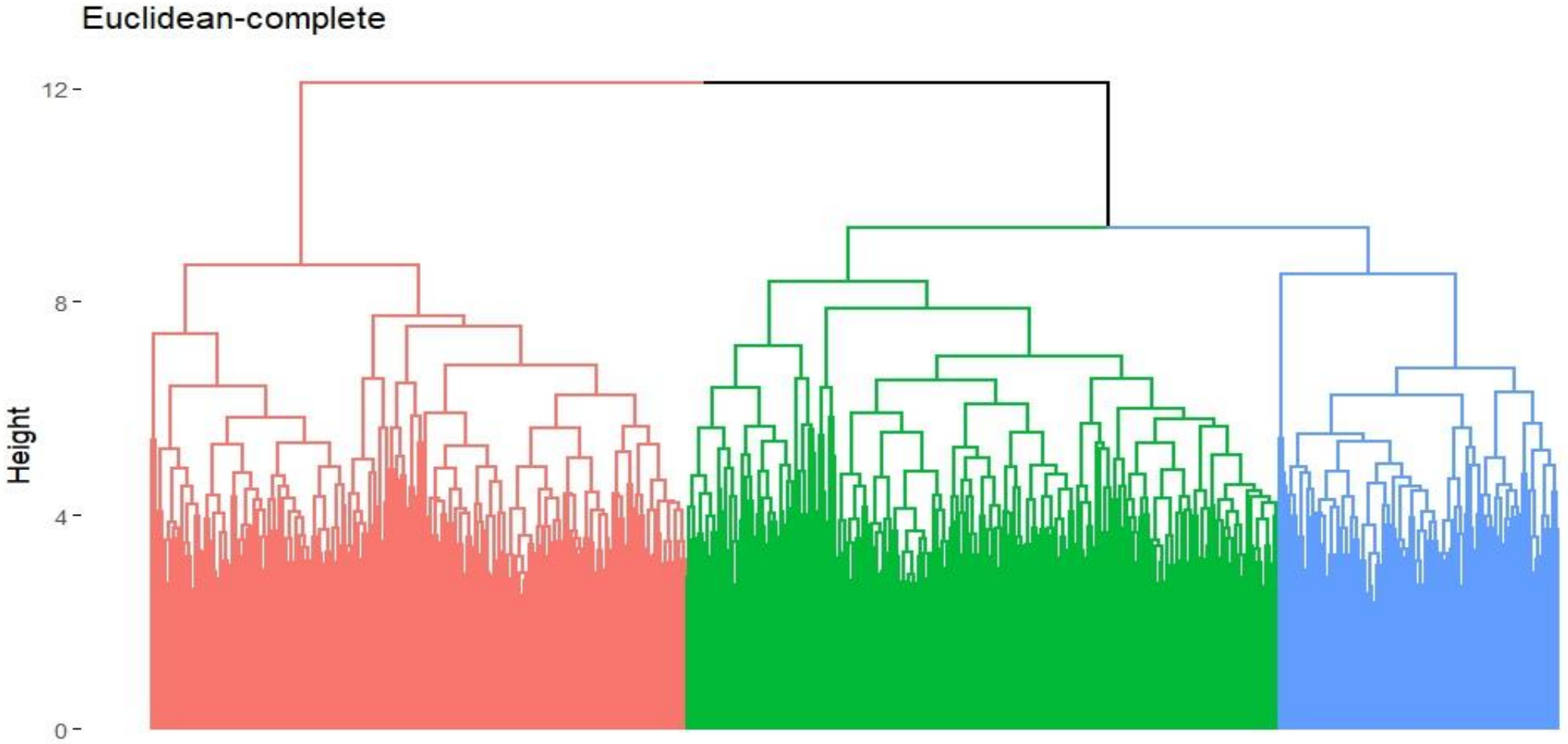
- Publication dates - 3 variables
  - 1) Application year, 2) Application month, and 3) Priority year
- ICT technology areas - 12 variables
  - 1) Security, 2) Human-interface, 3) High speed network, 4) Large-capacity information analysis, 5) Mobile communication, 6) cognition and meaning understanding, 7) imaging and sound technology, 8) high speed computing, 9) electronic measurement, 10) information communication device, 11) sensor and device network, and 12) Large-capacity and high-speed storage

Variables 2/2

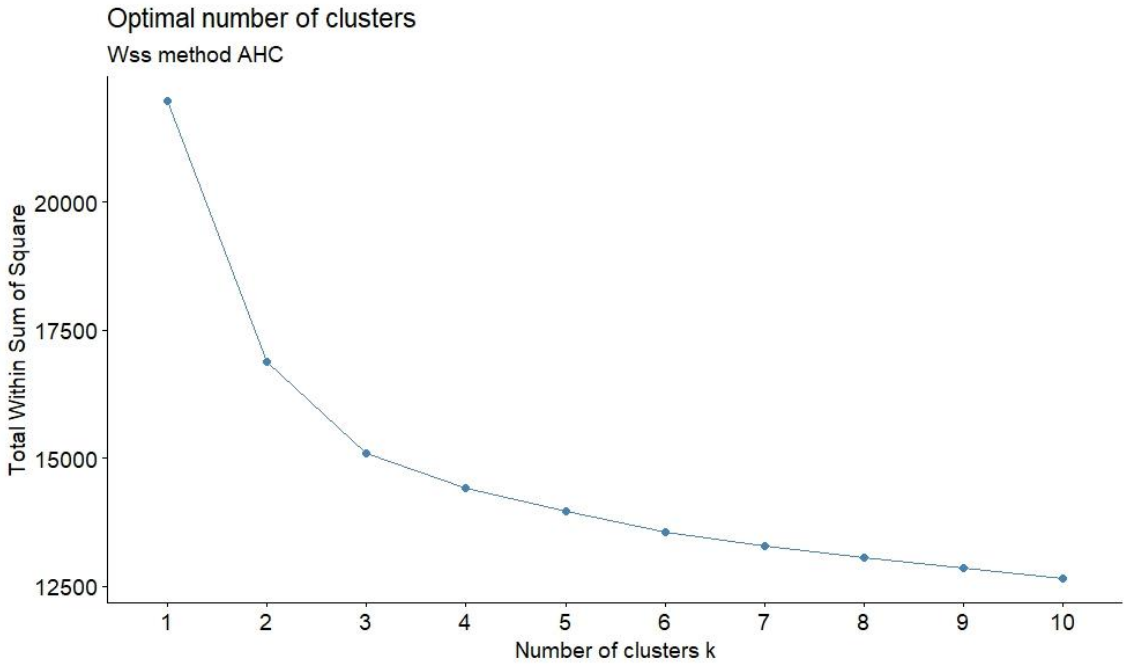
- Patent quality indicators - 14 variables
  - 1) technology field, 2) many technology field, 3) patent scope, 4) family size, 5) grant lag, 6) number of backward citations, 7) number of non-patent literature citations, 8) number of claims, 9) number of forward citations received up to 5 years after publication, 10) number of forward citations received up to 7 years after publication, 11) generality index, 12) originality index, 13) radicalness index 14) renewal

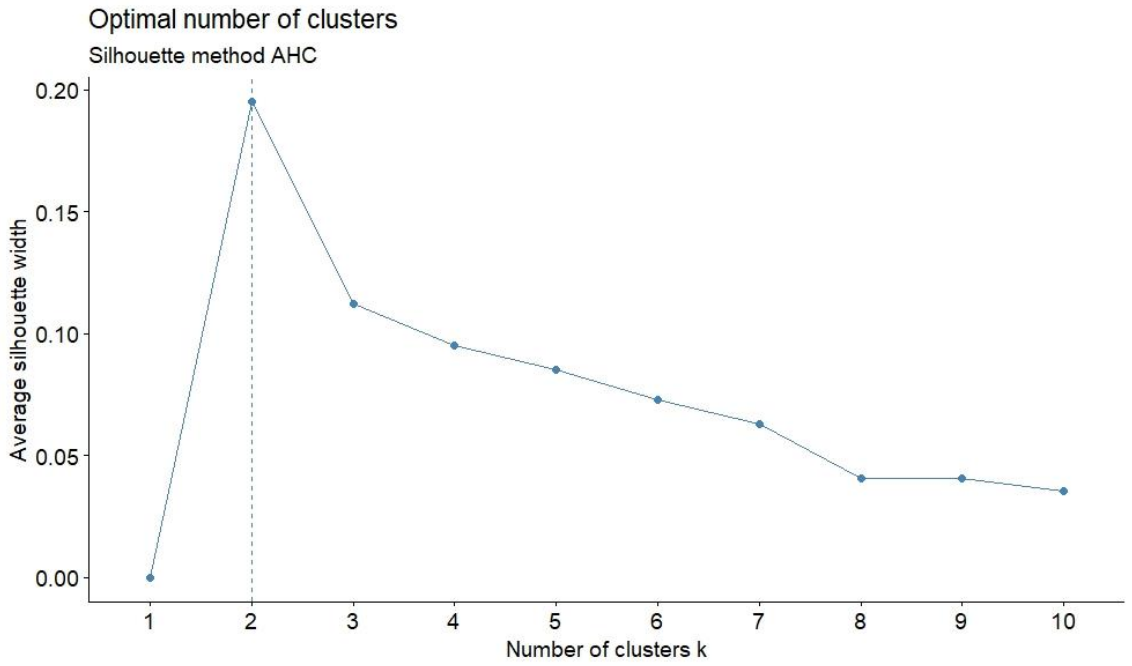
- Regional and national inventors and applicants' share - 4 variables
  - 1) co-invention share, 2) co-invention regional share, 3) co-application share, and 4) co-application regional share

Hierarchical clustering



Hierarchical clustering - WSS and Silhouette





Classification – RQ1

- **Simple model:** *Co-inventions = Originality*
- **Complete model:** *Co-inventions = .*
- **Stepwise model:** *Co-inventions = Human-interface+ Cognition and meaning understanding+ Imaging and sound technology+ Information and communication design+ Sensor and device network+ Non-patent literature+Claims+ number of forward citations received up to 5 years after publication*

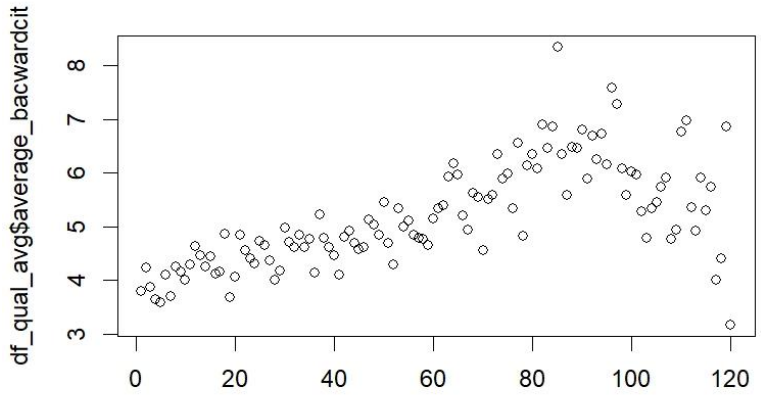
Classification – RQ1

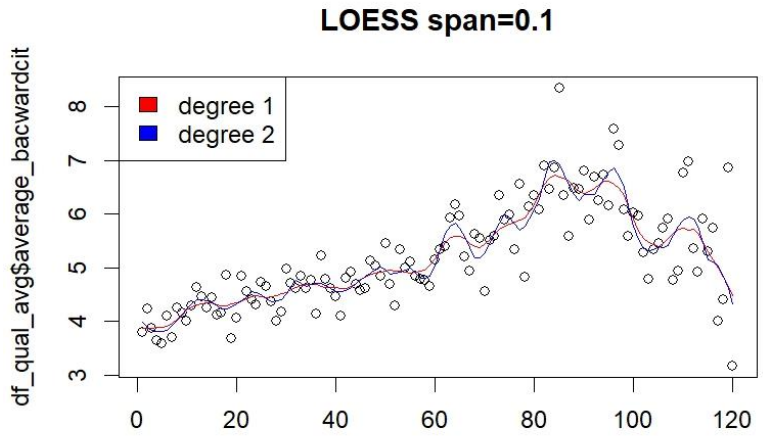
	Accuracy	df	AIC		Reference	
				Prediction	0	1
Simple model	0.6058	2	6663.8	0	0	0
				1	652	1002
Complete model	0.6070	29	6562.3	0	87	85
				1	565	917
Stepwise model	0.6094	9	6530.1	0	86	79
				1	567	923

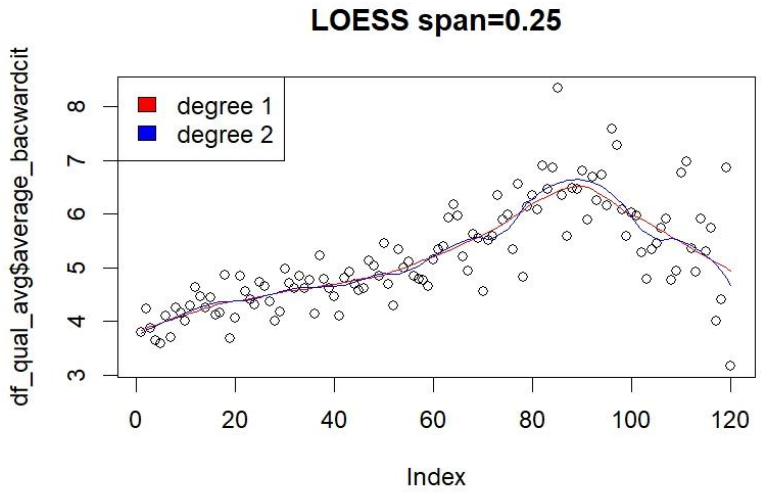
Classification – RQ1

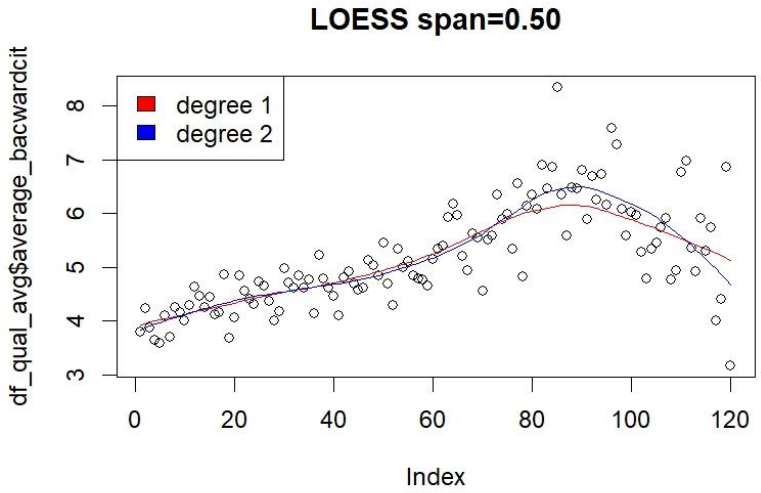
	Dep. Var.: Co-invention	
	Simple	**Stepwise**
Originality	-0.0096	
	(0.1428)	
Human-interface		-0.2741**
		(0.1169)
Cognition and meaning understanding		0.2894**
		(0.1411)
Imaging and sound technology		-0.2369***
		(0.0821)
Information communication device		0.3343***
		(0.0736)
Sensor and device network		-0.2510**
		(0.1159)
Non-patent literature citations		0.2614***
		(0.0371)
Claims		0.2092***
		(0.0497)
Forward citation up to 5 years		0.1205**
		(0.0546)

Smoothing – RQ2



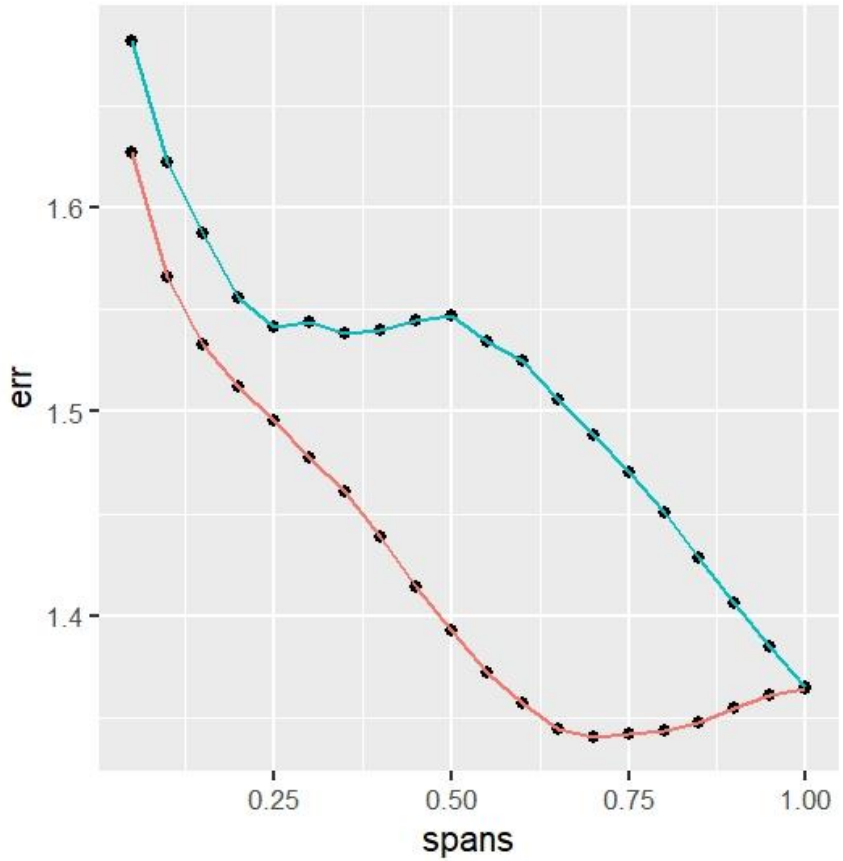




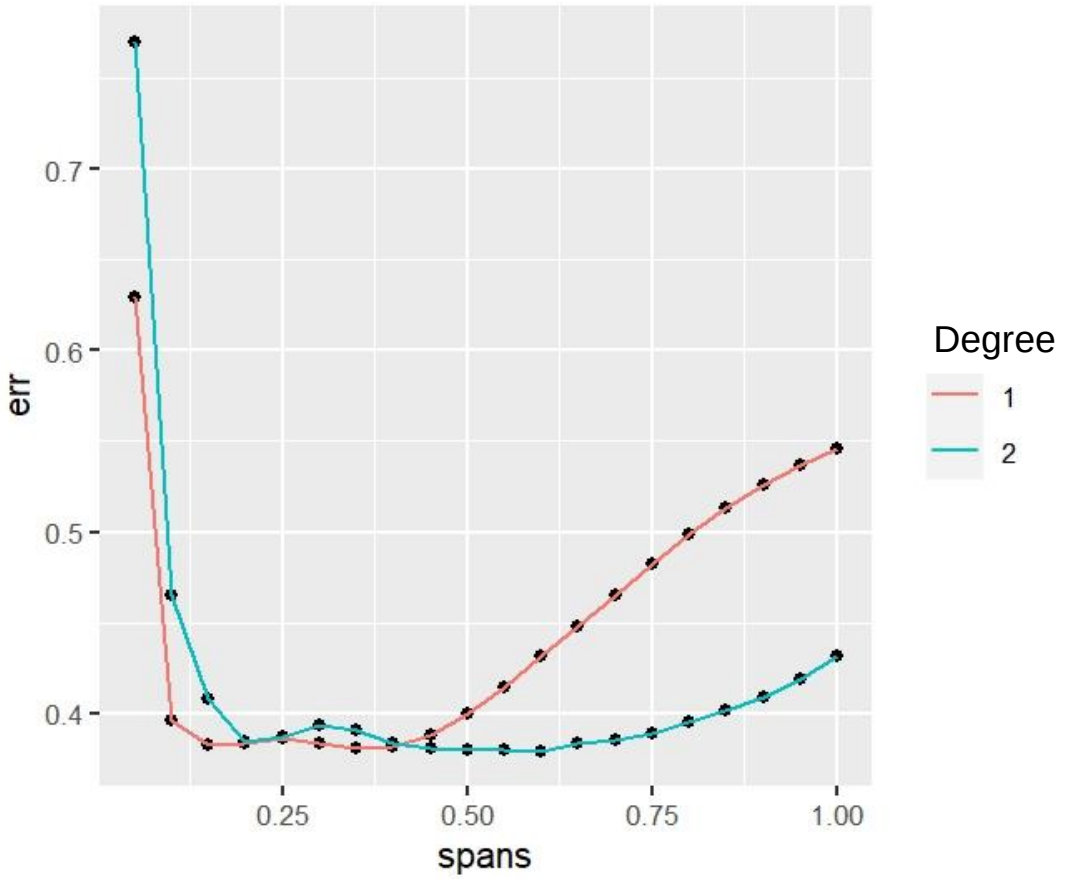


Cross Validation – RQ2

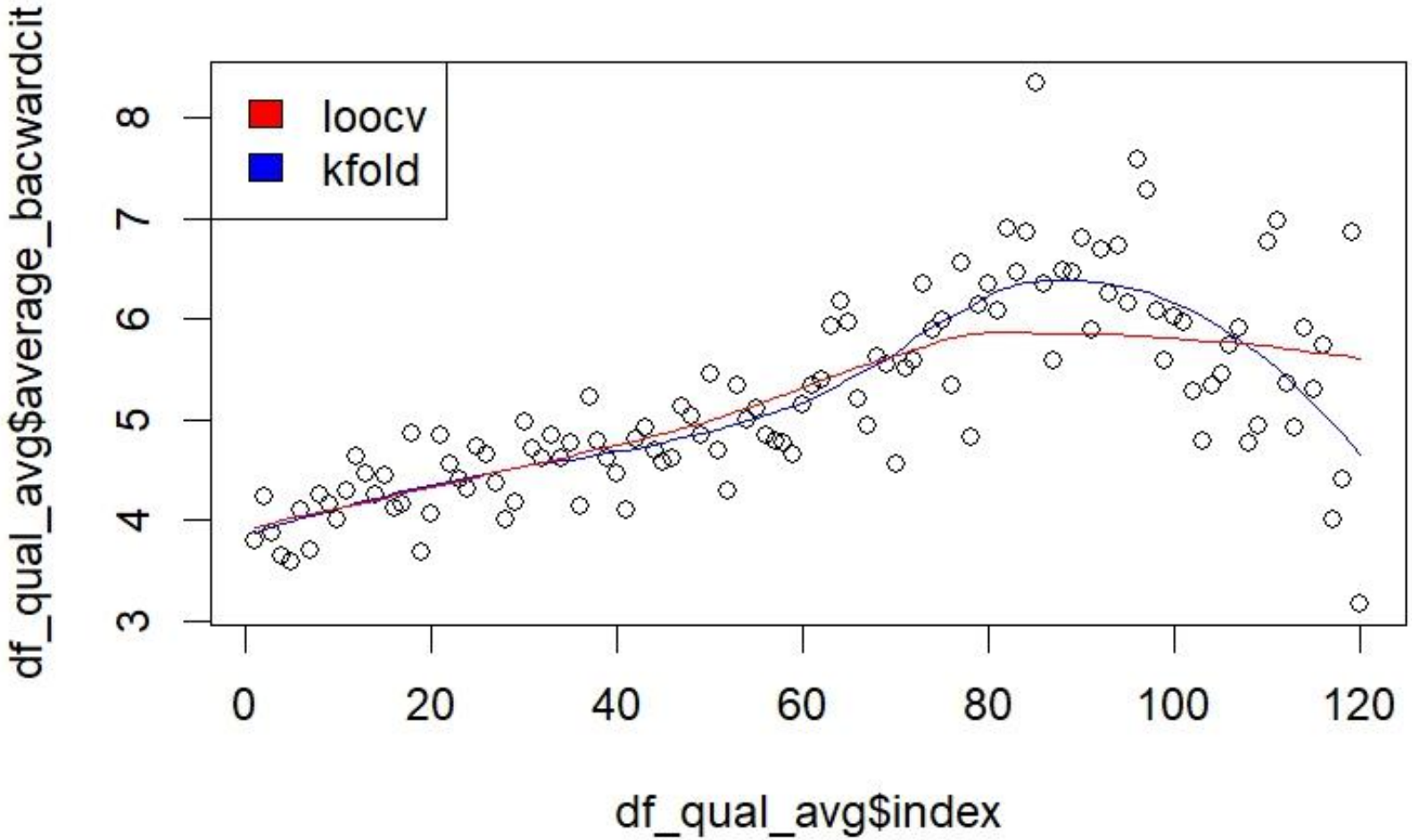
LOOCV



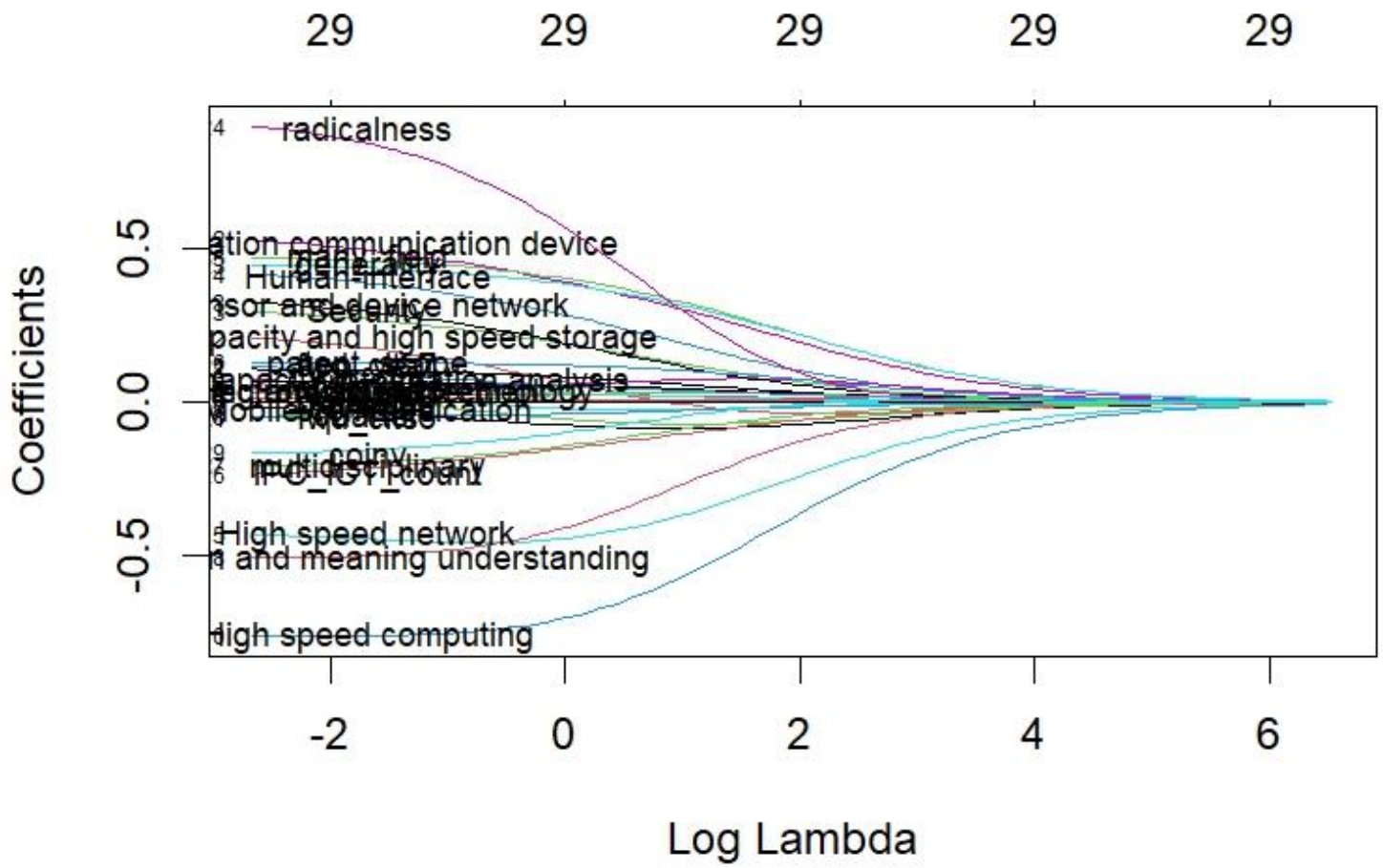
KFOLD



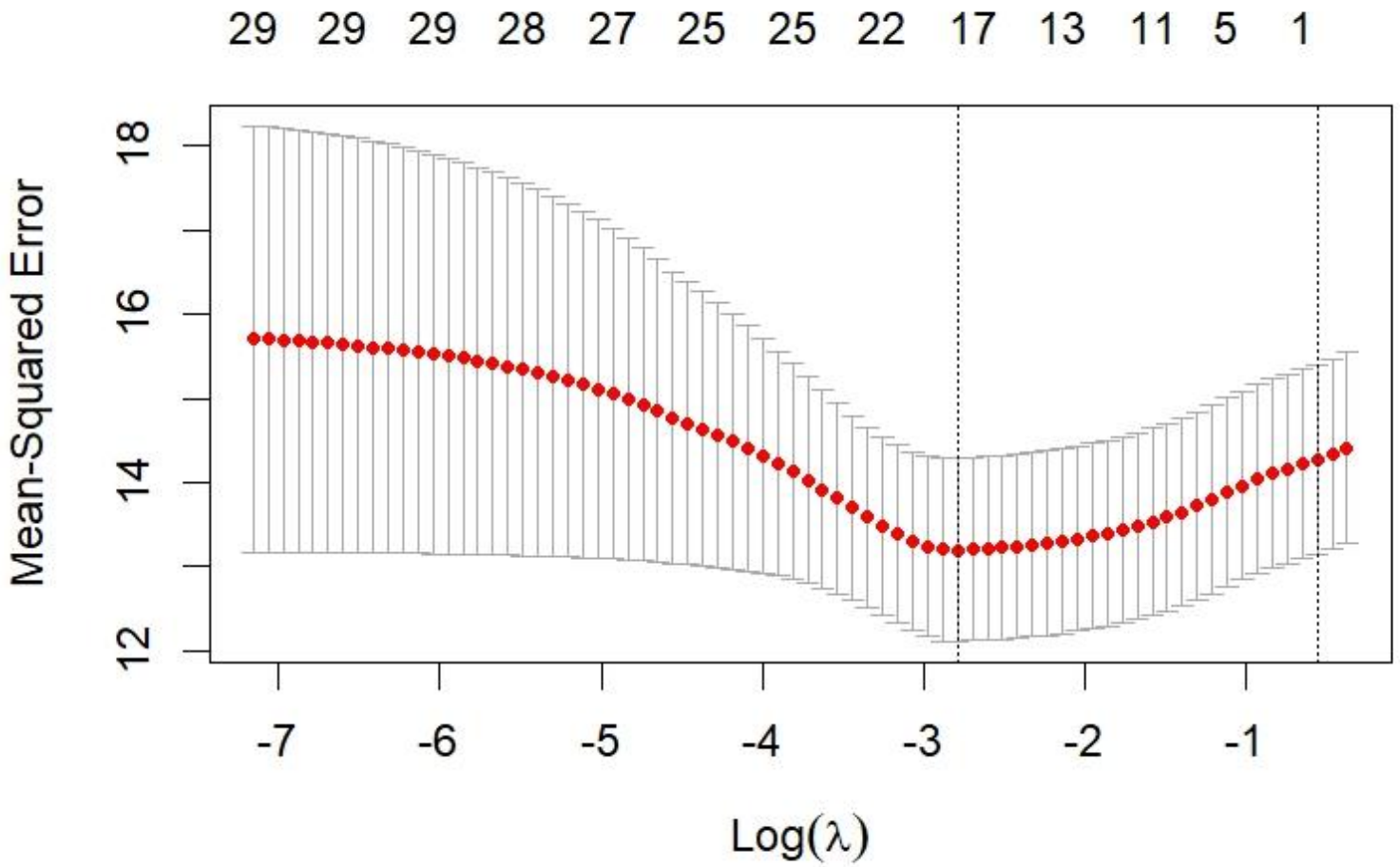
Cross Validation – RQ2



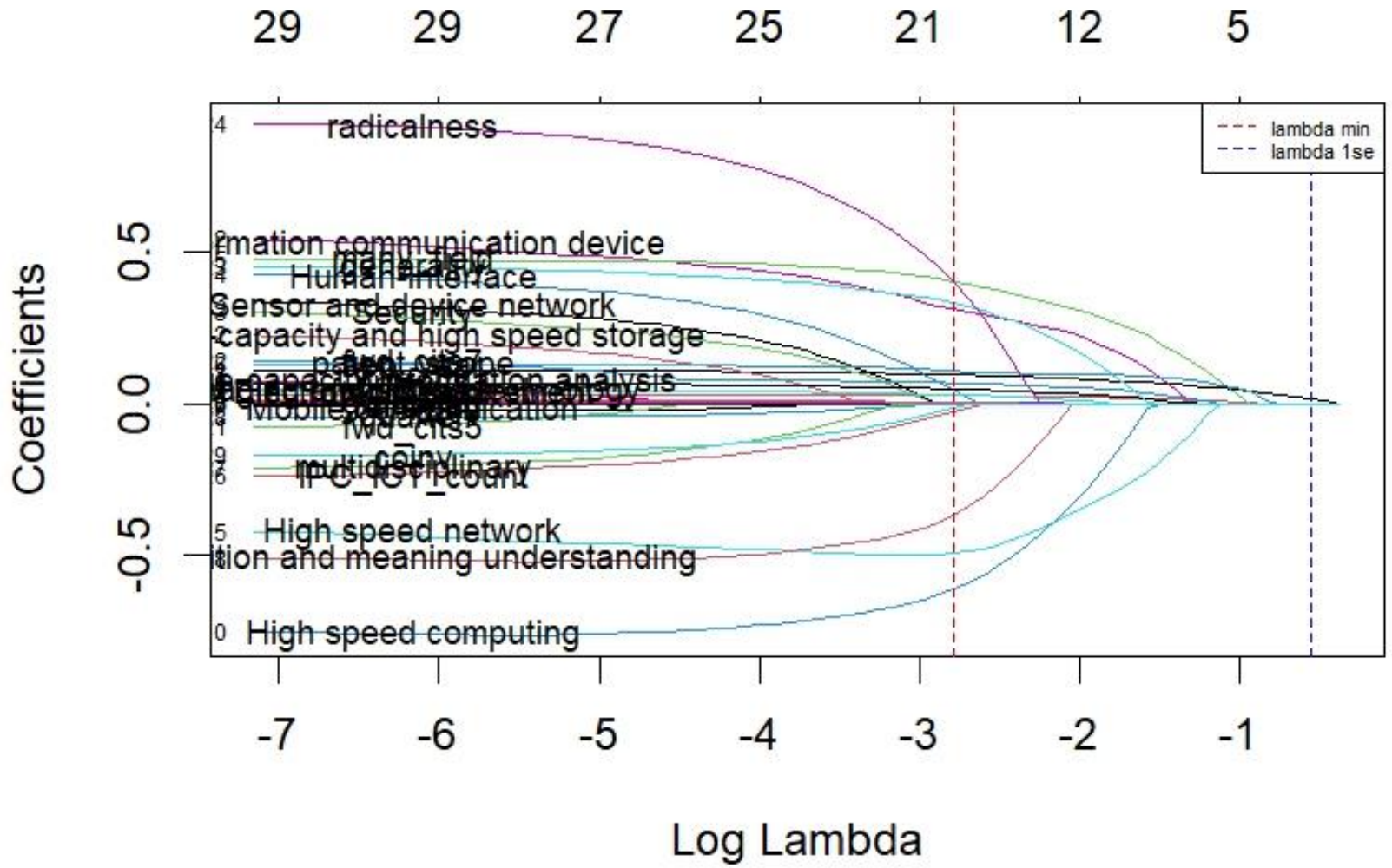
Ridge – RQ2


29
29
29
29
29
radicalness
ation communication device
Human-interface
sor and device network
pacity and high speed storage
High speed network
and meaning understanding
high speed computing
Coefficients
0.5
0.0
-0.5
-2
0
2
4
6
Log Lambda

Lasso – RQ2


29 29 29 28 27 25 25 22 17 13 11 5 1
Mean-Squared Error
18
16
14
12
-7
-6
-5
-4
-3
-2
-1
Log(λ)

Lasso - RQ2


29 29 27 25 21 12 5
lambda min
lambda 1se
radicalness
Human interface
Sensor and device network
capacity and high speed storage
High speed network
High speed computing
0.5
0.0
-0.5
Coefficients
-7 -6 -5 -4 -3 -2 -1
Log Lambda

Plans on implementing statistical learning on my research

- Analyse the role of ICT on I4.0 at firm-level
  1. classification;
  2. stepwise and feature selection;
  3. ridge and LASSO.

- Analyse the technological spillovers of ICT patents on the EU economic sectors
  1. functional data

Thank you!

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