Foreign Direct Investments and local recombinant novelty: evidence from European regions

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Motivation

- Recombination of knowledge components is a staple mechanism in technological progress, creative destruction, structural change, and economic growth (Schumpeter 1934, Weitzman 1998, Aghion and Howitt 1992)
- Understanding innovation as a knowledge-recombinant process (Arthur 2007), that might lead to breakthrough, opening up new technological trajectories (Dosi 1982; Antonelli et al. 2010).
- Recombinant innovation is widely studied, and has a lot of definitions (Arts et al. 2021). While breakthrough might stem from vertical search (Boschma et al. 2021) we focus on horizontal search (Verhoeven et al. 2016).

FDI as determinants of recombinant novelty

- We study Foreign Direct Investments (FDI) as a determinant in shaping the process of knowledge recombination.
- Through cross-border investments knowledge flows, be it **explicit** or **tacit** (know-how, expertise, company culture, technical standards, requirements for local producers): spillover on local innovation system.
- Multinational enterprises (MNE) investing beyond national borders represent **knowledge flows** can be intended as foreign agents of structural change for local regional innovation systems, creating external linkages (Neffke et al. 2018). We add onto the growing literature connecting GPN with EEG (Yeung 2021; Boschma 2022).

Mechanisms and direction

- Two main contrasting effects of FDI on innovation: (1) knowledge spillovers and R&D competition vs (2) efficiency gains in terms of productivity but detrimental on incumbent innovation.
- Some macro and GVC literature seems to support more the latter, regional literature the former (e.g. Antonietti and Franco 2021; García et al. 2013; Jin et al. 2019; Mercer-Blackman et al. 2021).
- Complex to model together: depends crucially measurement (Arts et al. 2021), timing (Antonietti and Franco 2021; Amoroso and Müller 2018).

Complexity of mechanisms btw FDI and innovation

- FDI definition (outward-inward) and timing (short-long).
- Mode of entry (Takayama 2021): greenfield vs M&A
- Absorptive capacities of firms, sectors, regions: García et al. (2013); Jin et al. (2019).
- Value chains: Ascani et al. (2020); Mercer-Blackman et al. (2021)
- Spatial and agglomeration dynamics effects: Burger and Meijers (2016); Ascani et al. (2020)
- Role of knowledge linkages and network structures (Aquaro et al. 2021; Kleineick et al. 2020; Berkes and Gaetani 2021).

What we do

One of the strongest results that spans macro, firm, and regional literature is the role of local absorptive capabilities. We hypothesise that:

- FDIs are knowledge flows, firms are agents of structural change (Neffke et al. 2018) creating external linkages to the regional innovation system (Yeung 2021)
- either through backward or forward linkages (Miguelez and Moreno 2018)
- knowledge flow interacts with regional recombinant capacities in generating (locally) novel knowledge. This depends on relatedness and symmetry between FDIs and local patenting (Frenken et al. 2007; Miguelez and Moreno 2018).

Research Questions

- **Hypothesis 1**: Greenfield FDIs, both in terms of inflows and outflows, are positively associated with (local) recombinant novelty in regions.
- **Hypothesis 2**: Relatedness density around FDIs (local recombinant capacities) is positively associated with recombinant novelty.

Recombinant novelty

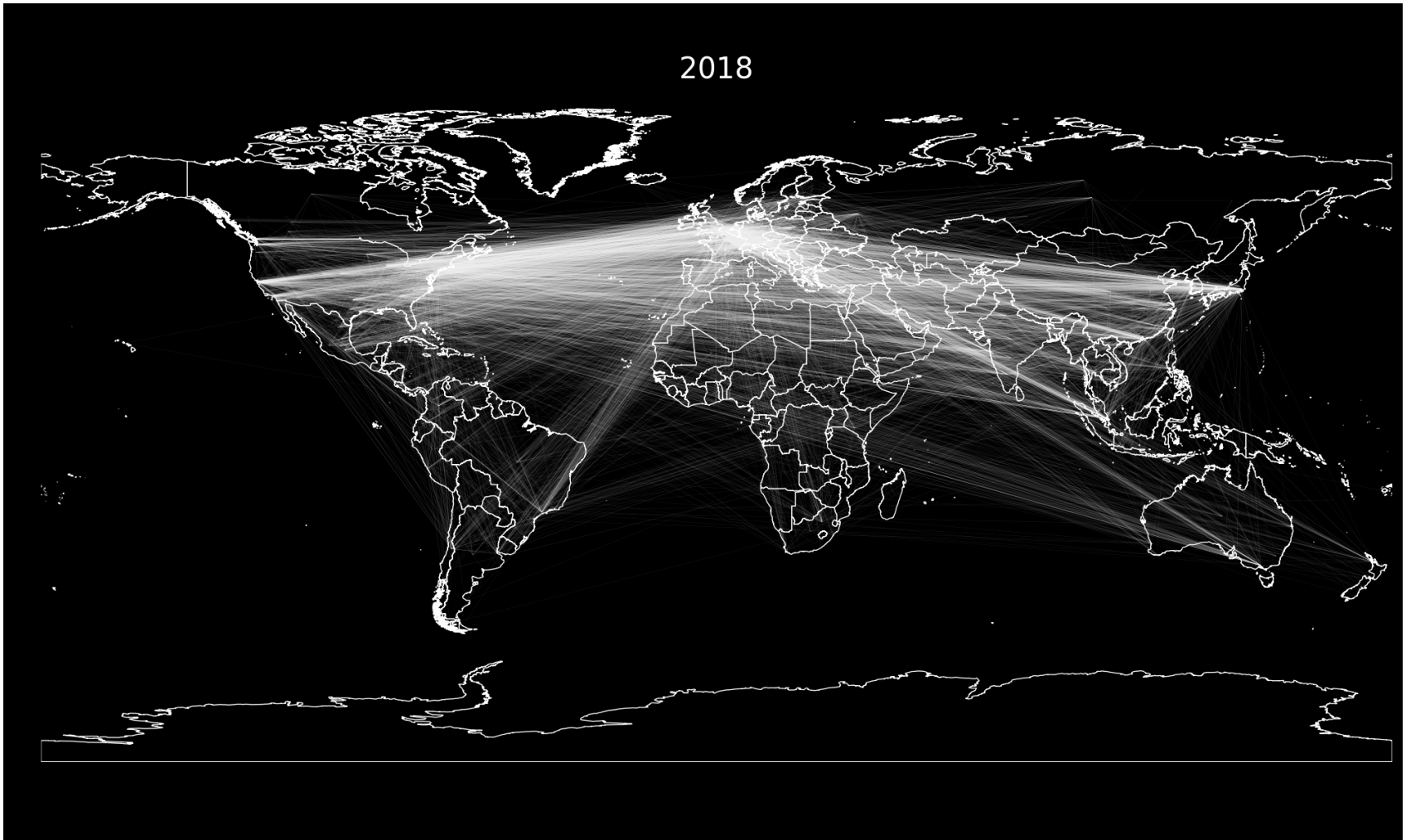
We use REGPAT (OECD) construct measures of recombinant novelty in innovation as appearance of previously unseen pairwise combinations of CPC-4digit sub-classes. (Verhoeven et al. 2016):

- Novelty in Recombination (focal patent CPC)
- Novelty in Knowledge Origins (citations CPC)
- Novelty in both

We compute novelty at the local level: combinations never appeared before in the region, with a 10-years memory-loss function.

Greenfield FDI flows - fDiMarkets (FT Intelligence)

Figure: FDI flows - *gif*



Greenfield Foreign Direct Investments

- fDiMarkets (Financial Times) allows us to track greenfield FDIs in bilateral flows.
- The classifications are poorly documented (proprietary): matching with Bureau Van Dijk / PATSTAT would be ideal.
- We construct regional measures of inward and outward **FDI stocks** with:

$$stock_{it} = (1 - r)stock_{i,t-1} + flows_{it} \quad (1)$$

Measuring absorptive capacity (H2)

- We map FDIs to technologies (Lybbert and Zolas 2014) and compute two measures to look at **local absorptive capacity**.
- **Relatedness-density** of patenting around FDIs. Intuition: the measure increases, the higher the average number of technologies related to FDIs' technologies. details
- **Symmetry** between FDIs and CPC structure at regional level (Miguelez and Moreno 2018):

$$Similarity_d = log \sum_j PAT_4(j) FDI_4(j)$$

Baseline model

$$y_{i,t} = \alpha + \beta_1 FDI_{i,t-2} + \beta \mathbf{X}_{i,t-2} + \gamma_1 + \gamma_2 + \epsilon_{i,t}$$

where:

- three novelty indicators as indep. var.
- FDI are separately tested (inward vs outward)
- **X** is a vector of controls:
  - Gross Fixed Capital Formation (ARDECO)
  - Unrelated Variety (REGPAT, Castaldi et al. (2015))
  - M&A (Zephyr)
  - Population Density (Eurostat)
  - Cohesion Funds payments (EC)
  - γ are region and time-fixed effects

Spatial econometrics model

$$y_{i,t} = \alpha + \lambda W y + \beta \mathbf{X}_{i,t-2} + \sigma W \mathbf{X}_{i,t-2} + \gamma_1 + \gamma_2 + \epsilon \qquad (2)$$

where:

- γ_1 are time-fixed
- γ_2 are region-fixed
- ϵ is the idiosyncratic error term
- $\mathbf{X}$ is the vector of control variables
- $\mathbf{W}$ is the spatial contiguity matrix

Instrumental variable approach

- A well-known instrument in the FDI literature exploits the **geographical distance** between source and host economies (arguably exogenous to their innovation system), but significantly predicting FDI flows (transaction costs). Danakol et al. (2017)
- Geolocate worldwide flows of greenfield FDIs to ADM-2 regions and get centroids' distances.
- Instrument: **weighted average of the geographical distance**. We calculate the weights as the share of that FDI flow (inward or outward) within the overall flows for that region-year.

Table: Two-way Fixed Effects: Novel patents

	lnr_r_nc	lnr_r_nc	lko_r_nc	lko_r_nc	lnov_r_nc	lnov_r_nc
L2.lsfdi_in	-0.0022	-0.0017	-0.055*	-0.054*	-0.017	-0.017
	(-0.10)	(-0.07)	(-1.95)	(-1.94)	(-0.69)	(-0.68)
L2.popdens	-0.18	-0.15	-0.51	-0.46	-0.11	-0.084
	(-0.73)	(-0.66)	(-0.98)	(-0.93)	(-0.37)	(-0.31)
L2.lgfcf	0.15**	0.14**	0.22***	0.21***	0.17***	0.16***
	(2.48)	(2.39)	(3.37)	(3.19)	(2.73)	(2.63)
L2.lmna	0.037*	0.036	0.057***	0.056***	0.035	0.035
	(1.67)	(1.64)	(2.71)	(2.66)	(1.62)	(1.59)
L2.UV		0.036*		0.068***		0.031*
		(1.75)		(3.16)		(1.78)
_cons	2.12	2.06	3.29	3.17	0.98	0.93
	(1.56)	(1.56)	(1.22)	(1.22)	(0.64)	(0.62)
N	3387	3387	3387	3387	3387	3387
Overall R2	0.084	0.155	0.001	0.002	0.304	0.391
Year FE	yes	yes	yes	yes	yes	yes

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table: Two-way Fixed Effects: Novel patents

	lnr_r_nc	lnr_r_nc	lko_r_nc	lko_r_nc	lnov_r_nc	lnov_r_nc
L2.lsfdi_out	0.044**	0.046**	0.014	0.018	0.053**	0.055**
	(2.23)	(2.34)	(0.56)	(0.69)	(2.34)	(2.40)
L2.popdens	-0.22	-0.19	-0.53	-0.49	-0.15	-0.13
	(-0.83)	(-0.77)	(-0.99)	(-0.94)	(-0.50)	(-0.45)
L2.lgfcf	0.15**	0.14**	0.22***	0.20***	0.16***	0.15**
	(2.41)	(2.31)	(3.25)	(3.07)	(2.64)	(2.54)
L2.lmna	0.035	0.034	0.054**	0.052**	0.032	0.031
	(1.57)	(1.53)	(2.54)	(2.49)	(1.47)	(1.43)
L2.UV		0.039*		0.069***		0.033*
		(1.83)		(3.15)		(1.88)
_cons	2.31	2.24	3.38	3.26	1.21	1.16
	(1.61)	(1.61)	(1.22)	(1.22)	(0.74)	(0.72)
N	3387	3387	3387	3387	3387	3387
Overall R2	0.115	0.188	0.000	0.006	0.325	0.406
Year FE	yes	yes	yes	yes	yes	yes

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table: Fixed Effects: Novel patents, inward symmetry/relatedness

	lnr_r_nc	lnr_r_nc	lko_r_nc	lko_r_nc	lnov_r_nc	lnov_r_nc
L2.reldens_fdiin	0.28*		0.47**		0.27	
	(1.69)		(2.26)		(1.36)	
L2.sim_in		0.019*		0.0067		0.021**
		(1.91)		(0.56)		(2.10)
N	3387	3387	3387	3387	3387	3387
Overall R2	0.228	0.332	0.020	0.008	0.467	0.544
FE	yes	yes	yes	yes	yes	yes

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table: Fixed Effects: Novel patents, outward symmetry/relatedness

	lnr_r_nc	lnr_r_nc	lko_r_nc	lko_r_nc	lnov_r_nc	lnov_r_nc
L2.reldens_fdiout	0.56***		0.57***		0.35*	
	(3.65)		(2.67)		(1.68)	
L2.sim_out		0.028***		0.015		0.024**
		(2.75)		(1.17)		(2.07)
N	3387	3387	3387	3387	3387	3387
Overall R2	0.393	0.303	0.040	0.016	0.536	0.520
FE	yes	yes	yes	yes	yes	yes

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table: Spatial Durbin Model with Two-Way Fixed Effects

	lnr_r_nc (1)	lko_r_nc (2)	lnov_r_nc (3)
sAR(1)	0.167***	0.255***	0.176***
	(0.029)	(0.027)	(0.029)
lsfdi_out	0.080***	0.049**	0.088***
	(0.018)	(0.019)	(0.020)
UV	0.033*	0.050**	0.025
	(0.015)	(0.016)	(0.017)
popdens	0.114	-0.248	0.032
	(0.193)	(0.199)	(0.211)
lgfcf	0.054	0.137*	0.125+
	(0.060)	(0.062)	(0.066)
lmna	0.026+	0.044**	0.024
	(0.014)	(0.014)	(0.015)
slag(lsfdi_out)	-0.077*	-0.036	-0.037
	(0.033)	(0.034)	(0.037)
slag(UV)	0.079*	0.157***	0.125***
	(0.034)	(0.035)	(0.037)
slag(popdens)	-0.629+	-1.210***	-0.775*
	(0.352)	(0.366)	(0.386)
slag(lgfcf)	0.144+	0.112	0.089
	(0.076)	(0.079)	(0.084)
slag(lmna)	0.012	-0.039	-0.030
	(0.025)	(0.026)	(0.027)
Observations	2834	2834	2834
Model	SDM + FE	SDM + FE	SDM + FE

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table: Spatial Durbin Model with Two-Way Fixed Effects

	lnr_r_nc (1)	lko_r_nc (2)	lnov_r_nc (3)
sAR(1)	0.146***	0.236***	0.166***
	(0.029)	(0.027)	(0.029)
lsfdi_in	0.013	-0.015	0.023
	(0.021)	(0.022)	(0.023)
UV	0.028+	0.047**	0.020
	(0.015)	(0.016)	(0.017)
popdens	0.161	-0.200	0.090
	(0.192)	(0.199)	(0.211)
lgfcf	0.066	0.149*	0.136*
	(0.060)	(0.062)	(0.066)
lmna	0.033*	0.051***	0.032*
	(0.014)	(0.014)	(0.015)
slag(lsfdi_in)	-0.212***	-0.210***	-0.191***
	(0.042)	(0.044)	(0.047)
slag(UV)	0.071*	0.146***	0.115**
	(0.034)	(0.035)	(0.037)
slag(popdens)	-0.645+	-1.212***	-0.706+
	(0.348)	(0.360)	(0.381)
slag(lgfcf)	0.170*	0.146+	0.111
	(0.077)	(0.079)	(0.084)
slag(lmna)	0.031	-0.016	-0.010
	(0.025)	(0.026)	(0.028)
Observations	2834	2834	2834
Model	SDM + FE	SDM + FE	SDM + FE

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table: Spatial Durbin Effects

	lnr_r_nc	lko_r_nc	lnov_r_nc
Total Effects			
lsfdi_out	0.0956***	0.0653***	0.1064***
	(0.0215)	(0.0228)	(0.0247)
UV	0.0397**	0.0676***	0.0302
	(0.0160)	(0.0209)	(0.0211)
popdens	0.1364	-0.3331	0.0391
	(0.2242)	(0.2498)	(0.2538)
lgfcf	0.0652	0.1846**	0.1516**
	(0.0680)	(0.0758)	(0.0796)
lmna	0.0309**	0.0587***	0.0291
	(0.0160)	(0.0178)	(0.0191)
Model	SDM with FE	SDM with FE	SDM with FE
Spatial Coefficient	0.1667***	0.2555***	0.1756***
Log Likelihood	-1075.0632	-1178.2295	-1332.848

Table: Spatial Durbin Effects

	lnr_r_nc	lko_r_nc	lnov_r_nc
Direct Effects			
lsfdi_out	0.0800***	0.0492***	0.0882***
	(0.0180)	(0.0172)	(0.0201)
UV	0.0332**	0.0510***	0.0250
	(0.0133)	(0.0155)	(0.0173)
popdens	0.1142	-0.2510	0.0324
	(0.1867)	(0.1882)	(0.2102)
lgfcf	0.0546	0.1391**	0.1257**
	(0.0567)	(0.0558)	(0.0651)
lmna	0.0258**	0.0442***	0.0242
	(0.0133)	(0.0133)	(0.0157)
Indirect Effects			
lsfdi_out	0.0156***	0.0161***	0.0182***
	(0.0044)	(0.0060)	(0.0056)
UV	0.0065**	0.0167***	0.0052
	(0.0029)	(0.0058)	(0.0040)
popdens	0.0222	-0.0821	0.0067
	(0.0382)	(0.0630)	(0.0443)
lgfcf	0.0106	0.0455**	0.0259*
	(0.0116)	(0.0208)	(0.0154)
lmna	0.0050*	0.0145***	0.0050
	(0.0029)	(0.0048)	(0.0036)
Model	SDM with FE	SDM with FE	SDM with FE
Spatial Coefficient	0.1667***	0.2555***	0.1756***
Log Likelihood	-1075.0632	-1178.2295	-1332.848

Table: Instrumental Variables

	lnr_r_nc	lnr_r_nc	lko_r_nc	lko_r_nc	lnov_r_nc	lnov_r_nc
L2.lsfdi_in	0.023		0.044		0.026	
	(0.32)		(0.59)		(0.34)	
L2.lsfdi_out		0.11**		0.080		0.085
		(2.11)		(1.50)		(1.57)
N	3387	3387	3387	3387	3387	3387
F-statistic	194.336	373.845	194.336	373.845	194.336	373.845
FE	yes	yes	yes	yes	yes	yes

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

What we did so far

- We test associations between greenfield FDIs and recombinant novelty of patents.
- **Outward FDIs** are positively associated with recombinant novelty in European regions, while we do not find any evidence for inward investments.
- **Technological relatedness-density** around FDIs is positively associated with regional novelty.

Research agenda

- Exploring mechanisms:
  - Should we work on inventors' mobility?
  - Different modes of entry = different mechanisms?
- Robustness: world-novelty, rather than local novelty behaves differently?
- Worth attempting on firm-level data matched with patents?
- Better value-chain consideration for science-intensive industries?
- Extension: network diffusion with bilateral data?

Comments and questions

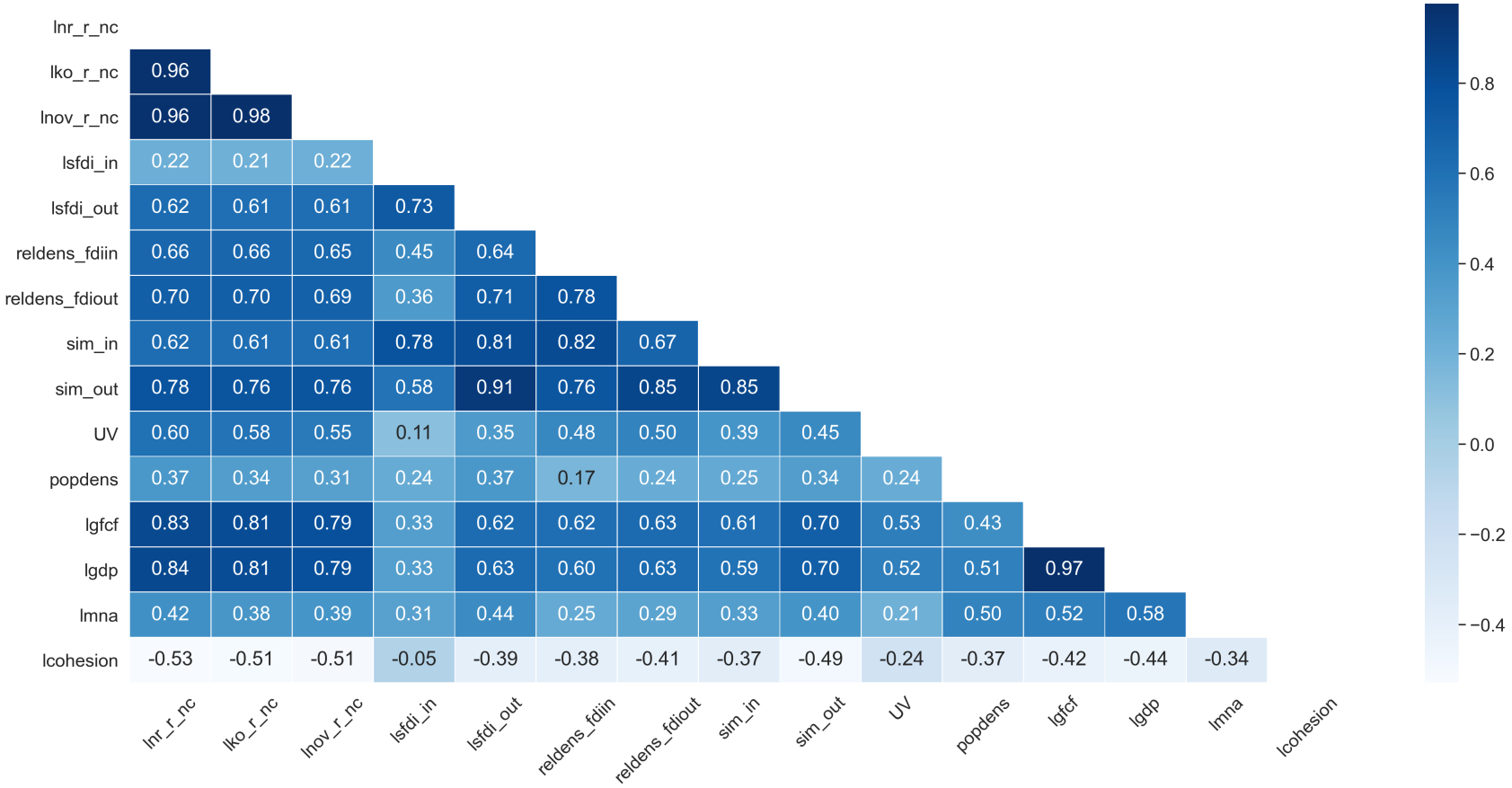
Thank you!

Descriptive Statistics

Table: Descriptive Statistics

	count	mean	std	min	25%	50%	75%	max
nr_r_nc	3905	43.23	69.45	0.00	5.00	19.00	52.00	908.00
ko_r_nc	3905	45.16	75.70	0.00	4.00	17.00	53.00	960.00
nov_r_nc	3905	18.65	29.07	0.00	2.00	8.00	23.00	460.00
sfdi_out	3905	97.58	294.15	0.00	1.90	14.04	71.69	4485.19
sfdi_in	3905	74.08	150.77	0.00	4.50	23.99	74.14	2159.16
reldens_fdiout	3905	0.22	0.15	0.00	0.09	0.25	0.33	0.59
reldens_fdiin	3905	0.21	0.14	0.00	0.08	0.23	0.32	0.67
lgfcf	3905	8.82	0.94	5.07	8.23	8.87	9.45	11.98
UV	3905	0.24	0.69	-3.48	0.17	0.47	0.59	0.89
popdens	3905	5.08	1.26	1.46	4.32	4.91	5.76	9.34
lmna	3905	1.72	1.53	0.00	0.00	1.39	2.77	7.10

Correlation table



Novelty distributions

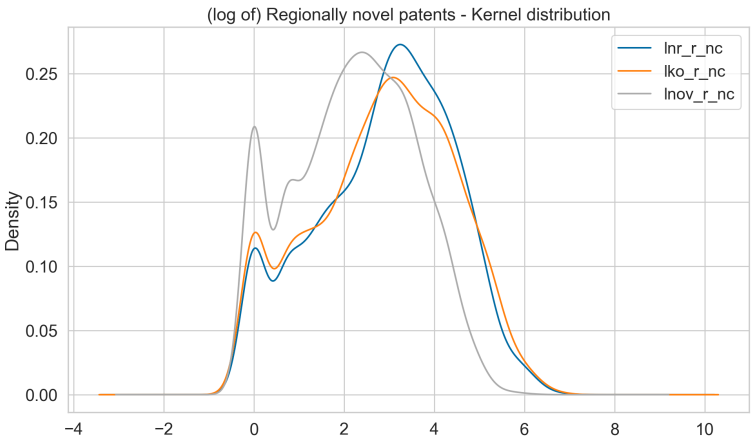


Figure: Kernel density of (log) Recombinant Novelty measures

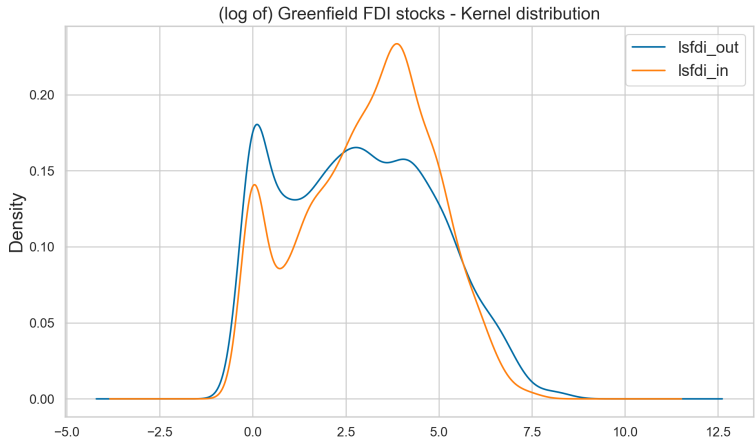


Figure: Kernel density of (log) greenfield FDIs

Novelty maps

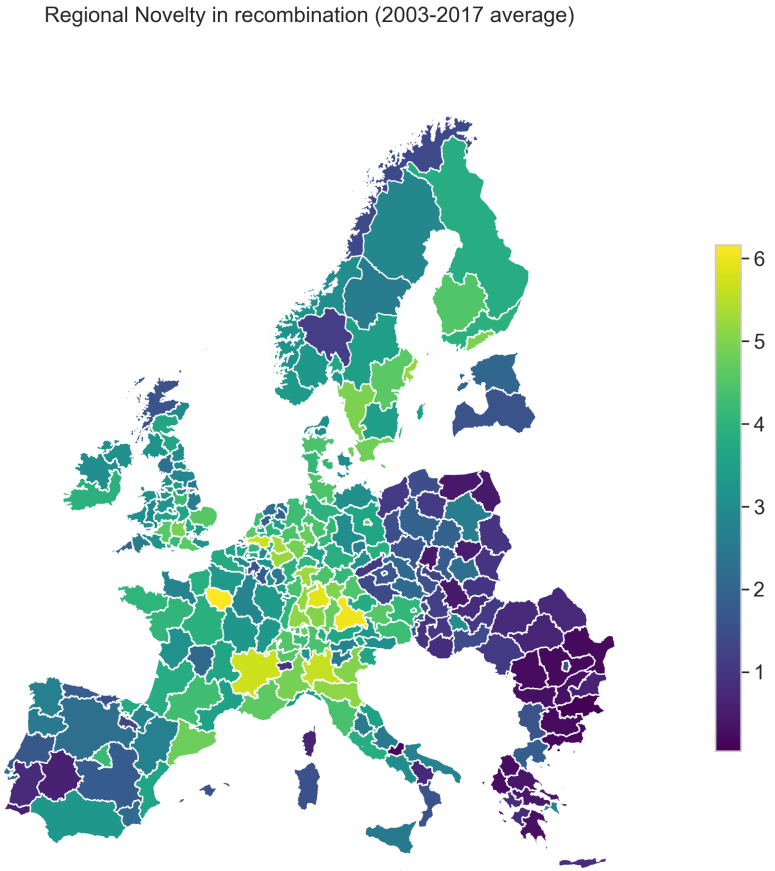


Figure: (log) Stock of novel patents (NR) (average)

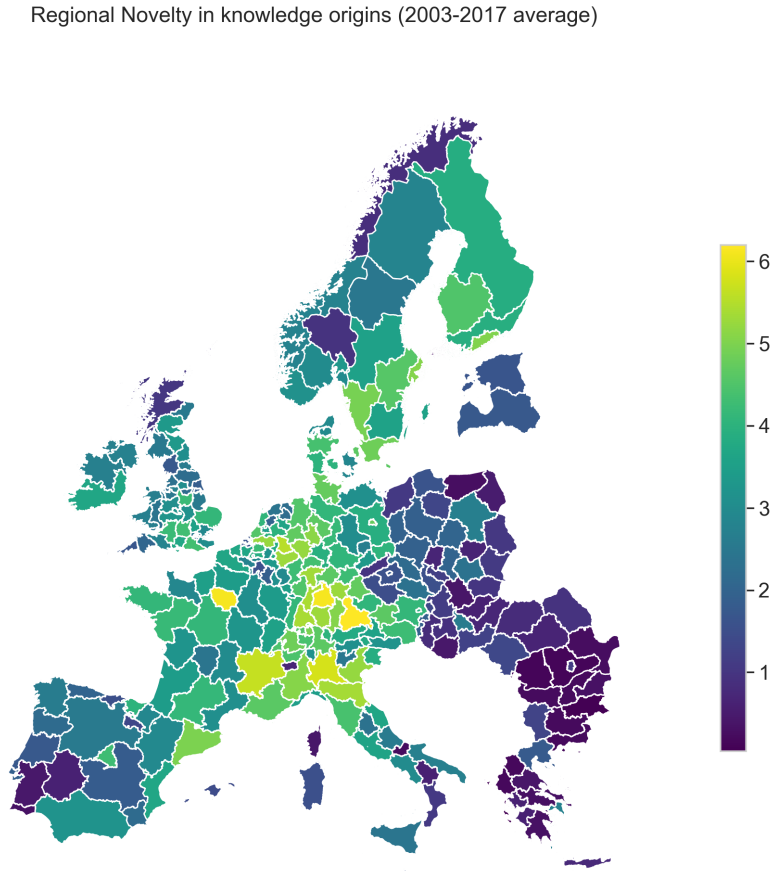


Figure: (log) Stock of novel patents (KO) (average)

FDIs

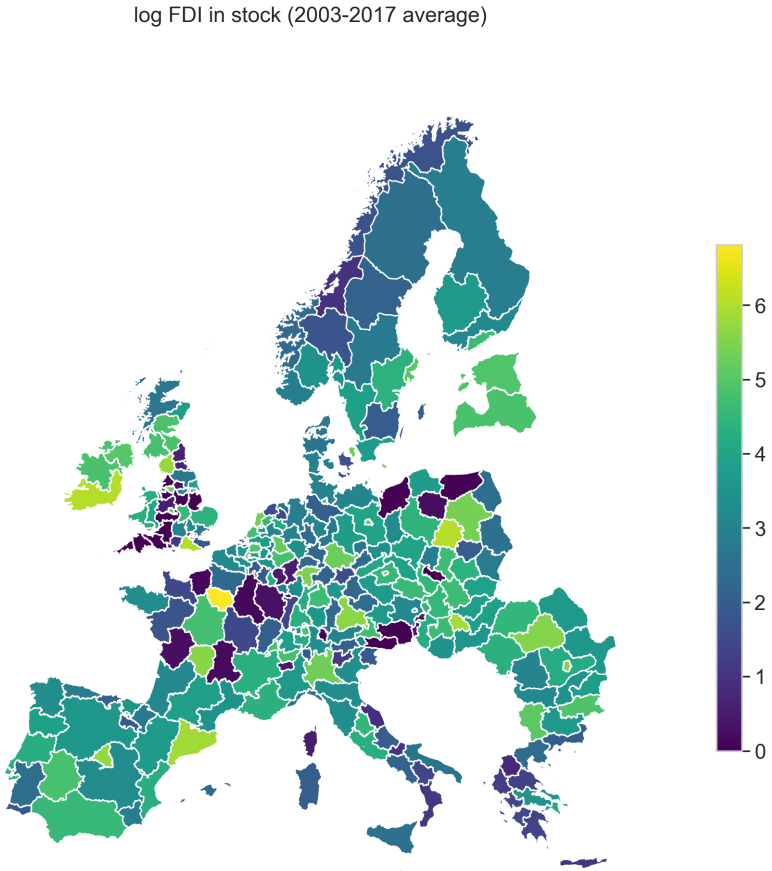


Figure: (log) Stock of inward FDIs (average)

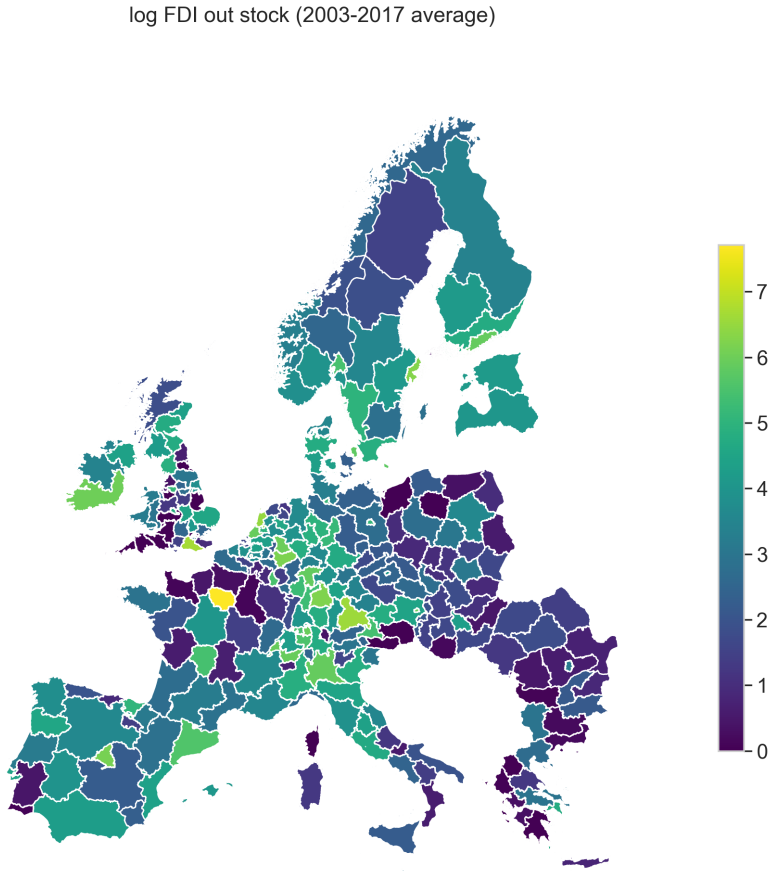
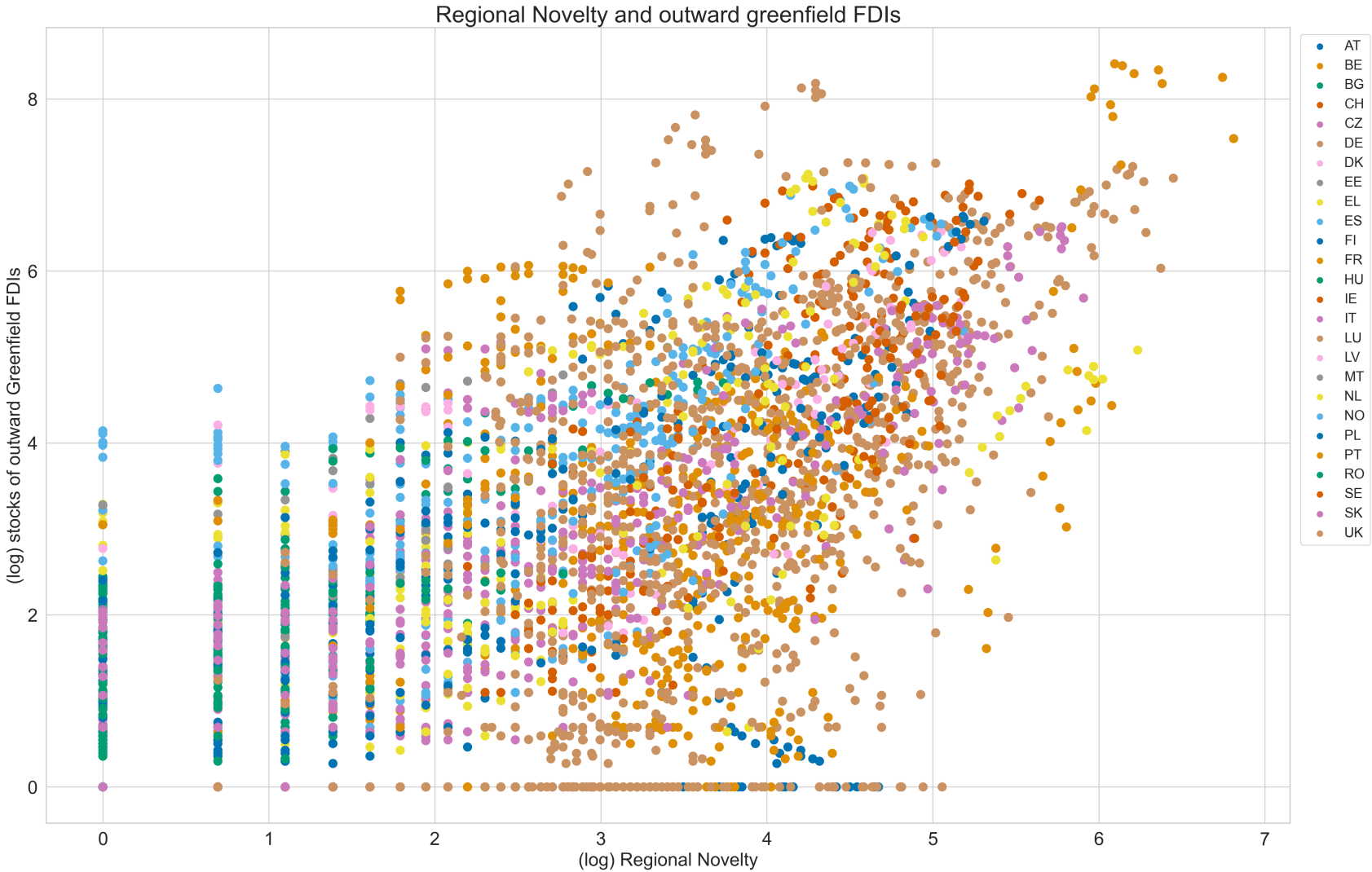


Figure: (log) Stock of outward FDIs (average)

Scatterplot



Relatedness density

$\phi_{i,j}$ is the product space (tech-tech proximity from patents).
$\psi_{i,r,t}$, obtaining the relatedness measures for each region-technology pairs:

$$\psi_{i,r,t} = \frac{\sum_{j \in r, j \neq i} \phi_{ij}}{\sum_{j \neq i} \phi_{ij}} \tag{3}$$

$\psi_{i,r,t}$ is relatedness between each technology and the rest of the technologies in the region.
$\omega_{i,r,t}$ as the number of FDIs in technological category i, for that region and year. The count is computed on the stocks of FDIs, and hence compounds in time.

$$reldens\_fdi_{r,t} = \frac{\sum_{j \neq i} \omega_{i,r,t} \psi_{i,r,t}}{\sum_{i \neq j} \omega_{i,r,t}} \tag{4}$$

back

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