University of Stavanger

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The relationship of skill-complexity, diversity, and relatedness with regional growth

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Motivation

⚪ Places shape innovation & growth (Glaeser et al. 1992, Boschma & Iammarino 2009, Capello & Lenzi 2016, Eriksson et al. 2017)

⚪ Explosion of (additional) empirical research in recent years

⚪ Focus on specific factors (Frenken et al. 2007, Balland et al. 2019, Mewes & Broekel 2020)
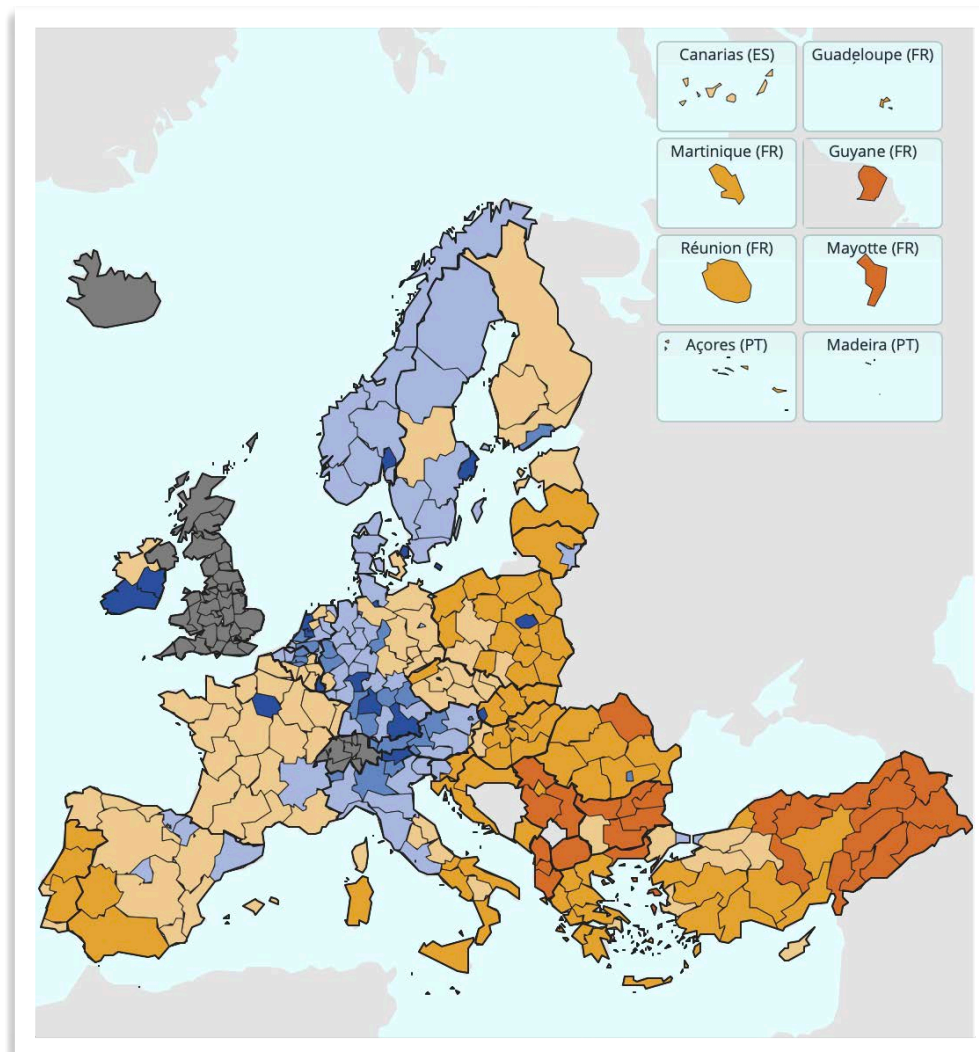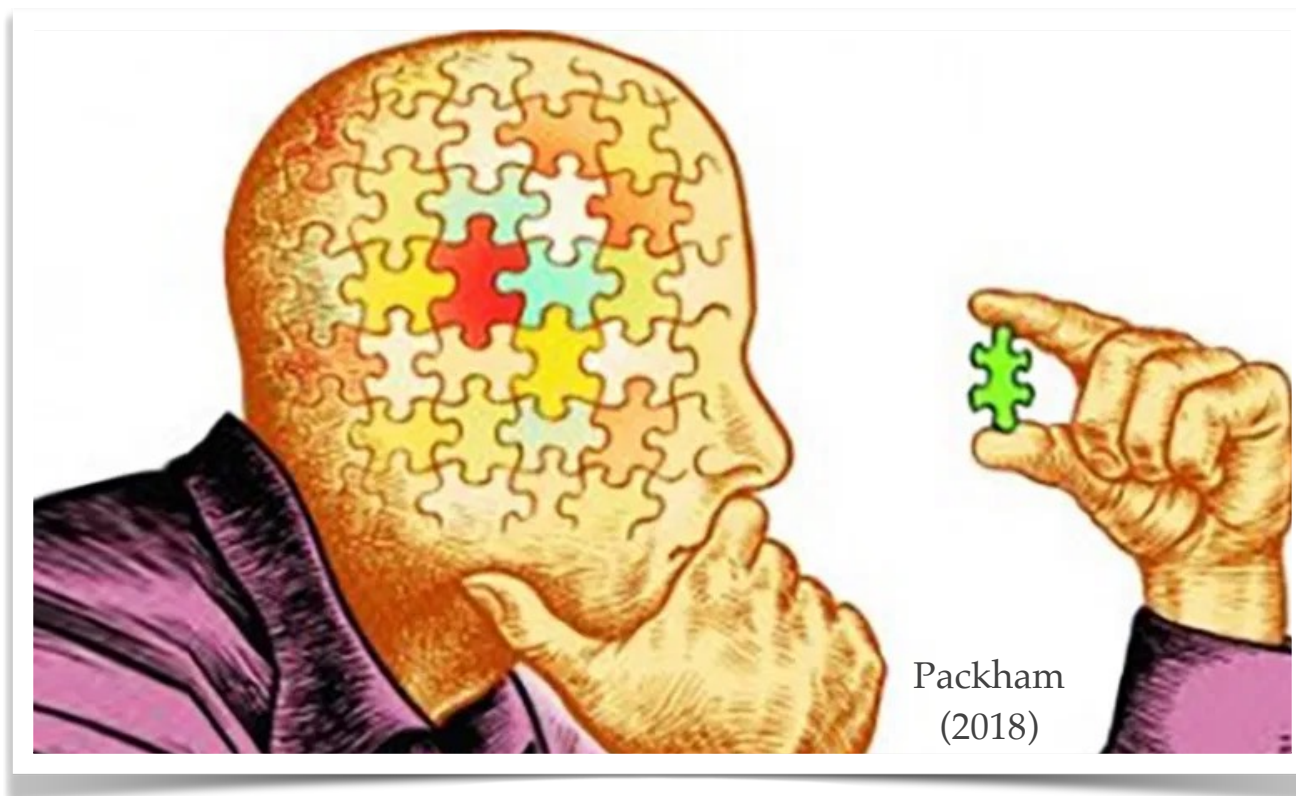
⚪ Specialisation

⚪ **Diversity**

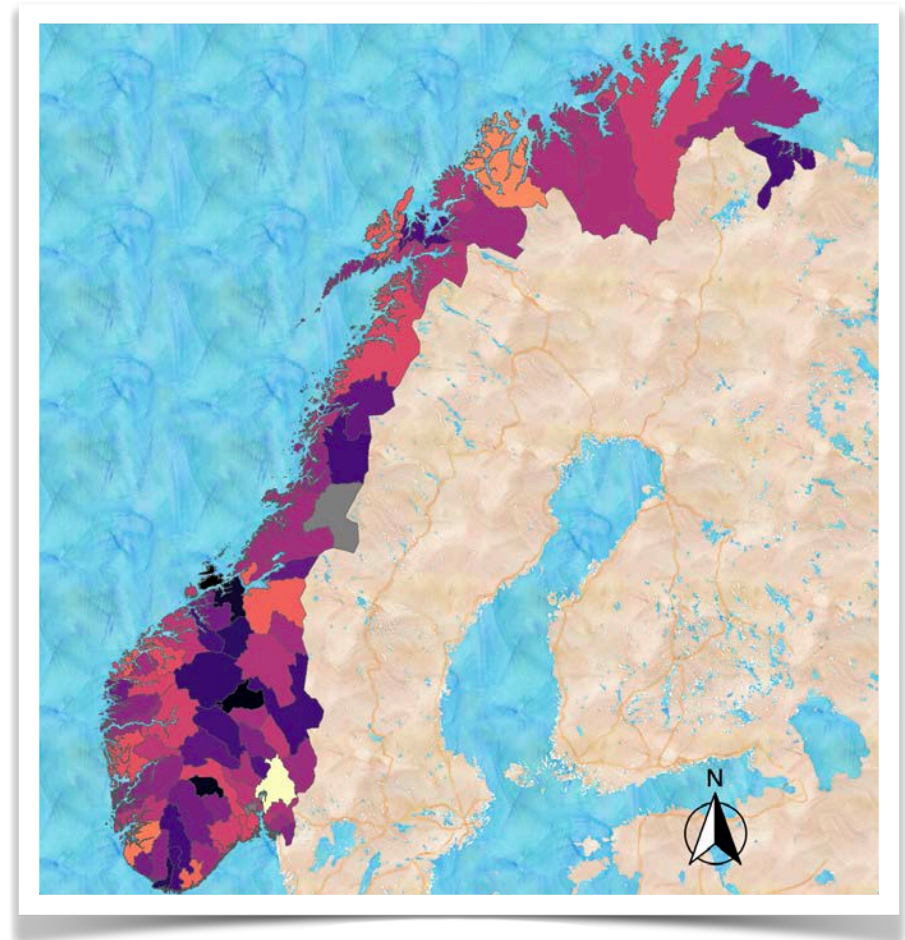⚪ **Relatedness**

⚪ **Complexity**

⚪ …

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Motivation

- Literature (still) with a number of shortcomings

  - Dimensions evaluated **separately** - > relative importance?

  - Attention on diversification -> what about **economic growth**?

  - Few insights into **context-sensitivity** of dimensions' effects

Packham (2018)

Outline

- Motivation

- Theory

  - Relatedness, complexity, diversity

- Empirical study

  - Data, estimations, results

- Conclusion

Theory: Relatedness

- Strong overlap & similarity in context, terminology, scientific principles

- Belonging to same (superior) technology or emergent from same basic technology

| Biotech | Aerospace | Car manuf. |

Technological relatedness

- Relatedness helps diversification & expansion -> growth

- Massive empirical evidence, see, e.g. Hidalgo et al. (2018)

Theory: Complexity

⦿ Engaging in complex activities difficult and requires non-tradable (spatial) capabilities (Hidalgo & Hausmann 2009)

⦿ Complexity (and rareness thereof) -> **Economic value**

    ⦿ Exclusiveness & lower competitive pressure

    ⦿ Access to (even) more complex activities

    ⦿ Competitive advantage

    ⦿ Near to monopolistic rents
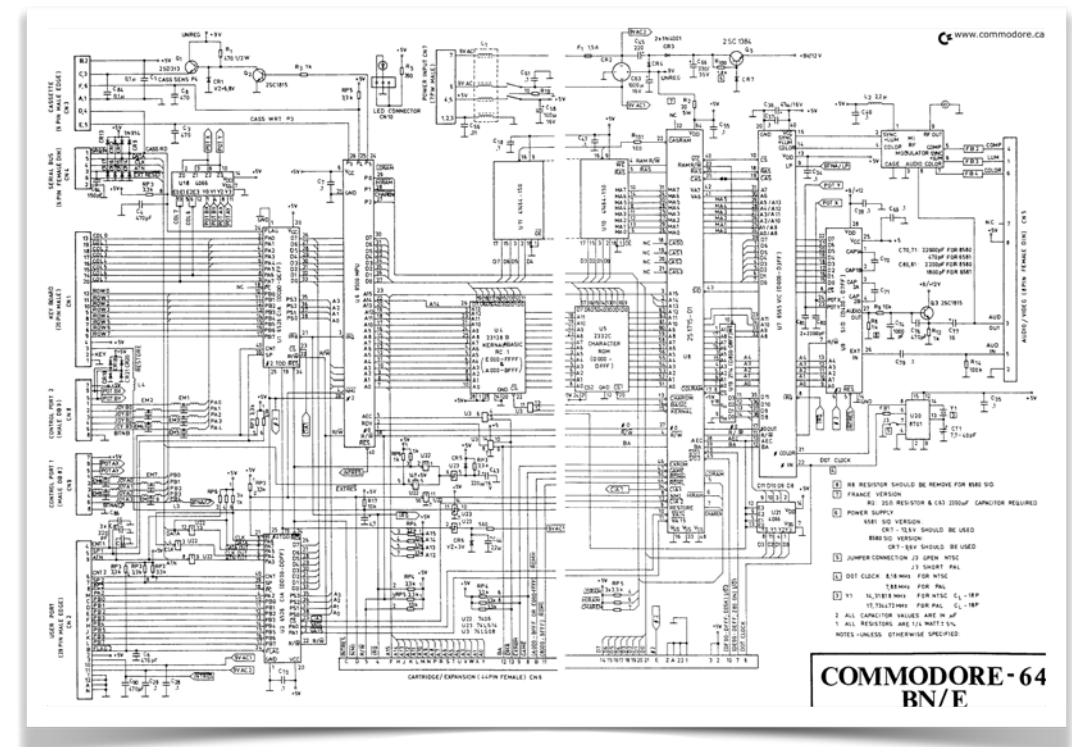
Theory: Complexity

- Empirical evidence for complexity's relevance

  - **Factor** in **diversification** at national level (Hidalgo & Hausman 2009)

  - **Spatially rare** & little diffusion of complex knowledge (Hidalgo & Hausman 2009, Balland & Rigby 2017)

  - Requires **more efforts & collaboration** (Broekel 2019)

  - **Correlates** with economic **wealth,** higher income equality, and regional growth (Hidalgo & Hausman 2009, Hartmann et al. 2017, Mewes & Broekel 2019)

  - …

Theory: Diversity

- Relatedness fuels path-dependent developments

- Danger of narrowing knowledge bases -> lock-ins (Grillitsch et al. 2018)

- Presence and sustaining of (unrelated) diversity

  - Crucial for absorbing (external) shocks (Frenken et al. 2007)

  - Basis for radical and valuable innovation (Nooteboom 2000)

- Diversity essential ingredient for (long-term) development

Motivation: Shortcomings

- Dimensions evaluated **separately**

- Much evidence for diversification of industrial portfolio **≠ growth**

- Few studies on **other** than employment **dimensions of growth**

- Little insights into **context/place sensitivity**

- Occupational perspective less utilised in comparison to industrial

Outline

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- **Empirical study**

  - Data, estimations, results

- **Conclusion**
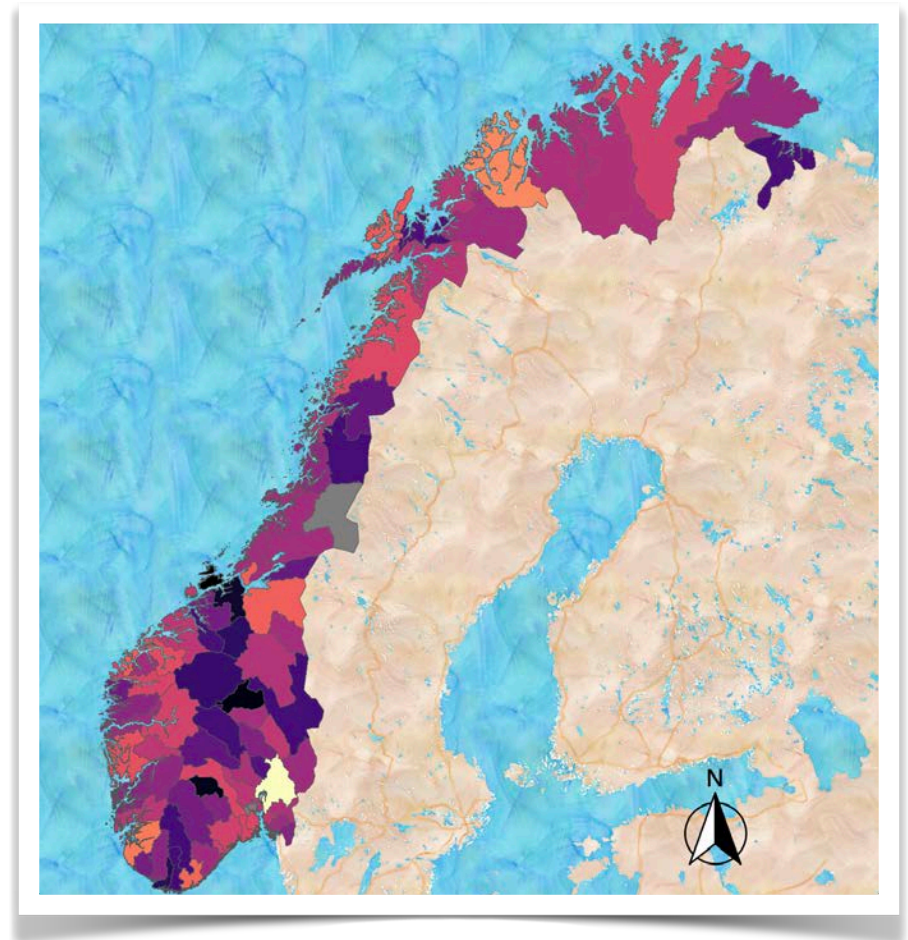
Empirical study: Data

- Individual-level register-data linked to establishments for Norway

- Information on workplace, industry, work location of employees in private sector 2009 - 2016

    - Numbers of workers in occupation i and industry j in region r and moves in between

    - Regions: NUTS 4 combined to 78 labor markets (Gundersen & Juvkam 2013)

    - Industries: 4-digit NACE level

    - Occupations: 4-digit ISCO level

- Aggregation to **industries** in **regions** (units: **industry-regions**)

Empirical study: Relatedness

- Revealed skill relatedness (Neffke & Henning 2013, Fitjar & Timmermans 2017)

- **Industrial relatedness**

  - Job changes between two industries larger than statistical expectation

- **Occupational relatedness**

  - Job changes between two occupations larger than statistical expectation

Empirical study: Relatedness

Industrial relatedness density

- Relatedness of industry i to all other industries in region r weighted by (regional) employment shares of industries

Occupational relatedness density

- Relatedness of occupation i to all other occupations in region r weighted by (regional) employment shares of occupations weighted with occupation

- Weighted by occupation i's share in industry j in region r

- Summed of all occupations in industry j in region r

Empirical study: Occupational relatedness

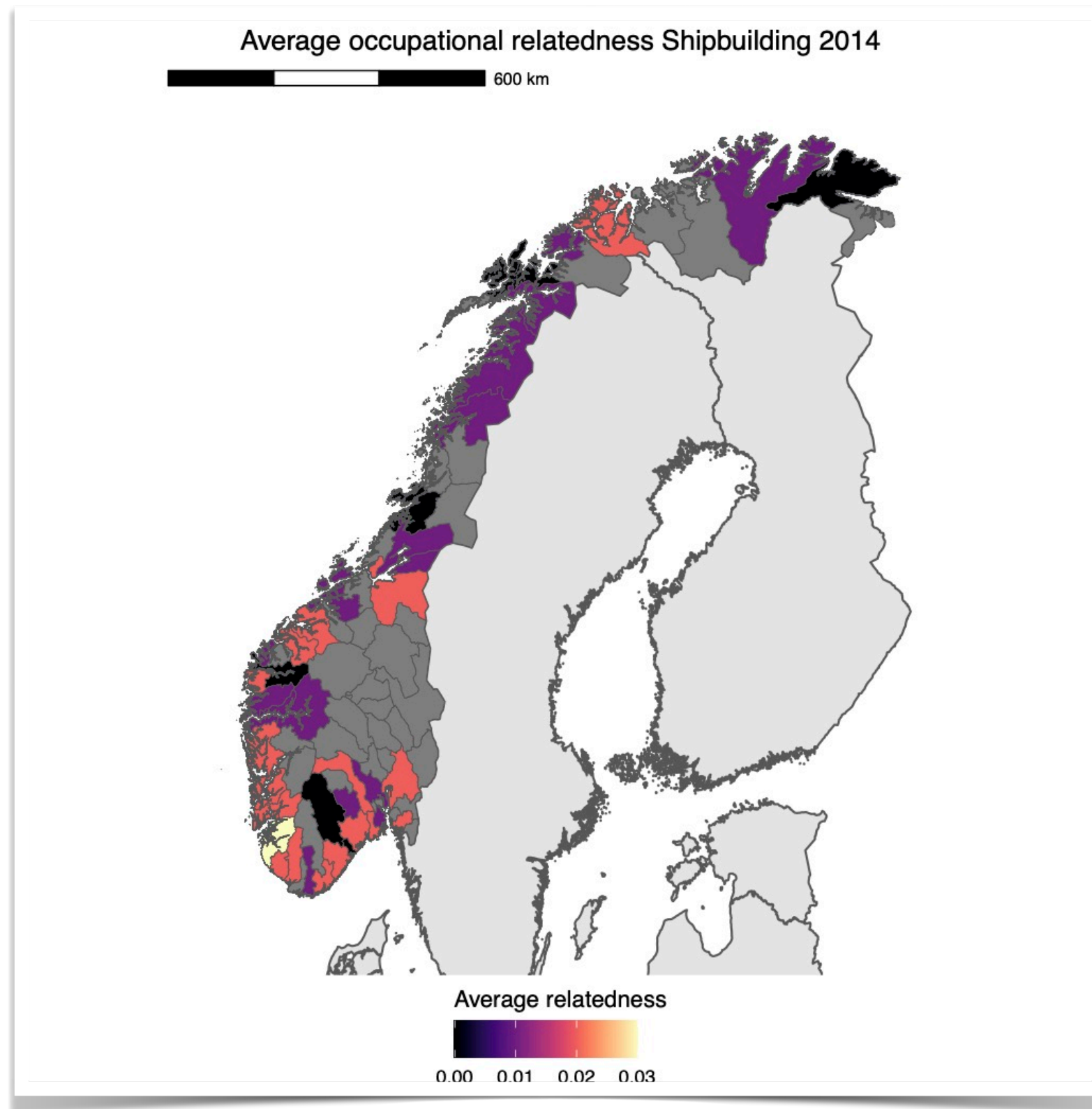|	NACE	Industry	Occupational relatedness
1	47.21	Retail sale of fruit and vegetables	0.046
2	47.26	Retail sale of tobacco products	0.038
3	06.10	Extraction of crude petroleum	0.037
4	47.63	Retail sale of music and video recordings	0.034
5	66.11	Administration of financial markets	0.033
6	10.12	Processing and preservation of poultry and meat	0.032
7	03.21	Marine aquaculture	0.031
8	62.02	Computer consultancy activities	0.030
9	10.82	Manufacturing of cocoa, chocolate etc.	0.030
10	62.03	Computer facilities management activities	0.030

Empirical study: Occupational relatedness

Average occupational relatedness Shipbuilding 2014

Average relatedness

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Empirical study: Industrial relatedness

Table 4: Industry with the highest average industrial related density

	NACE	Industry	Industry relatedness
1	09.10	Supply for petroleum/natural gas extraction	0.317
2	28.92	Manufacturing of machinery for mining/quarrying/construction	0.242
3	07.10	Mining of iron ores	0.220
4	25.40	Manufacturing of weapons and ammunition	0.110
5	30.11	Building ships and floating structures	0.105
6	71.12	Engineering activities/related technical consultancy	0.095
7	47.11	Non-specialist stores with food, beverages, etc.	0.094
8	69.20	Accounting/bookkeeping/tax consultancy	0.090
9	16.21	Manufacturing of veneer sheets, wood-based materials	0.083
10	10.20	Processing and preservation of fish, etc.	0.081

Empirical study: Industrial relatedness

Average industry relatedness Shipbuilding 2014

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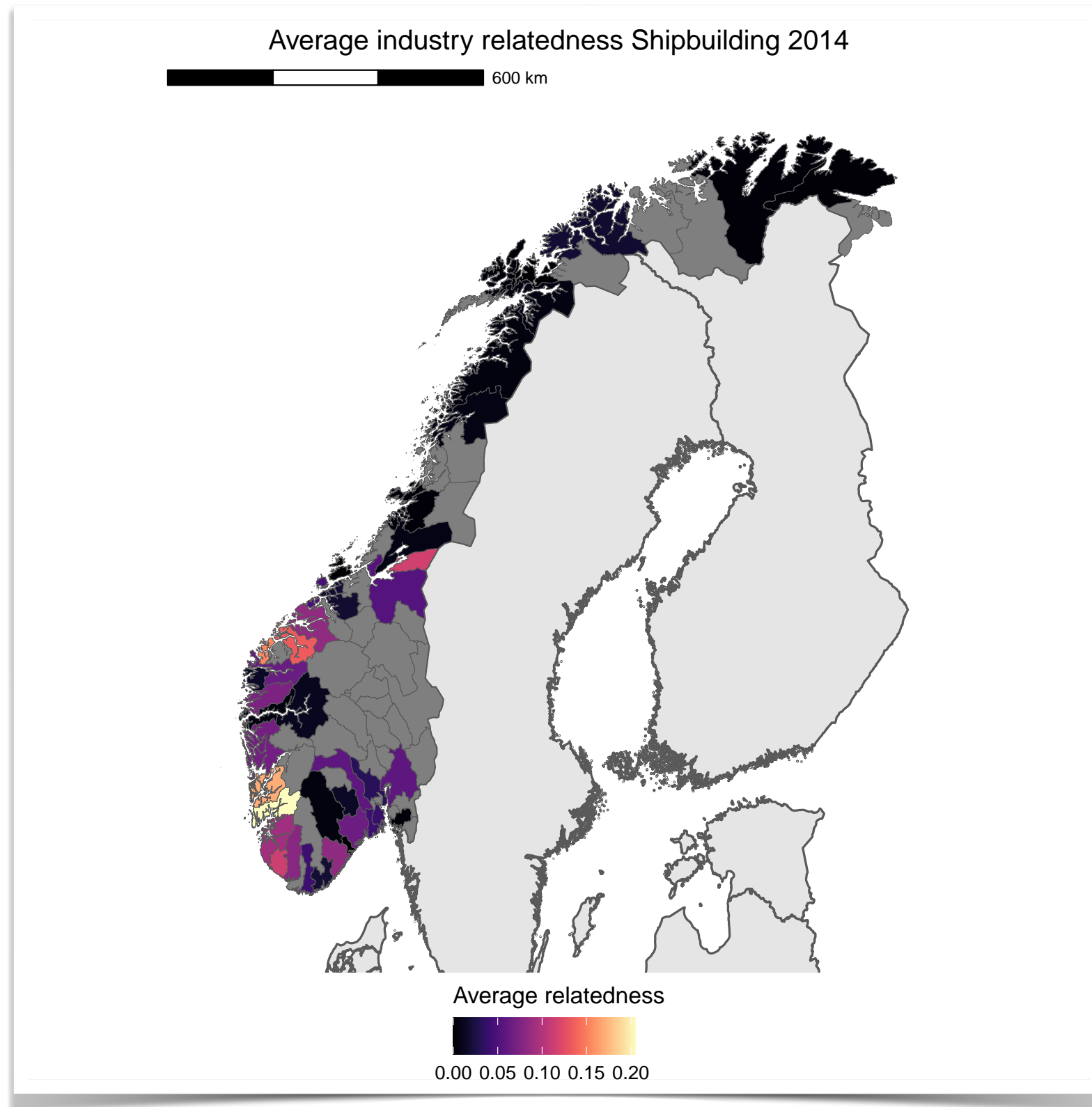
Empirical study: Occupational diversity

- Fractionalisation measure (Alesina et al. 2003)

$$DIVERSE_{irt} = 1 - \sum_{o=1}^{O} s_{oirt}^2$$

- With s as proportion of employees in industry i in region r in occupation o and O being the numbers of different occupations in one industry-region

Empirical study: Occupational diversity

Table 1: Occupational diversity in Norwegian industries

	NACE	Industry	Diversity
1	28.91	Manufacturing of machinery for metallurgy	0.928
2	07.29	Mining of other non-ferrous metal ores	0.906
3	28.95	Manufacturing of machinery for paper/paperboard production	0.901
4	64.20	Activities of holding companies	0.899
5	20.30	Manufacturing of paints, varnishes and coatings	0.895
6	26.60	Manufacturing of electromedical/electrotherapeutical equipment	0.884
7	21.10	Manufacturing of basic pharmaceutical products	0.880
8	23.51	Manufacturing of cement	0.868
9	08.91	Mining of chemical/fertiliser minerals	0.866
10	28.15	Manufacturing of bearings, gears, gearing/driving elements	0.858

Empirical study: Occupational diversity

Average diversity Shipbuilding 2014

600 km

Average diversity

0.5 0.6 0.7 0.8

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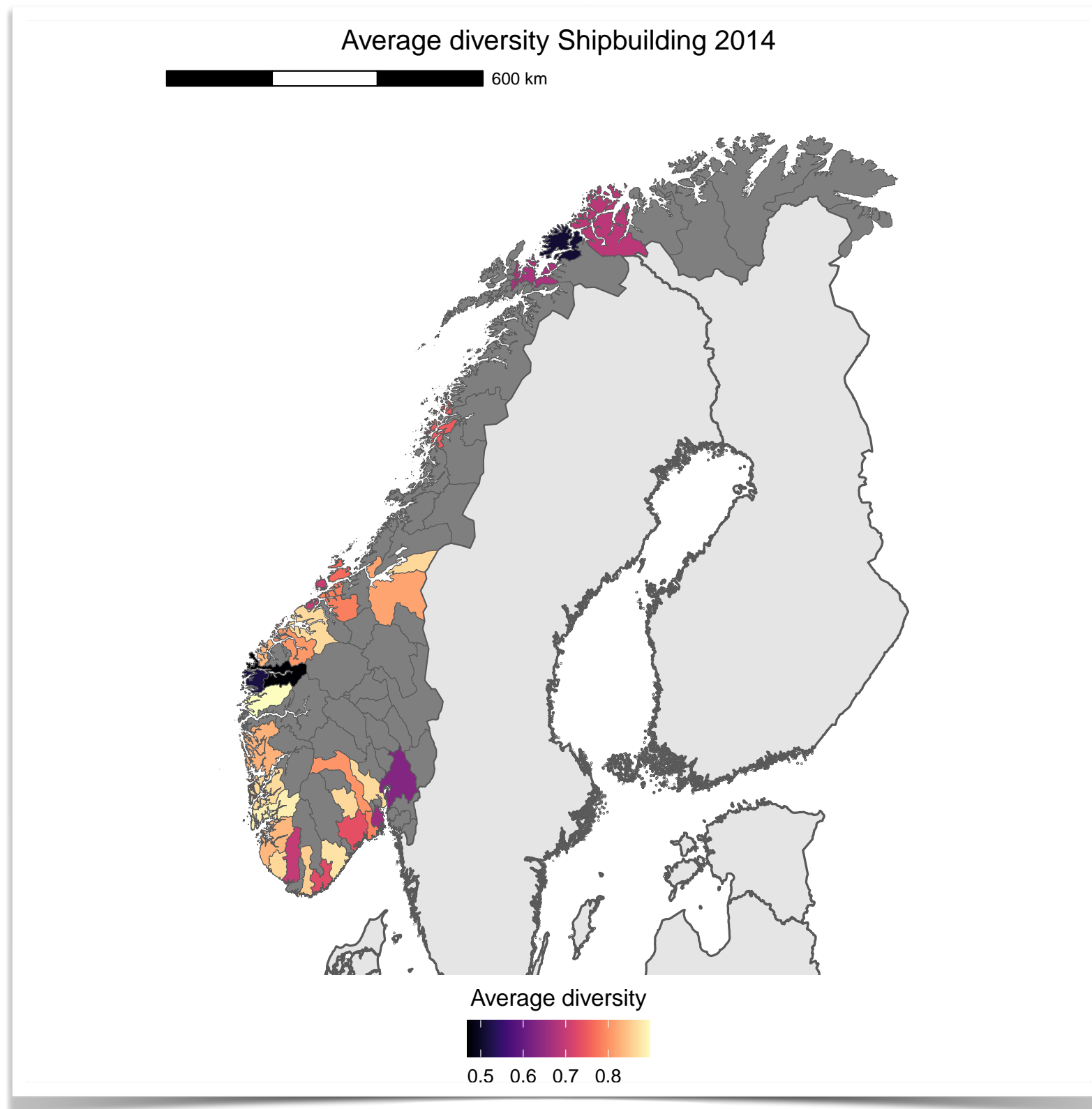
Empirical study: Occupational complexity

- Weighted average of industry i's occupations' complexity in region r

- Occupations' complexity (Caines et al. 2017)

  - Complexity of tasks (e.g., processing of information & communicating)

  - Weighted aggregation of 35 variables from US O*NET subsections

  - Transformation to SOC -> ISCO via concordances from US Bureau of Labor

  - Complexity values for 424 ISCO occupations aggregated to industry levels via industry-specific regional occupation shares

Empirical study: Occupational complexity

Table 2: Occupational complexity in Norwegian industries

	NACE	Industry	Complexity
1	35.23	Trade of gas through mains	72.282
2	71.11	Architectural activities	69.945
3	06.10	Extraction of crude petroleum	64.370
4	72.11	R&D on biotechnology	63.574
5	72.19	Other R&D on natural sciences etc.	63.237
6	62.02	Computer consultancy activities	61.720
7	62.09	Other information technology/computer services activities	61.622
8	62.01	Computer programming activities	61.146
9	62.03	Computer facilities management activities	61.114
10	71.12	Engineering activities/related technical consultancy	59.757

Empirical study: Occupational complexity
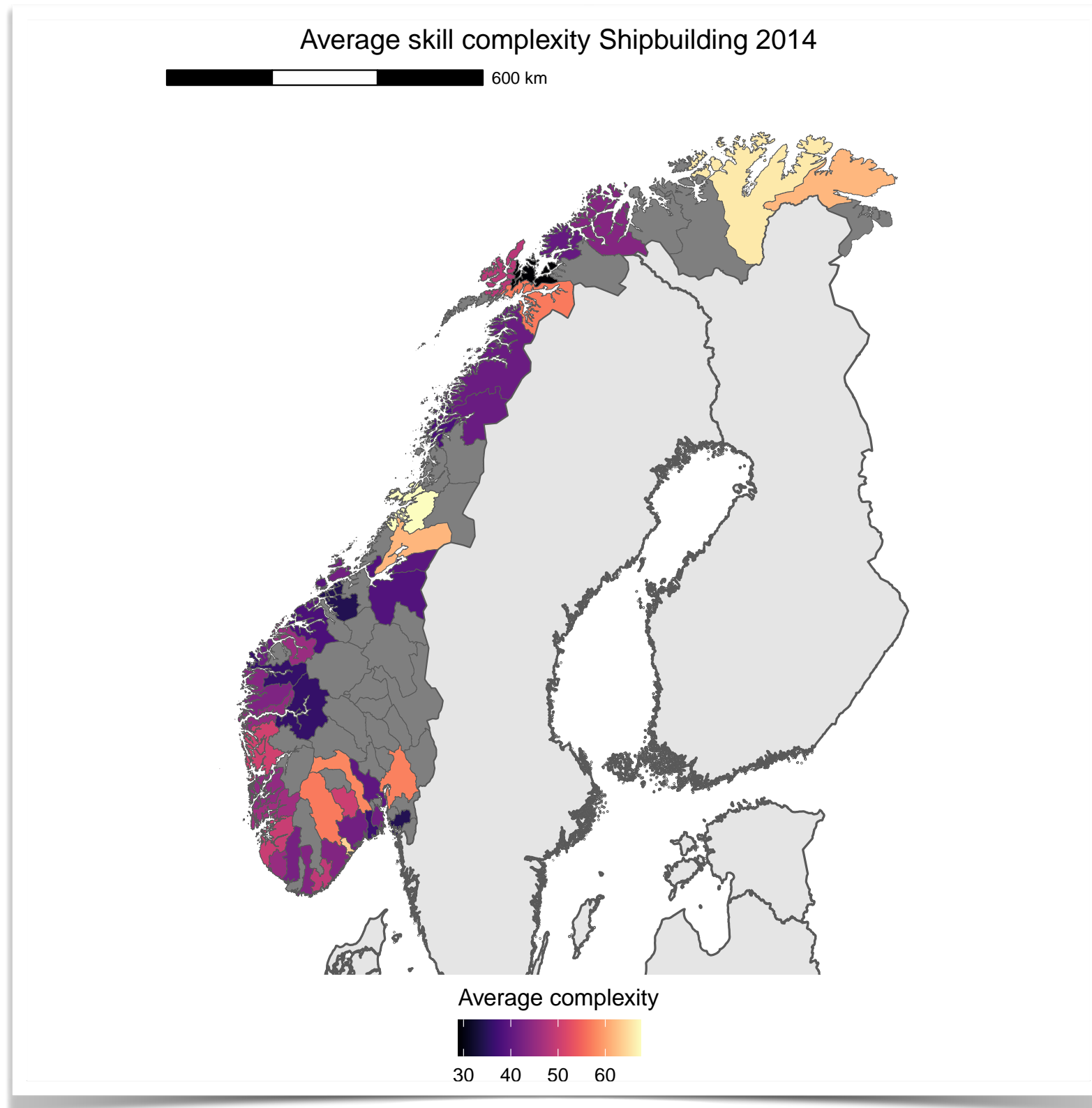
Average skill complexity Shipbuilding 2014

600 km

Average complexity

30   40   50   60

Outline

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- **Empirical study**

  - Data, **estimations, results**

- **Conclusion**
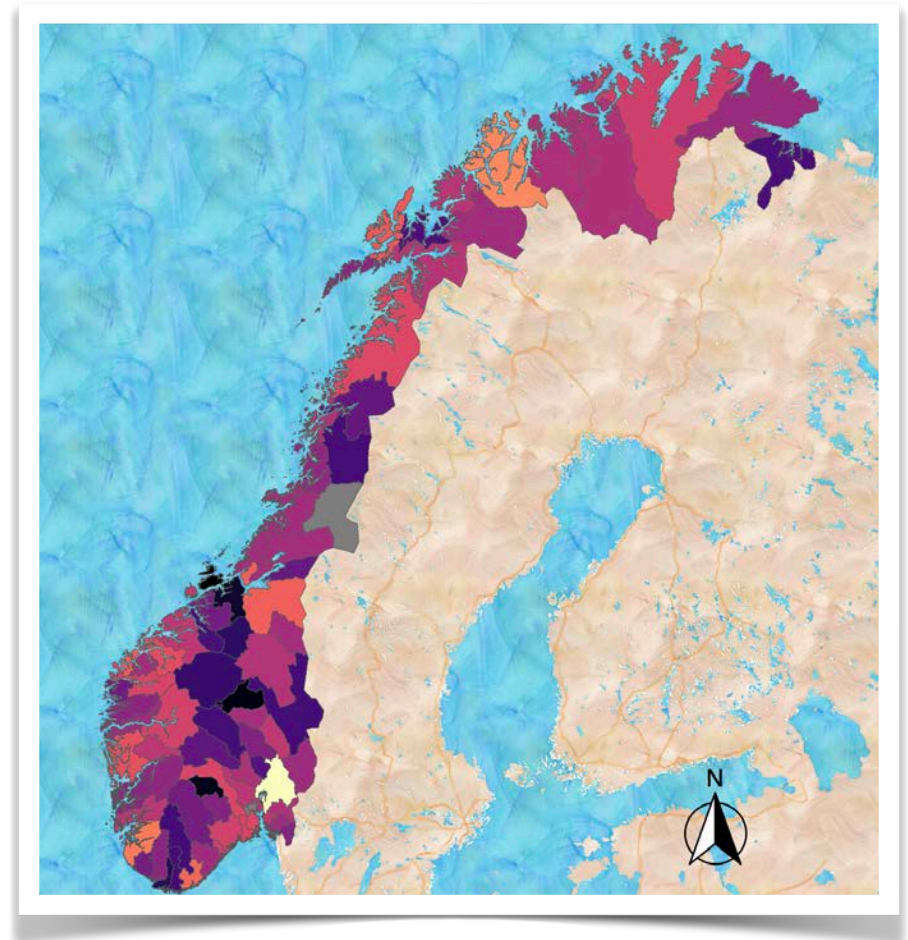
Empirical study: Estimations

- Long-term perspective as core variables with little temporal variance

- **Dependent**: average annual growth in **employment** and **wages** for industry-regions between 2009-2014

- **Explanatory** variables in levels of 2009

  - Diversity, relatedness, complexity

- Controls

  - Population density

  - Location quotient of industry i in region r

Empirical study: Estimations

- OLS growth regression with multiway clustered std. errors

  - Four-digit NACE & regions

  - Industry fixed effects at two-digit NACE level

  - Initial level of wages & employment

- Concentration on industry-regions with at least 5 employees in each year

- Estimation for all regions & subsamples

  - Low, middle, high complex industries

  - Rural, intermediate, urban regions

Outline

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Empirical study

- Data, estimations, **results**

Conclusion
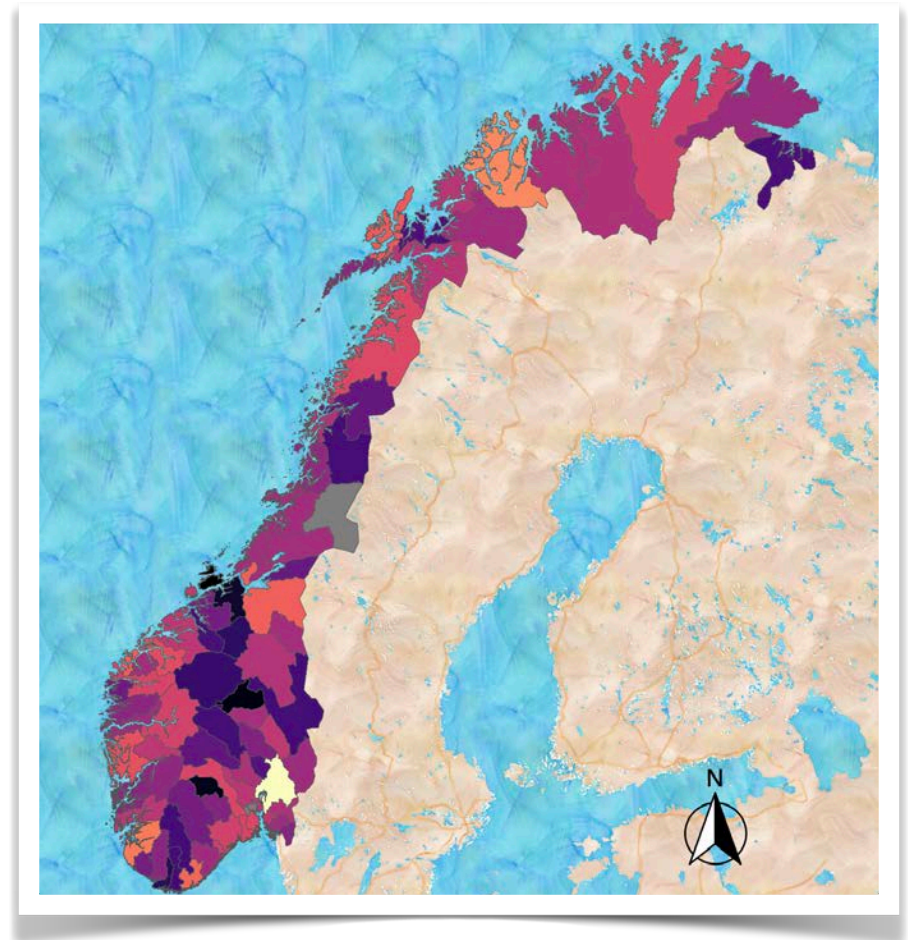
Empirical study: Results

	Employment growth				Wage growth			
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 1**	**Model 2**	**Model 3**	**Model 4**
lEMPL	-0.012***	-0.012***	-0.012***	-0.013***	0.003**	0.003**	0.002**	0.002*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
lPOP.DEN	0.007***	0.007**	0.007***	0.006**	-0.000	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
lLQ	-0.006	-0.006	-0.006	-0.006	0.001	0.000	0.001	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)
IND.REL	0.085*	0.085*	0.090*	0.092*	-0.027*	-0.029*	-0.022	-0.022
	(0.042)	(0.042)	(0.041)	(0.042)	(0.014)	(0.014)	(0.013)	(0.013)
DIVERS		-0.002	-0.004	-0.003		0.014*	0.014*	0.014*
		(0.013)	(0.013)	(0.014)		(0.006)	(0.006)	(0.006)
COMPLEX			0.000	0.000			0.000**	0.000**
			(0.000)	(0.000)			(0.000)	(0.000)
OCC.REL				0.280				0.032
				(0.248)				(0.095)
lWAGE					-0.037***	-0.039***	-0.043***	-0.044***
					(0.005)	(0.005)	(0.005)	(0.005)
NACE-2 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered std. err. NACE-4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered std. err. Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	6226	6226	6226	6226	6226	6226	6226	6226
R^2 (full model)	0.052	0.052	0.052	0.052	0.065	0.067	0.070	0.070
R^2 (proj model)	0.010	0.010	0.011	0.011	0.038	0.040	0.043	0.043
Adj. R^2 (full model)	0.041	0.041	0.041	0.041	0.055	0.056	0.059	0.059
Adj. R^2 (proj model)	-0.000	-0.001	-0.001	-0.000	0.027	0.029	0.032	0.032
Num. groups: NACE2	65	65	65	65	65	65	65	65

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Empirical study: Results

- Overall employment growth

    - **Industrial relatedness** ➕

- Overall wage growth

    - **Diversity** ➕

    - **Complexity** ➕

- Notable heterogeneity when differentiating regions & industries!

Empirical study: Results

- Employment growth

  - **Industrial relatedness** in **intermediate** regions

  - **Occupational relatedness** in **urban** regions (weakly)

  - **Diversity** in middle **complex** industries (weakly)

- Wage growth

  - **Complexity** in **rural** & **intermediate** regions

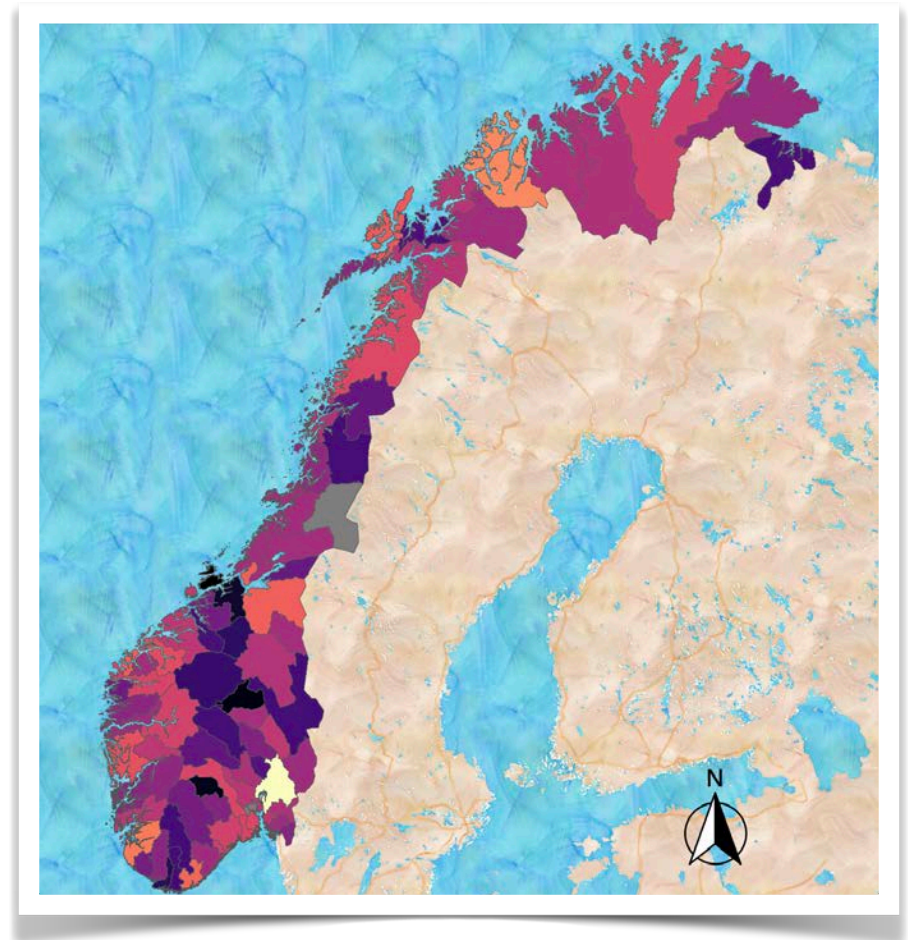 - **Diversity** in **intermediate** regions (weakly) and **simple** industries

  - **Occupational relatedness** in **urban** regions

Outline

● Motivation

● Theory

    ● Relatedness, complexity, diversity

● Set-up of empirical study

● Results

● **Conclusion**

Conclusion

- **Diversity** & **relatedness** & **complexity** matter for regional **growth**

- Importance **conditional on**

  - Types of regions

  - Sophistication of industries' knowledge base

  - …

- Empirical results **country** (Norway) **specific**?

- **Occupational** & **industrial** perspective **enriches** analysis but increases **complexity**

Conclusion

 Norwegian paradox?

	Mean wage growth 2009-2014		Mean employment growth 2009-2014	
	Simple	Complex	Simple	Complex
Rural	-0.0080	-0.0031	-0.0012	0.0041
Urban	-0.0058	-0.0089	0.0047	-0.0071

More research!!!!

University of Stavanger

Thank you for your attention

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