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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)

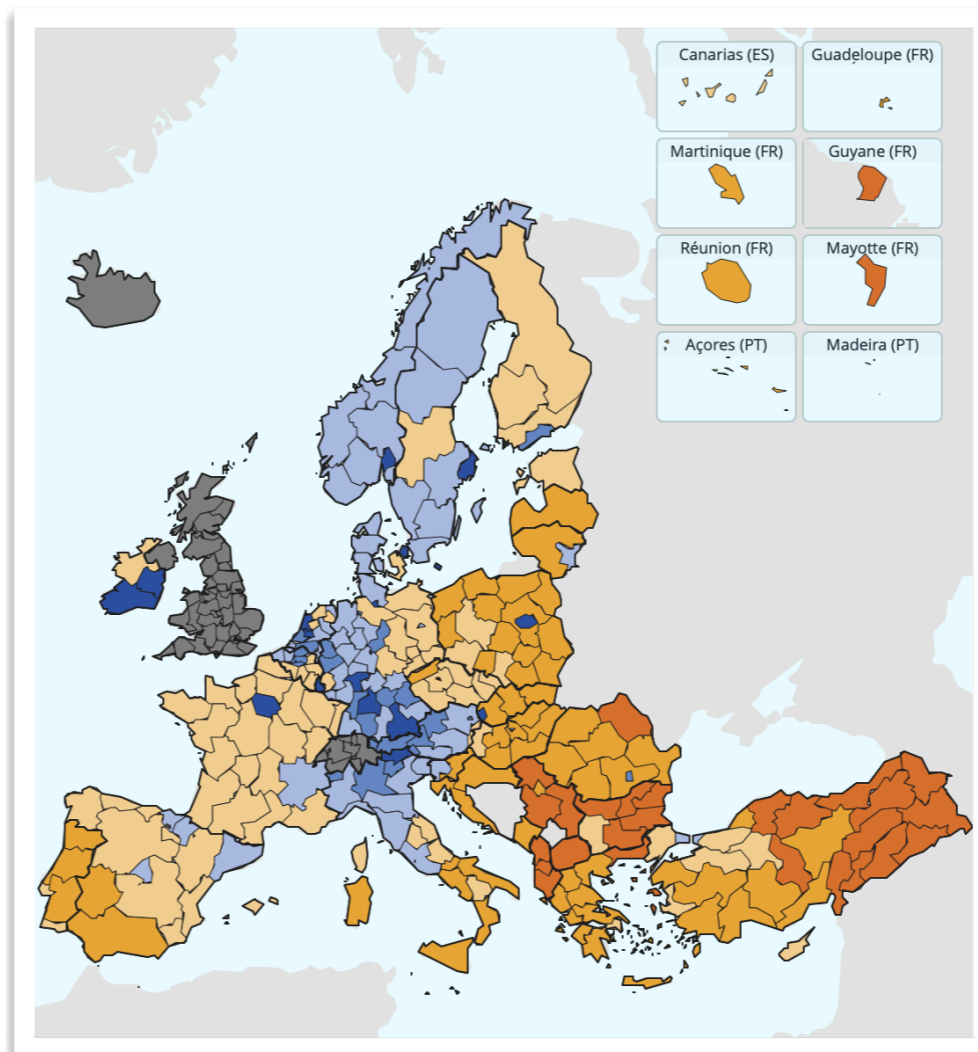
- Specialisation

- Diversity

- Relatedness

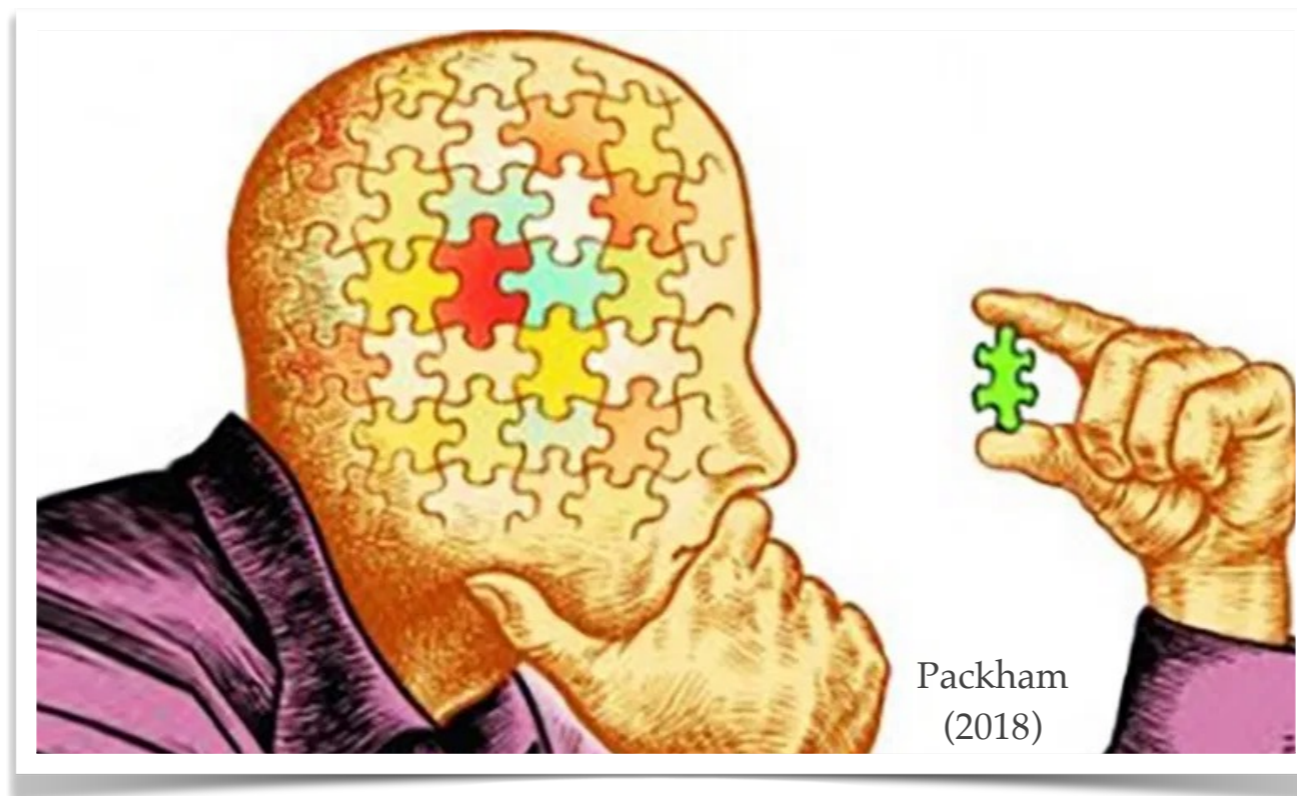
- Complexity

- ...



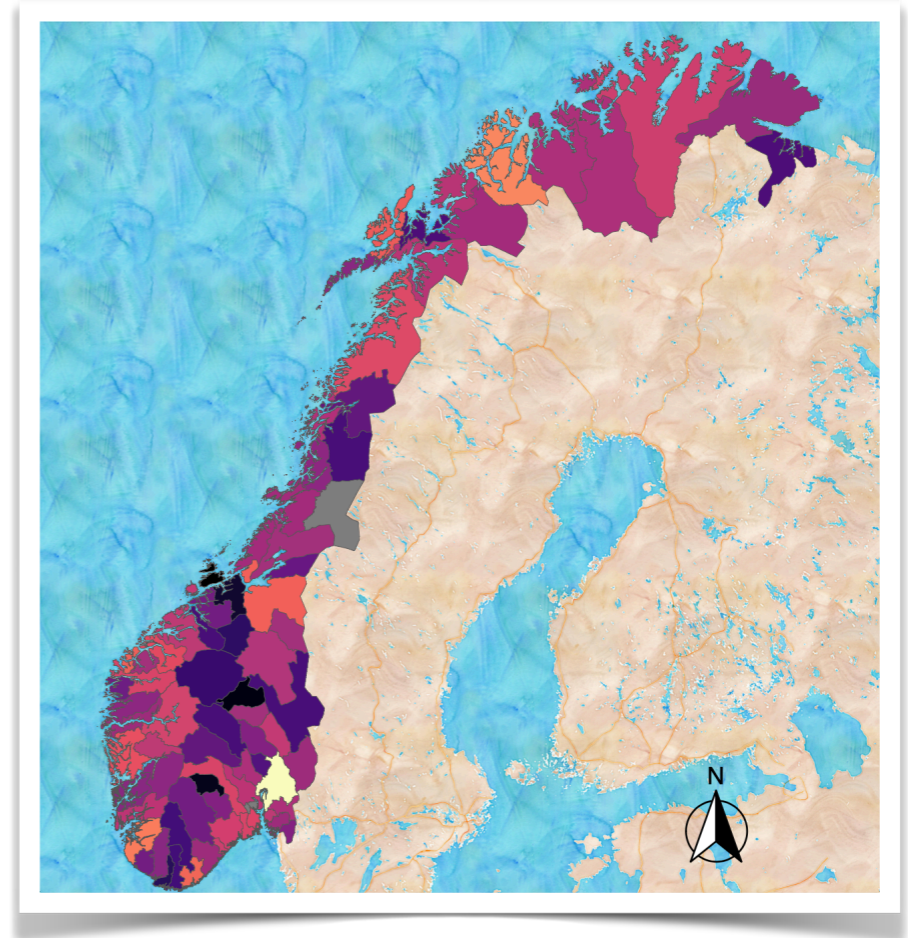
# Motivation

- 🌐 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



# Outline

- ① Motivation
- ① Theory
  - ① Relatedness, complexity, diversity
- ① Empirical study
  - ① Data, estimations, results
- ① Conclusion



# Theory: Relatedness

- Strong overlap & similarity in context, terminology, scientific principles
- Belonging to same (superior) technology or emergent from same basic technology

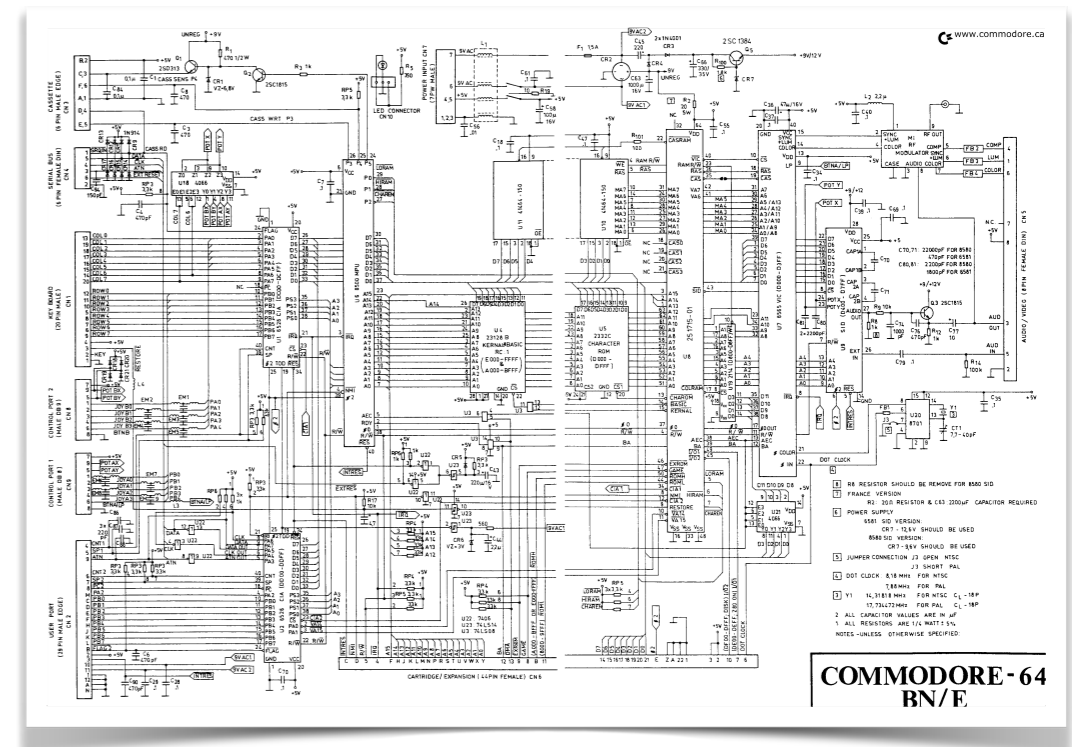


- Relatedness helps diversification & expansion -> growth
- Massive empirical evidence, see, e.g. Hidalgo et al. (2018)

# 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



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# Theory: Complexity

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- 🌐 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)
  - 🌐 ...

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# Theory: Diversity

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- 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



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# Motivation: Shortcomings

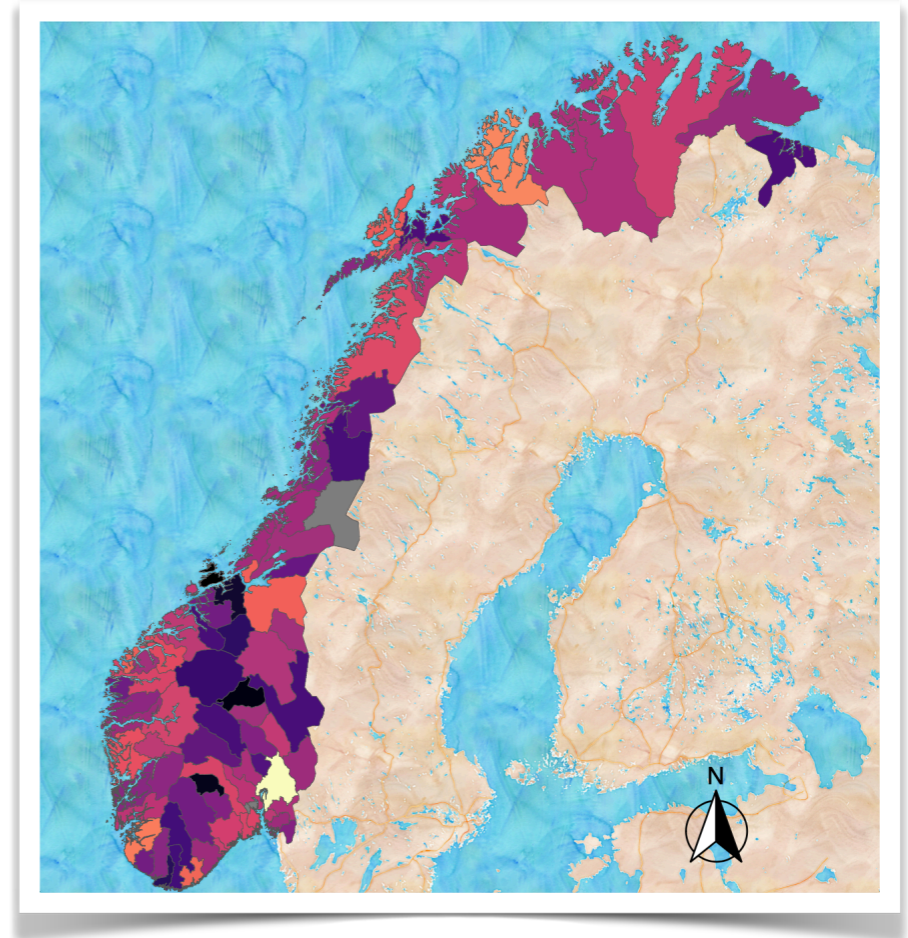
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- ① Dimensions evaluated **separately**
- ① Much evidence for diversification of industrial portfolio  $\neq$  **growth**
- ① Few studies on **other** than employment **dimensions of growth**
- ① Little insights into **context/place sensitivity**
- ① Occupational perspective less utilised in comparison to industrial

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# Empirical study: Data

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- 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**)

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# Empirical study: Relatedness

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🌐 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

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# Empirical study: Relatedness

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## **Industrial relatedness density**

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

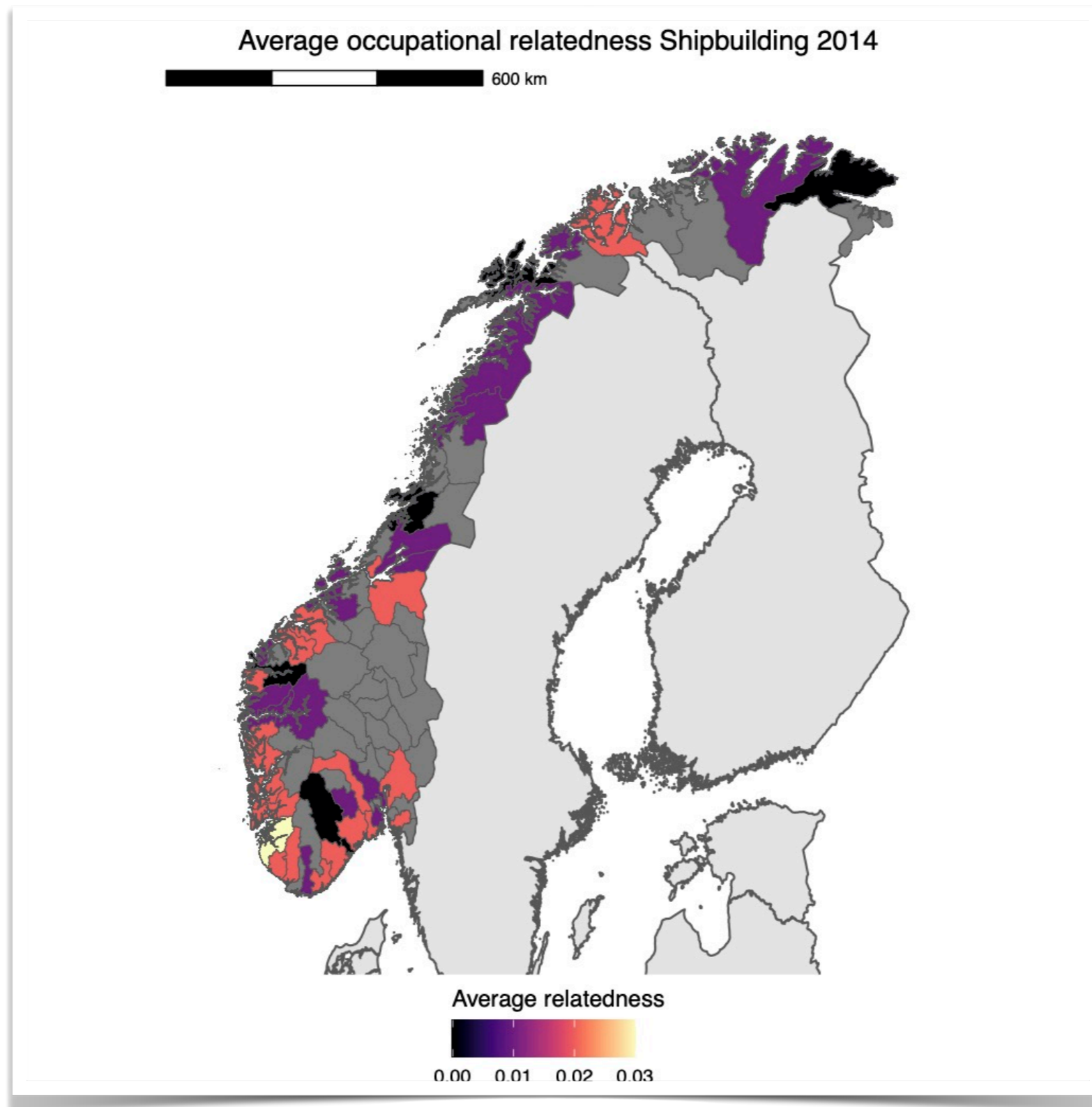
## **Occupational relatedness density**

-  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



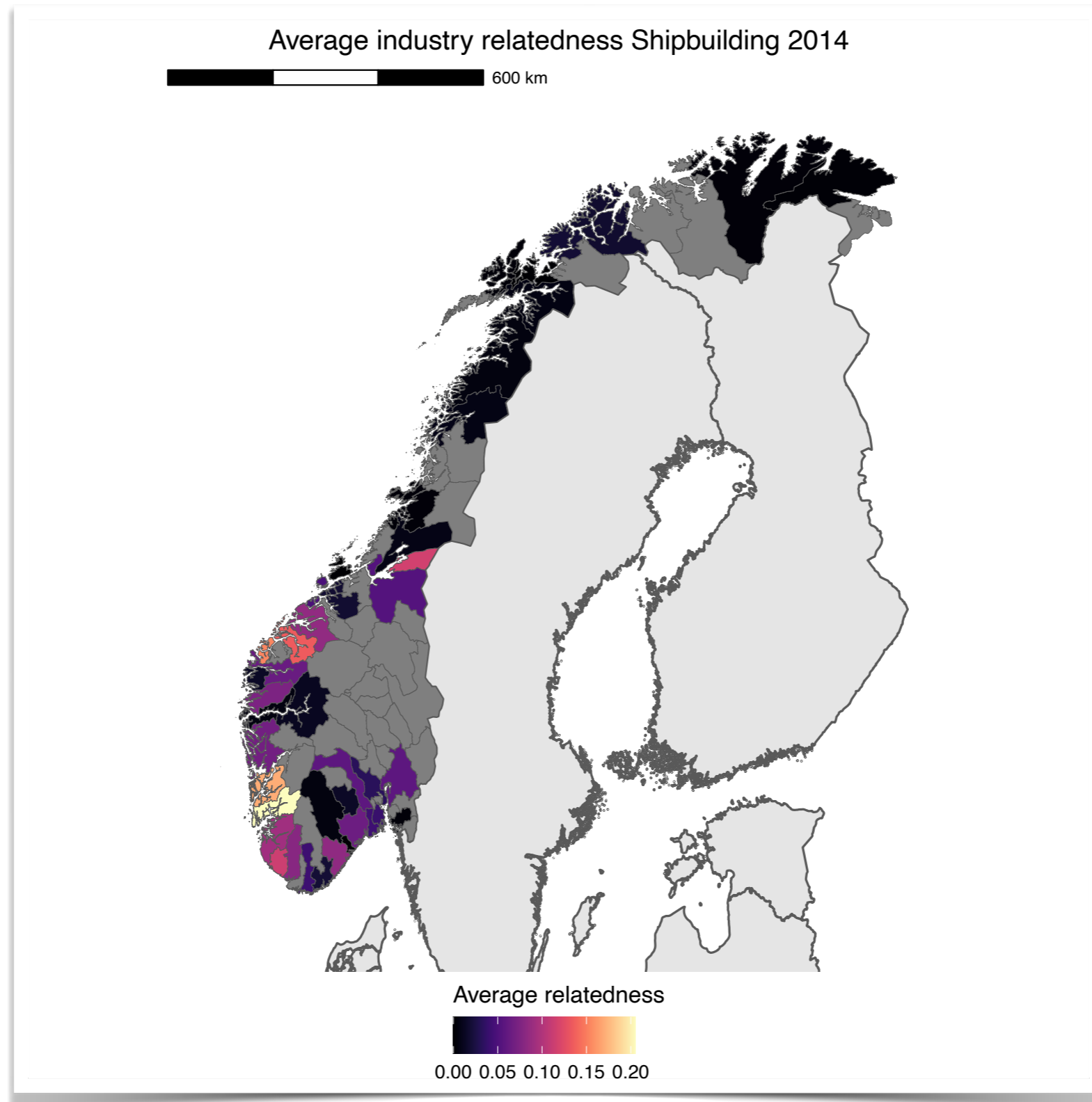
# Empirical study: Industrial relatedness

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



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# Empirical study: Occupational diversity

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- Fractionalisation measure (Alesina et al. 2003)

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

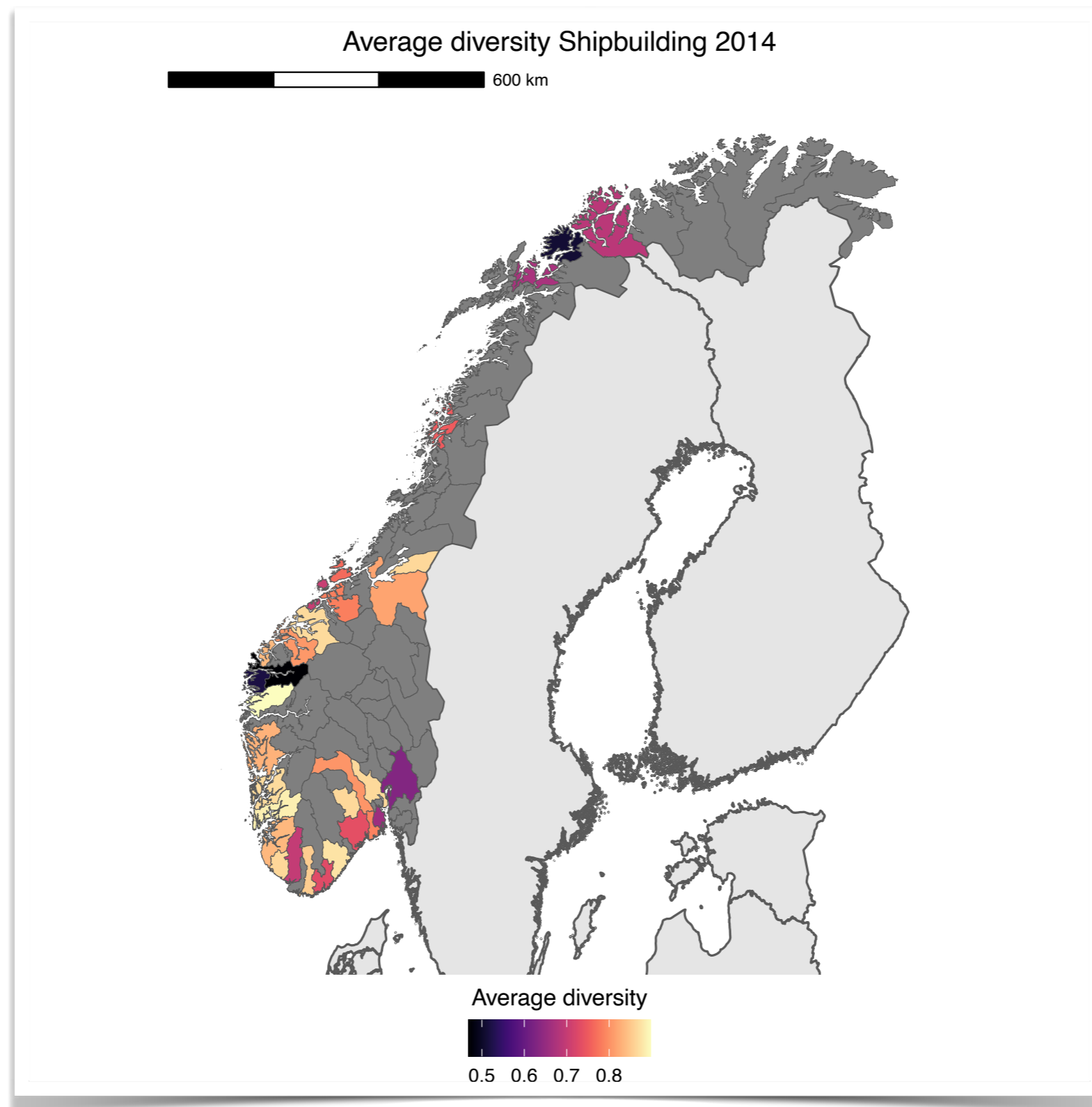
- With  $s$  as proportion of employees in industry  $i$  in region  $r$  in occupation  $o$  and  $O$  being the numbers of different occupations in one industry-region

# 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



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# Empirical study: Occupational complexity

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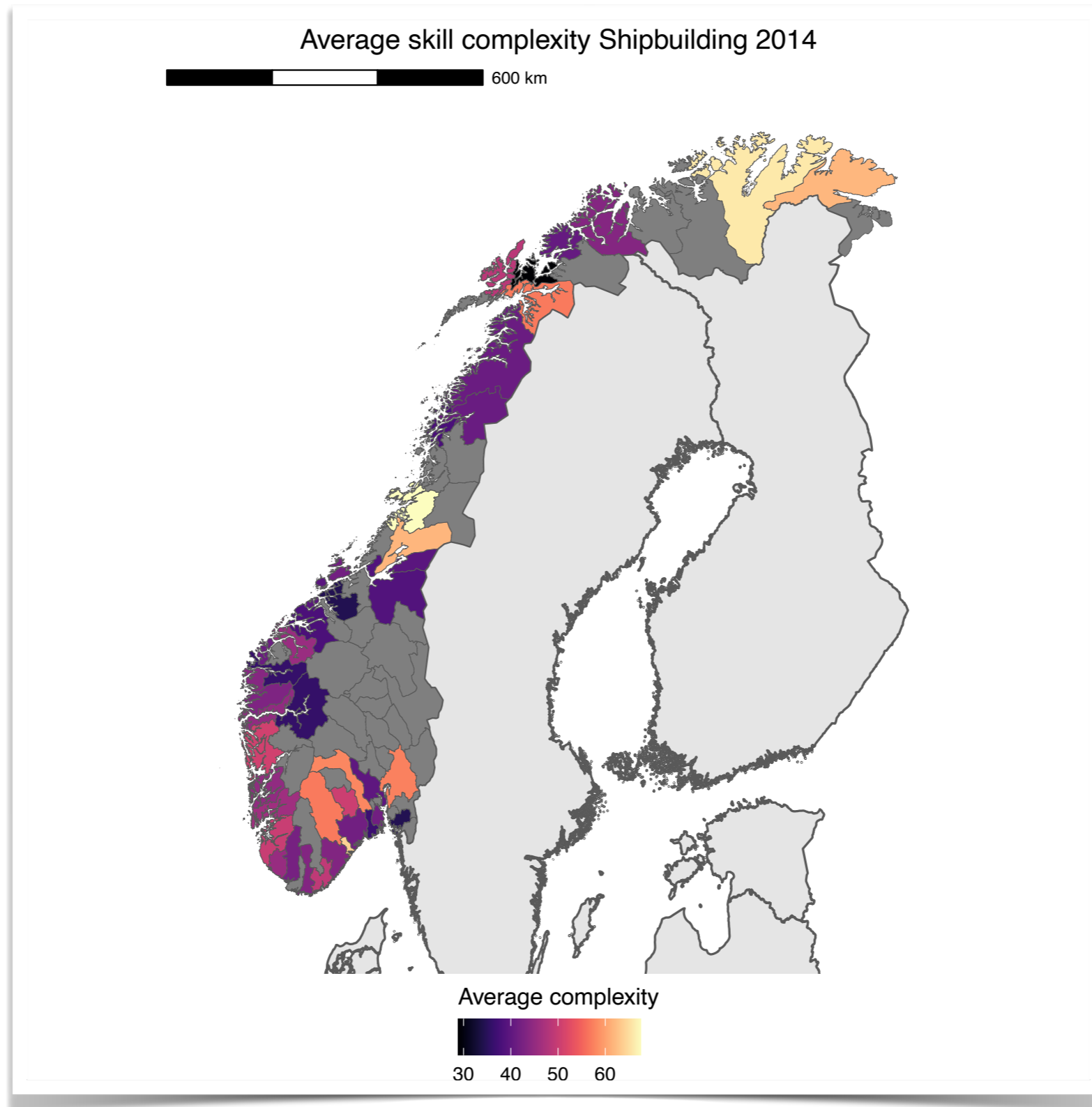
- Weighted average of industry  $i$ 's occupations' complexity in region  $r$
- Occupations' complexity (Caines et al. 2017)
  - Complexity of tasks (e.g., processing of information & communicating)
  - Weighted aggregation of 35 variables from US O\*NET subsections
  - Transformation to SOC -> ISCO 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

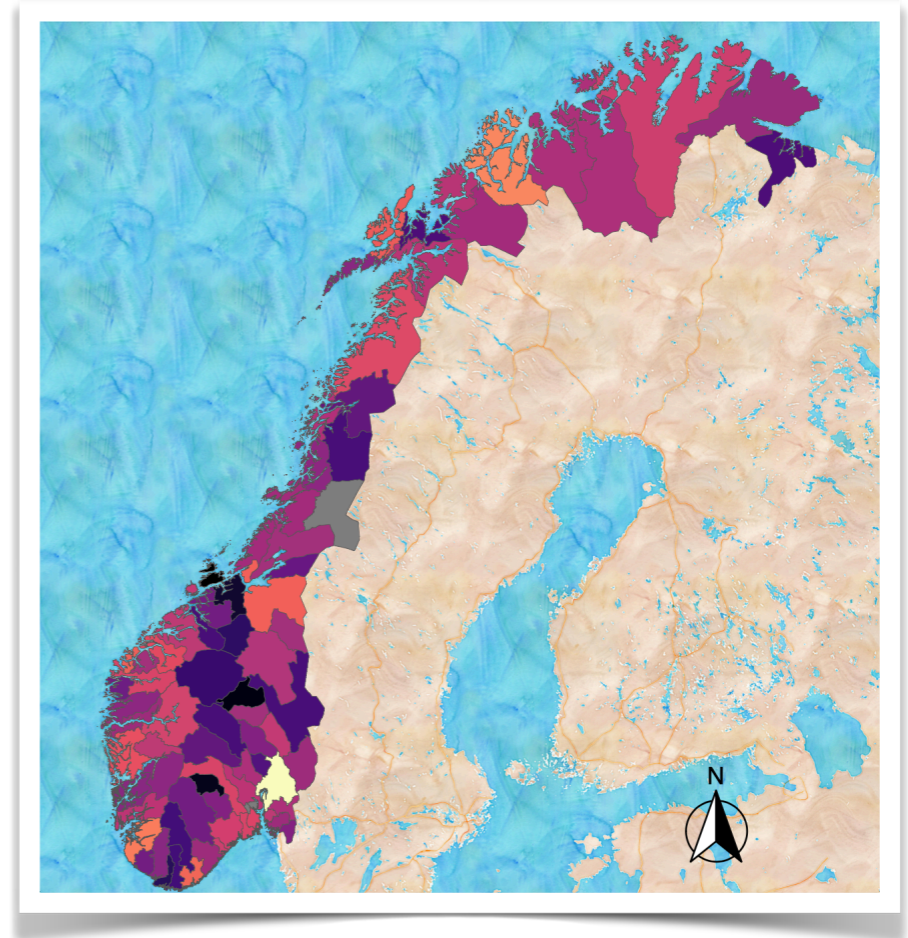
	NACE	Industry	Complexity
1	35.23	Trade of gas through mains	72.282
2	71.11	Architectural activities	69.945
3	06.10	Extraction of crude petroleum	64.370
4	72.11	R&D on biotechnology	63.574
5	72.19	Other R&D on natural sciences etc.	63.237
6	62.02	Computer consultancy activities	61.720
7	62.09	Other information 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



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# Empirical study: Estimations

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- 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  $r$

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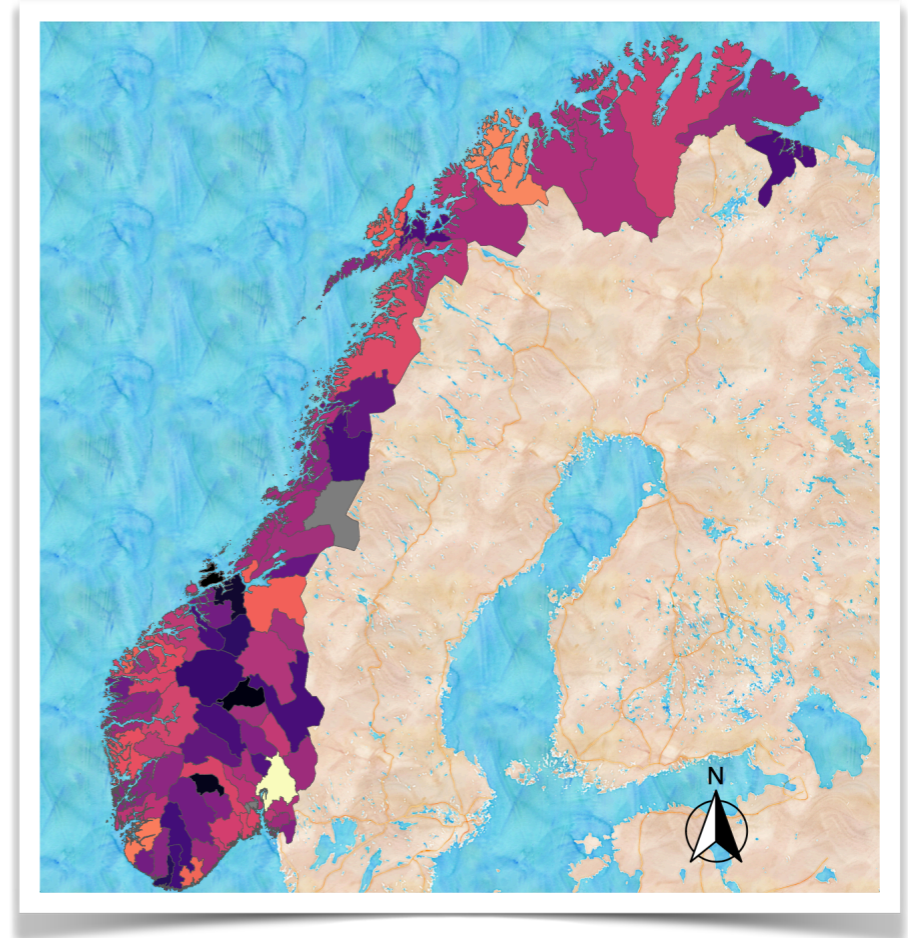
# Empirical study: Estimations

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- 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

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# Empirical study: Results

	Employment growth				Wage growth			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
IEMPL	-0.012*** (0.003)	-0.012*** (0.003)	-0.012*** (0.003)	-0.013*** (0.003)	0.003** (0.001)	0.003** (0.001)	0.002** (0.001)	0.002* (0.001)
IPOP.DEN	0.007*** (0.002)	0.007** (0.002)	0.007*** (0.002)	0.006** (0.002)	-0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
ILQ	-0.006 (0.003)	-0.006 (0.003)	-0.006 (0.003)	-0.006 (0.003)	0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	0.000 (0.001)
IND.REL	0.085* (0.042)	0.085* (0.042)	0.090* (0.041)	0.092* (0.042)	-0.027* (0.014)	-0.029* (0.014)	-0.022 (0.013)	-0.022 (0.013)
DIVERS		-0.002 (0.013)	-0.004 (0.013)	-0.003 (0.014)		0.014* (0.006)	0.014* (0.006)	0.014* (0.006)
COMPLEX			0.000 (0.000)	0.000 (0.000)			0.000** (0.000)	0.000** (0.000)
OCC.REL				0.280 (0.248)				0.032 (0.095)
IWAGE					-0.037*** (0.005)	-0.039*** (0.005)	-0.043*** (0.005)	-0.044*** (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 <sup>2</sup> (full model)	0.052	0.052	0.052	0.052	0.065	0.067	0.070	0.070
R <sup>2</sup> (proj model)	0.010	0.010	0.011	0.011	0.038	0.040	0.043	0.043
Adj. R <sup>2</sup> (full model)	0.041	0.041	0.041	0.041	0.055	0.056	0.059	0.059
Adj. R <sup>2</sup> (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

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# Empirical study: Results

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 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

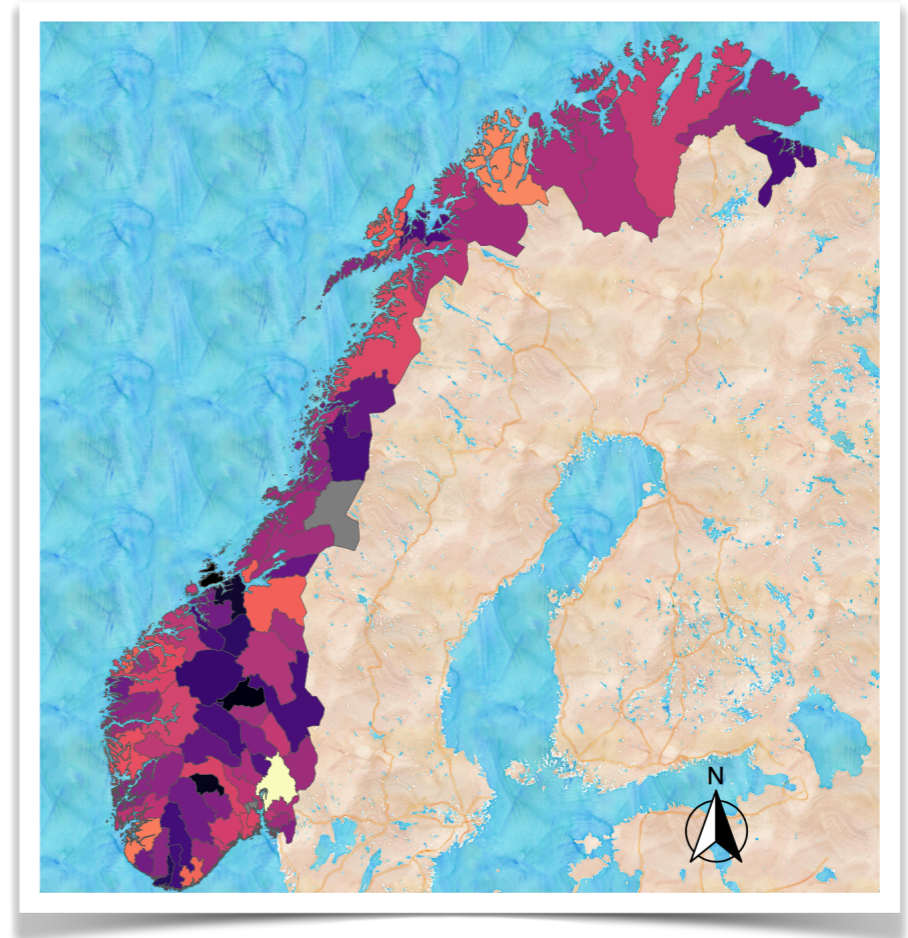
 **Complexity in rural & intermediate** regions 

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

 **Occupational relatedness in urban** regions 

# Outline

- ① Motivation
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- ① Set-up of empirical study
- ① Results
- ① Conclusion



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# Conclusion

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- **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?

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

**More research!!!!**

*Thank you for your attention*

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