

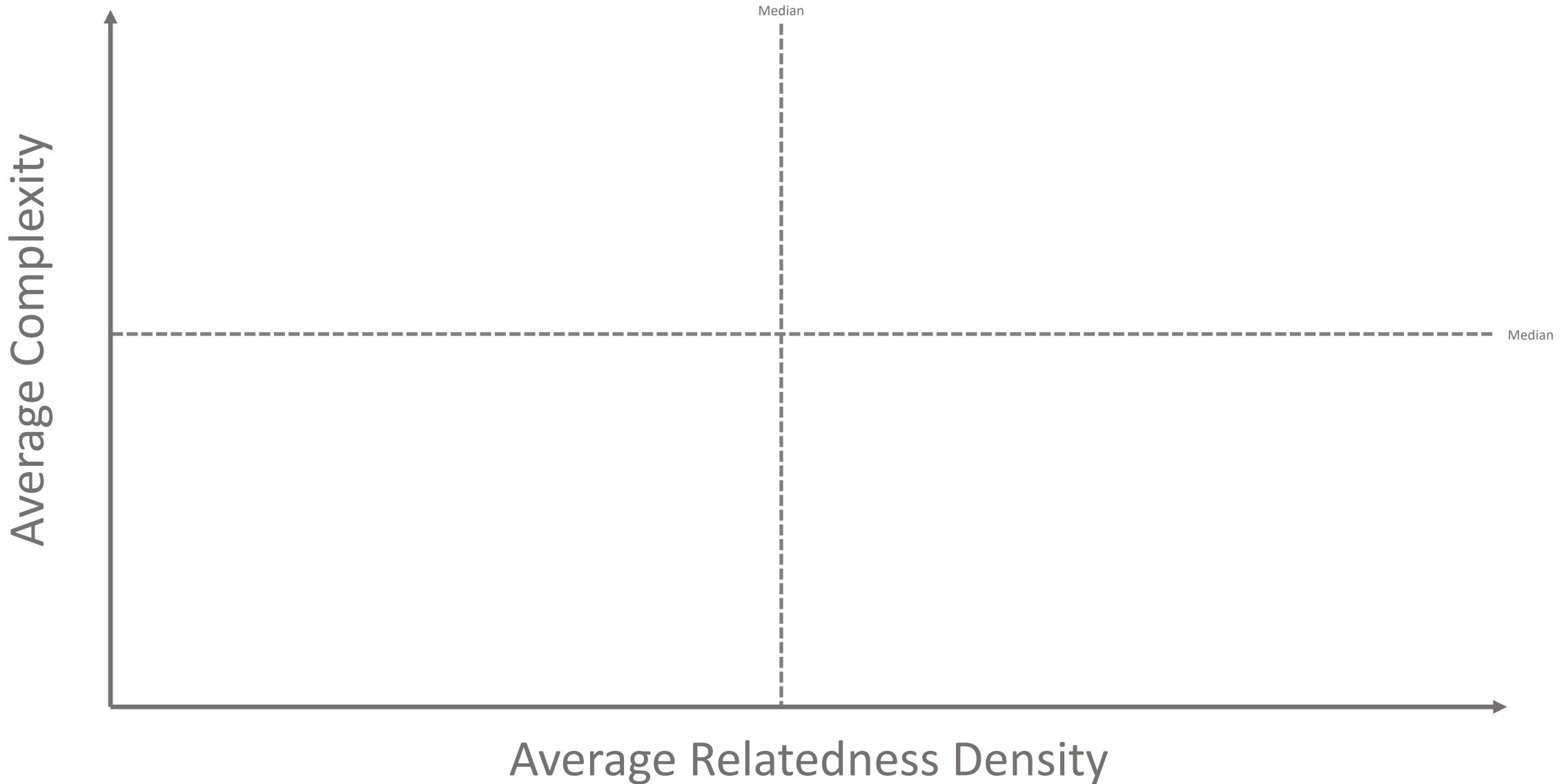
Complexity loops, structural traps & regional development



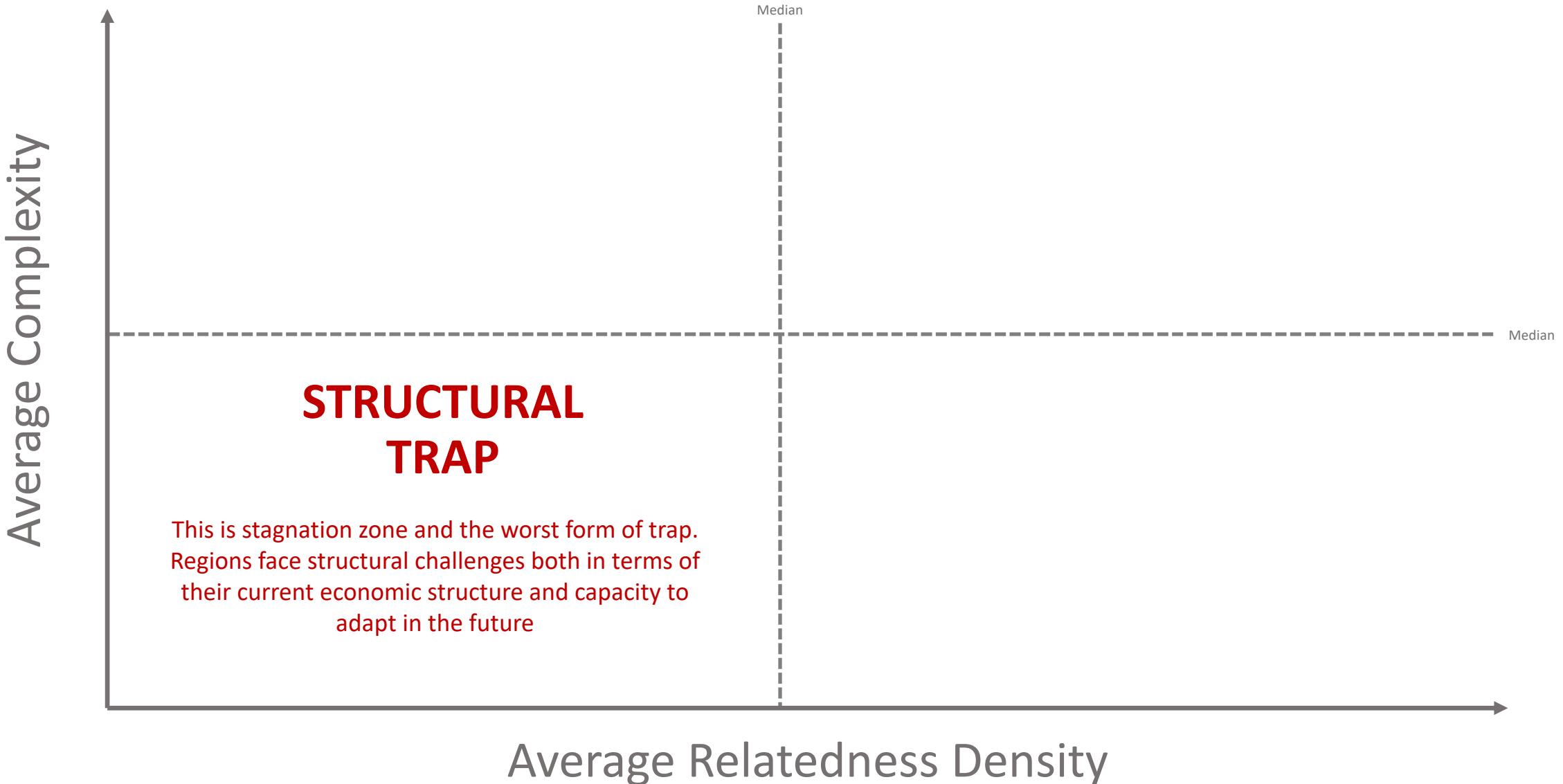
Pierre-Alex Balland & Ron Boschma

AN EVOLUTIONARY FRAMEWORK FOR DEVELOPMENT TRAPS

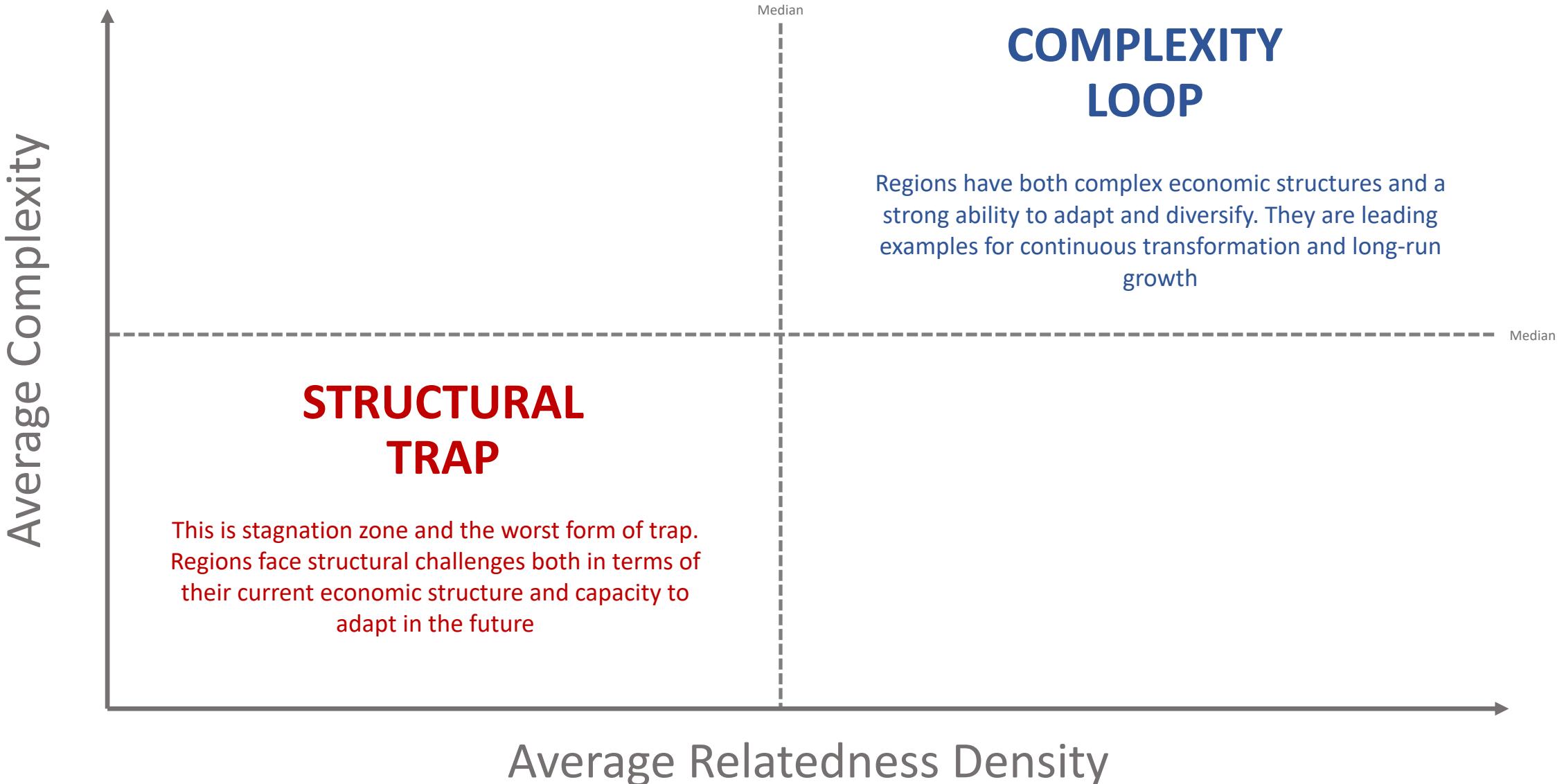
Complexity Loops and Structural Traps



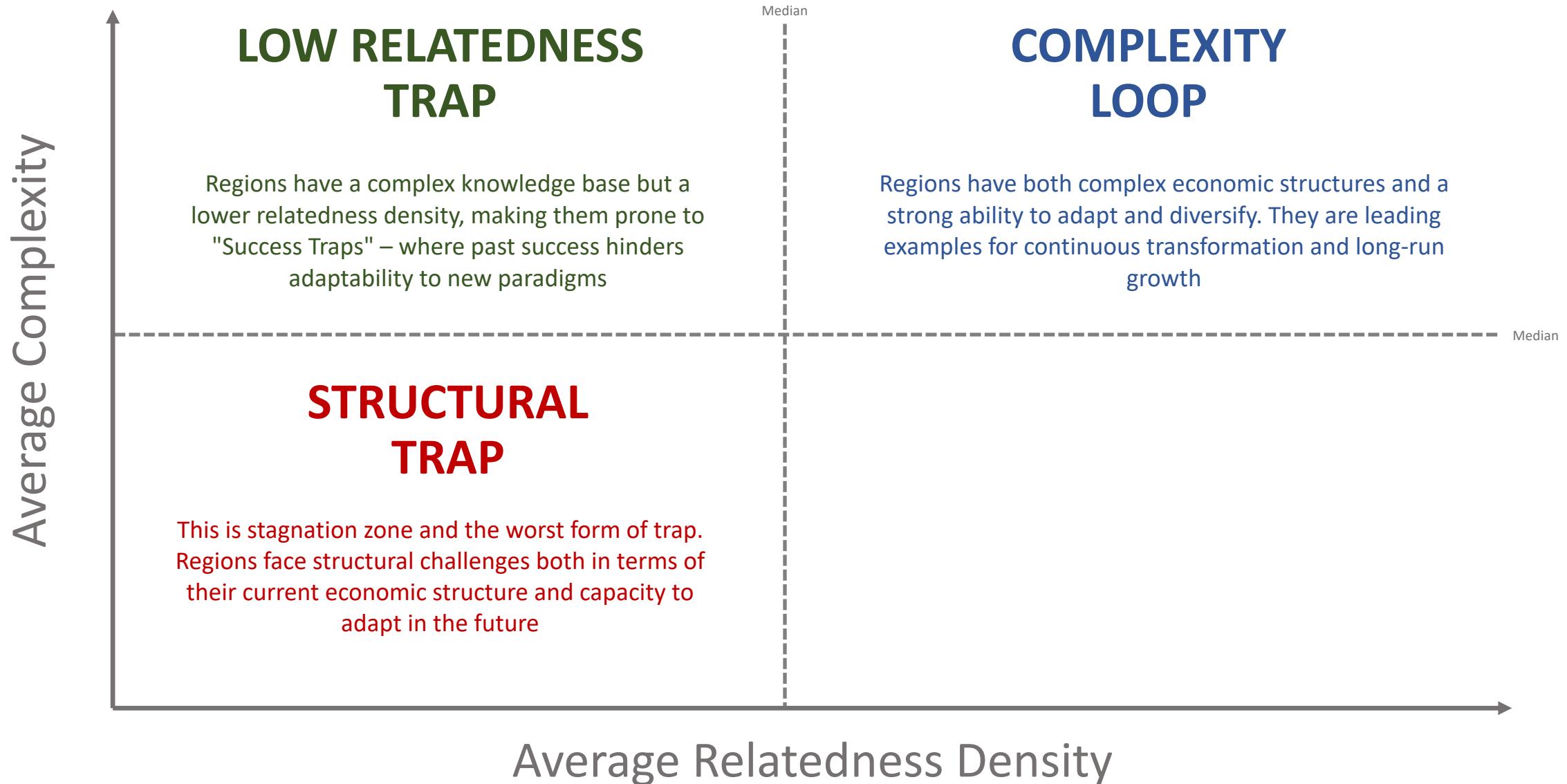
Complexity Loops and Structural Traps



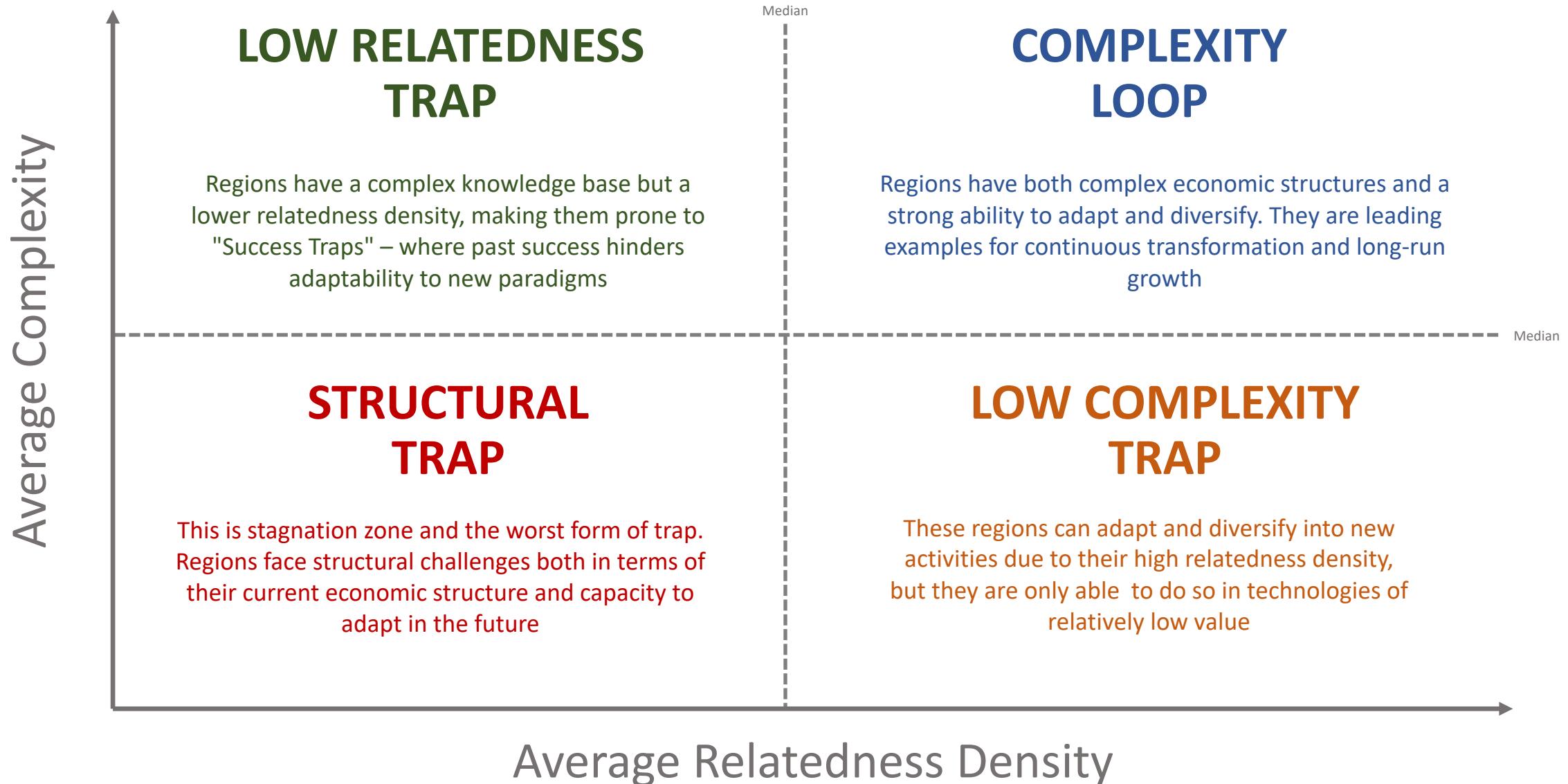
Complexity Loops and Structural Traps



Complexity Loops and Structural Traps



Complexity Loops and Structural Traps



MEASURING STRUCTURAL TRAPS WITH INDUSTRY DATA (SBS)

| nace | nace.name | compTCI |
|------|--|---------|
| J59 | Motion picture, video and television programme production, sound recording and music publishing activities | 0.320 |
| J62 | Computer programming, consultancy and related activities | 0.301 |
| N7 | Administrative and support service activities | 0.269 |
| J61 | Telecommunications | 0.268 |
| M70 | Activities of head offices; management consultancy activities | 0.266 |
| K-N | K-N residual | 0.253 |
| M73 | Advertising and market research | 0.246 |
| M72 | Scientific research and development | 0.240 |
| J58 | Publishing activities | 0.203 |
| M71 | Architectural and engineering activities; technical testing and analysis | 0.146 |
| N81 | Services to buildings and landscape activities | 0.124 |
| J60 | Programming and broadcasting activities | 0.095 |
| O-U | O-U residual | 0.049 |
| N82 | Office administrative, office support and other business support activities | 0.048 |
| M69 | Legal and accounting activities | 0.034 |
| J63 | Information service activities | 0.029 |
| L68 | Real estate activities | 0.022 |
| H | Transporting and storage | 0.002 |
| M75 | Veterinary activities | 0.002 |
| M74 | Other professional, scientific and technical activities | -0.012 |
| C2C | Manufacturing of machinery and transport | -0.045 |
| I55 | Accommodation | -0.051 |
| G45 | Wholesale and retail trade | -0.056 |
| C2B | Manufacturing of electrical, electronic and computers | -0.059 |
| I56 | Food and beverage service activities | -0.071 |
| G-J | G-J residual | -0.091 |
| F | Construction | -0.094 |
| C1C | Manufacturing of chemicals & metals | -0.106 |
| N80 | Security and investigation activities | -0.187 |
| E | Electricity, gas, water collection, swerage and waste | -0.211 |
| C1A | Basic manufacturing | -0.231 |
| B | Mining and quarrying | -0.346 |
| A | Agriculture, forestry and fishing | -0.357 |

Industry Complexity Rankings (2011)

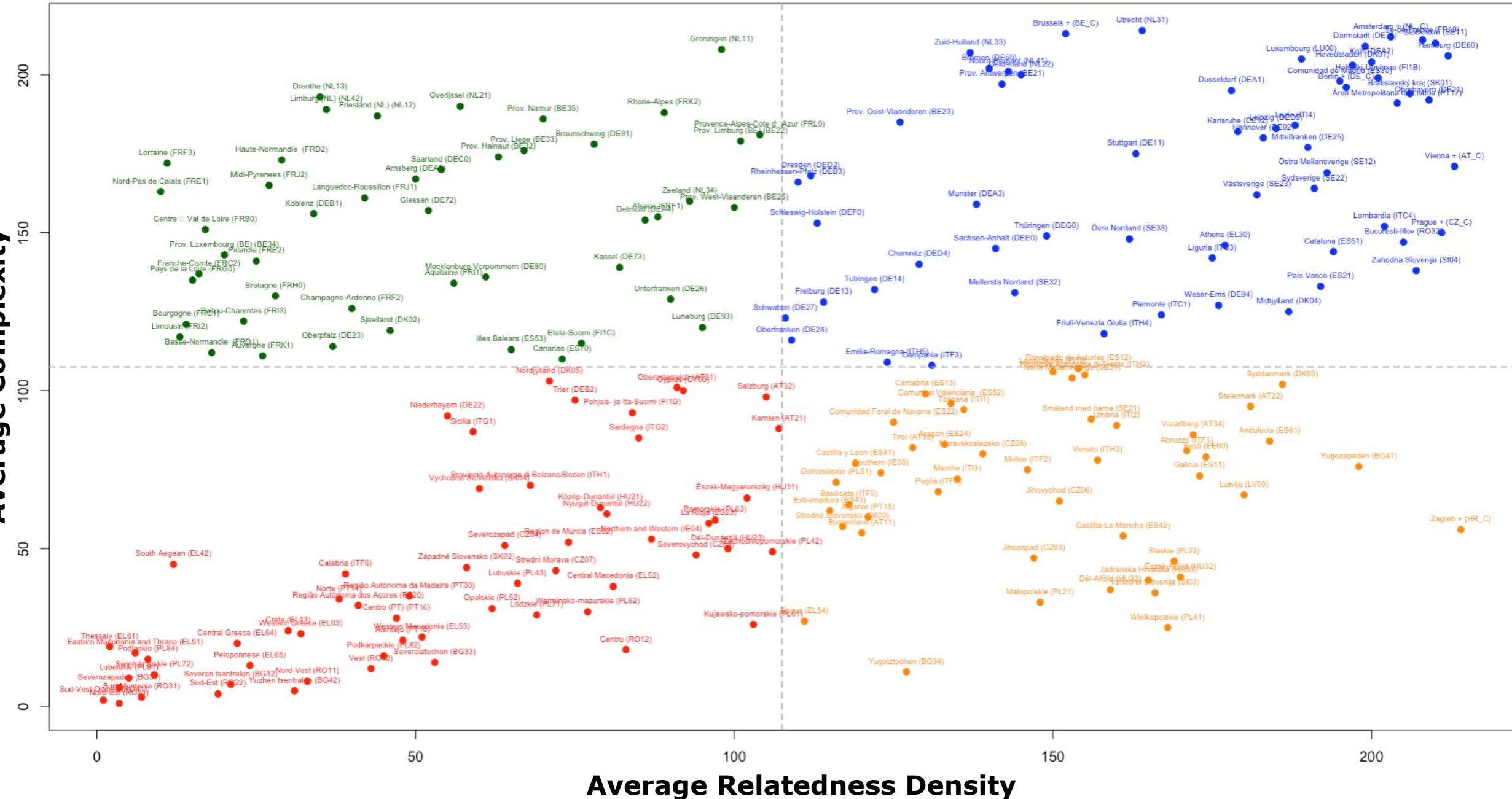
DATA:

- Structural Business Statistics (SBS) employment data by NUTS2 regions and NACE. Source of data: Eurostat.
- Annual Regional Database of the European Commission (ARDECO) employment data by NUTS2 regions and NACE. Source: Joint Research Centre & Directorate General for Regional and Urban Policy.

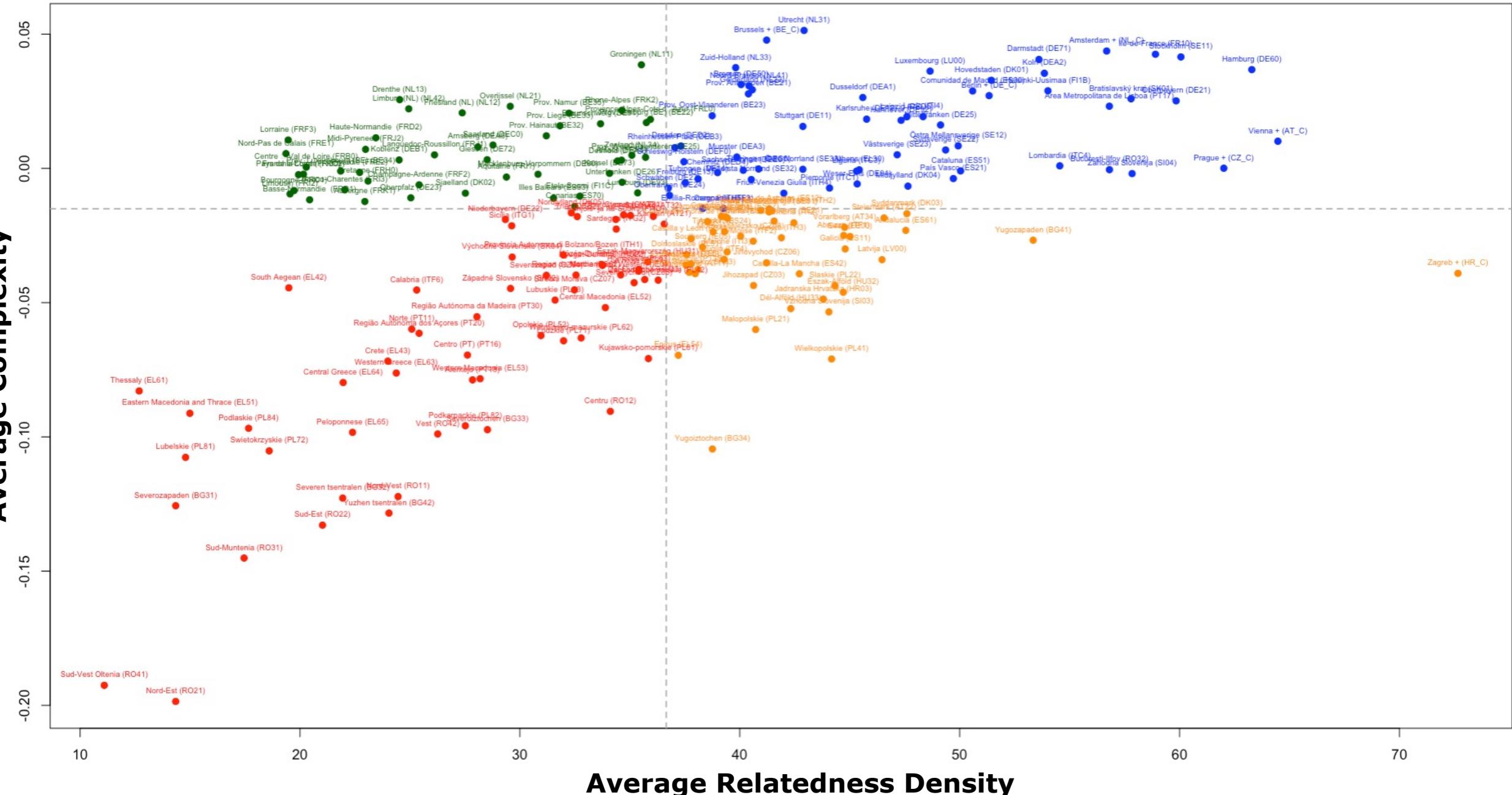
METHODOLOGICAL NOTE:

- SBS provides more disaggregated NACE codes (level 1, 2 and 3) but some sectors are entirely missing (A, K...)
- ARDECO is very comprehensive but much more aggregated
- We combine both datasets, and when relevant we subtract SBS employment count from ARDECO employment count (K-N residual for instance)
- By historical legacy, the NACE classification provides a more detailed classification for low-complex sectors such as manufacturing, so we re-aggregated to provide a more consistent employment count across categories.
- Complexity scores are computed following the eigenvector reformulation. See Hidalgo & Hausman (2009) and for a more recent discussion of economic complexity indicators Balland et al. (2022).

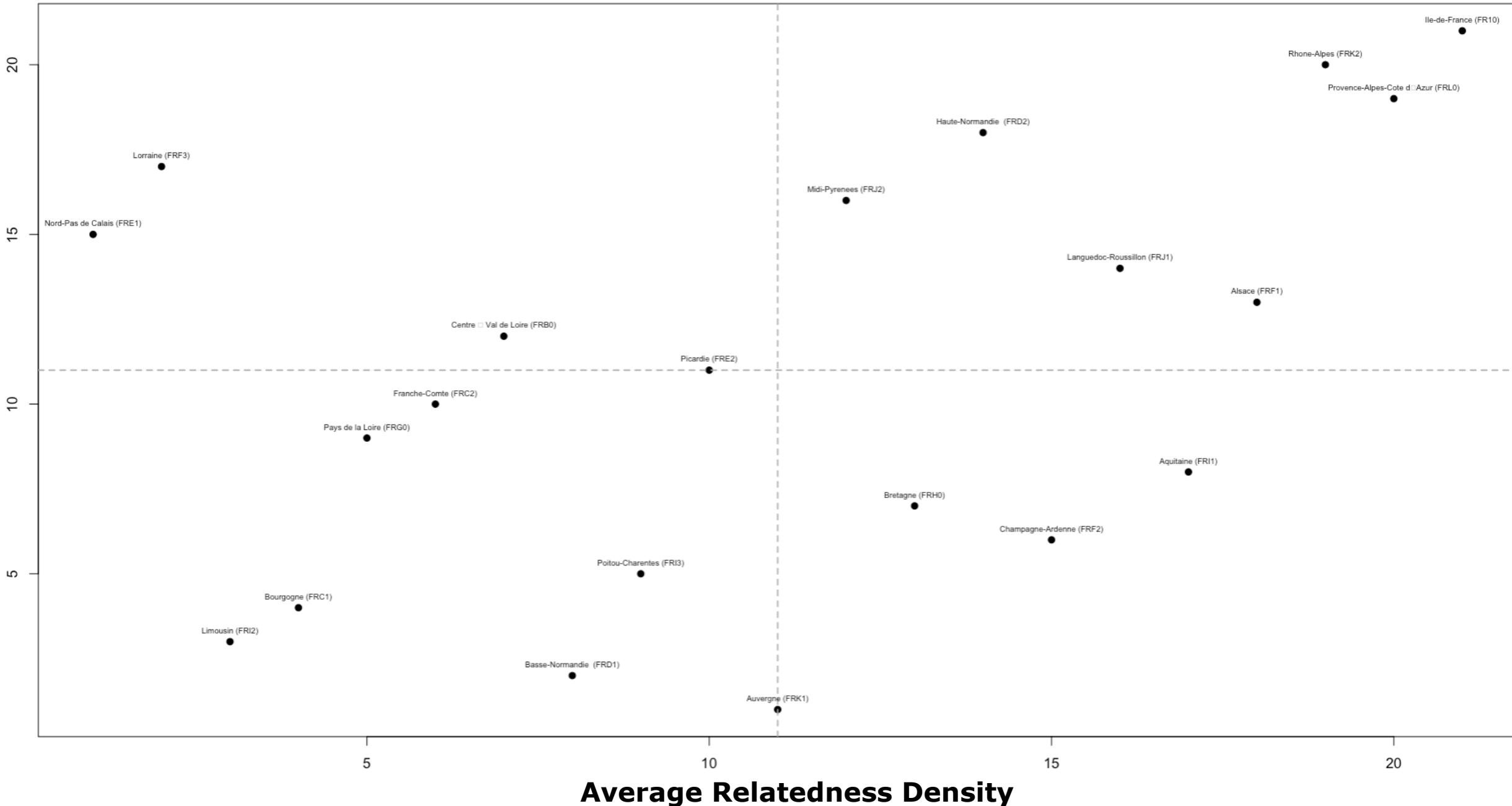
Complexity Loops & Structural Traps – Industries (rank)



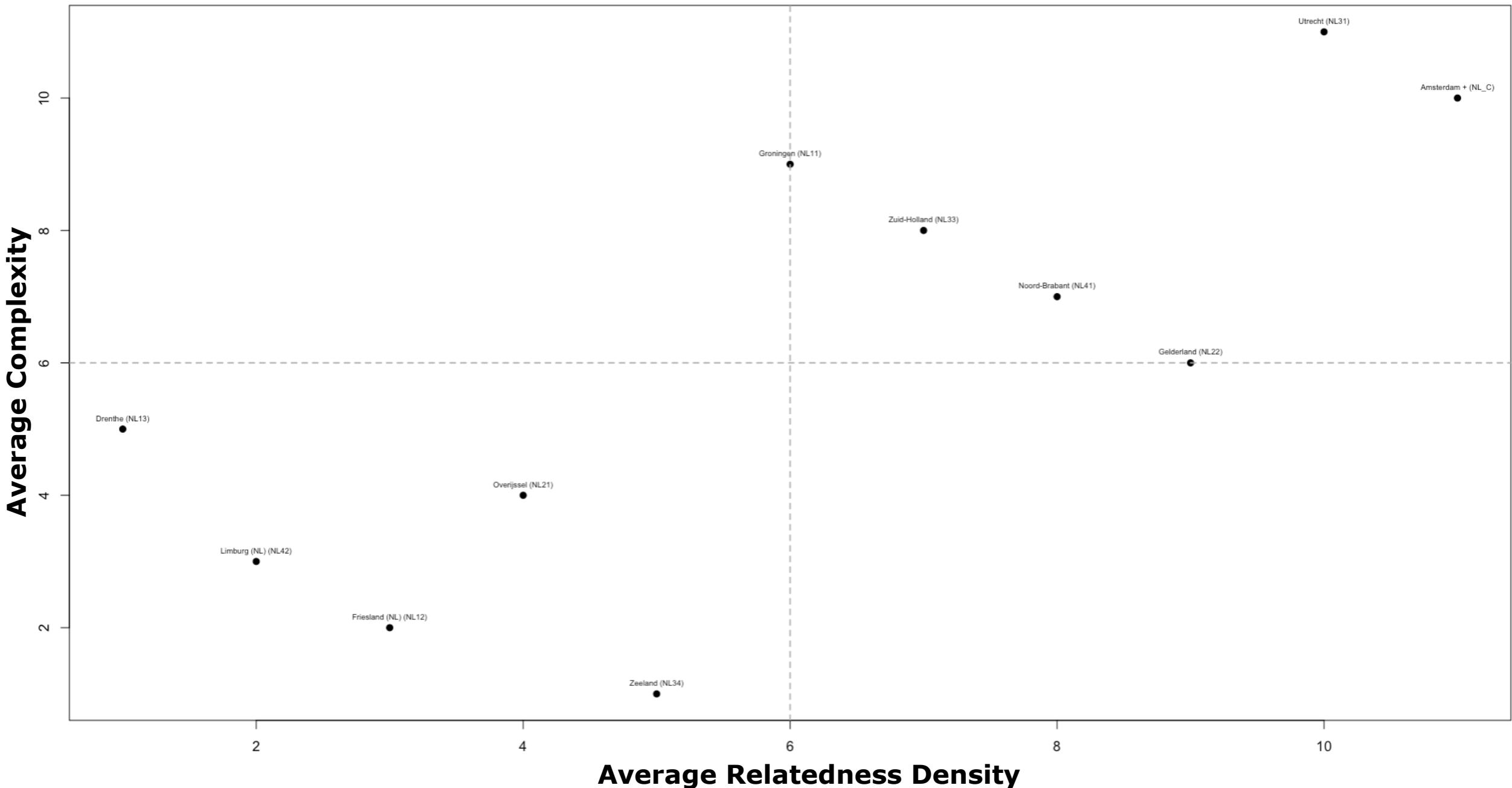
Complexity Loops & Structural Traps – Industries (values)



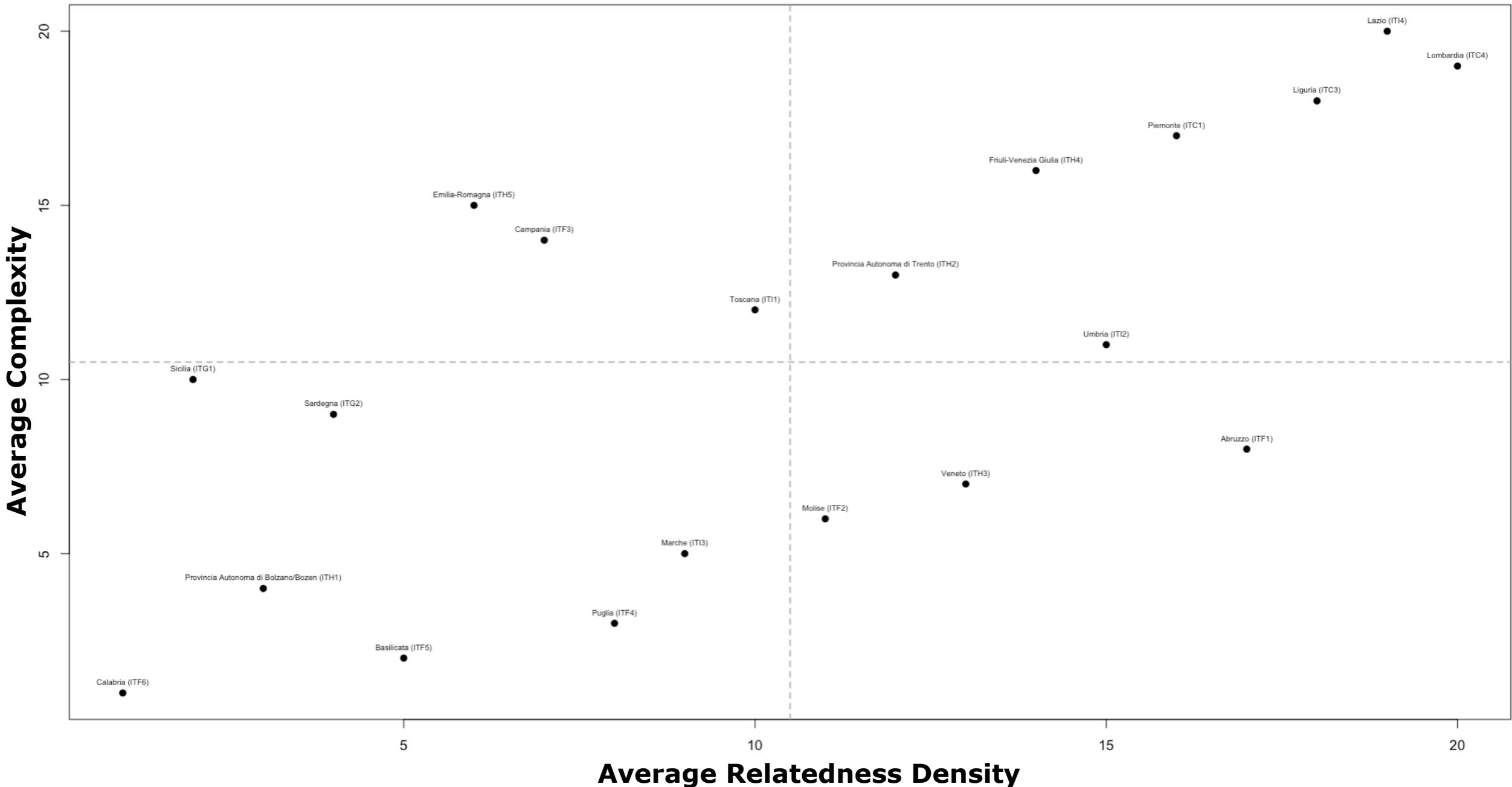
Complexity Loops & Structural Traps for France - Industries (rank)



Complexity Loops & Structural Traps for the NL - Industries (rank)

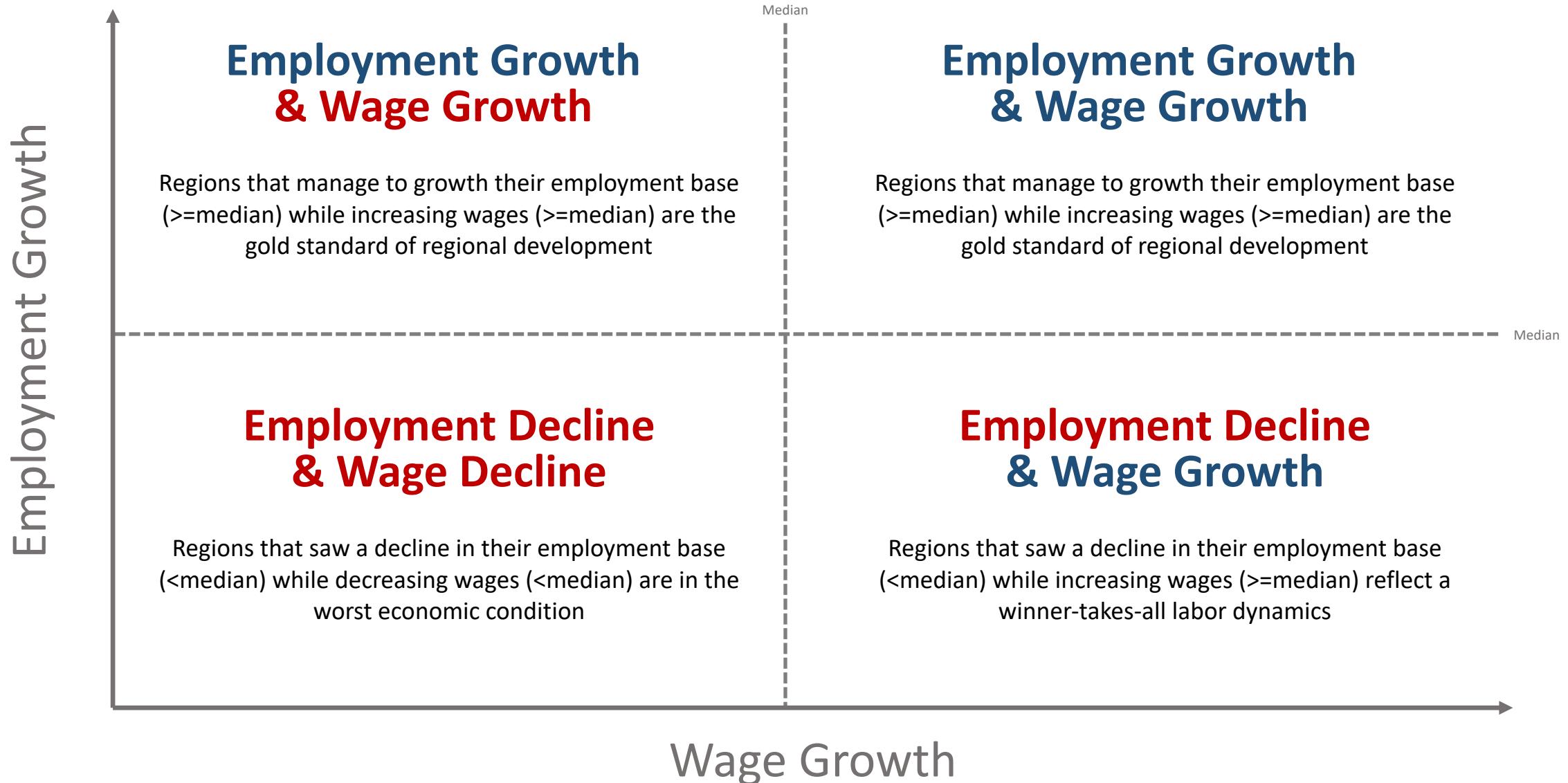


Complexity Loops & Structural Traps for Italy - Industries (rank)

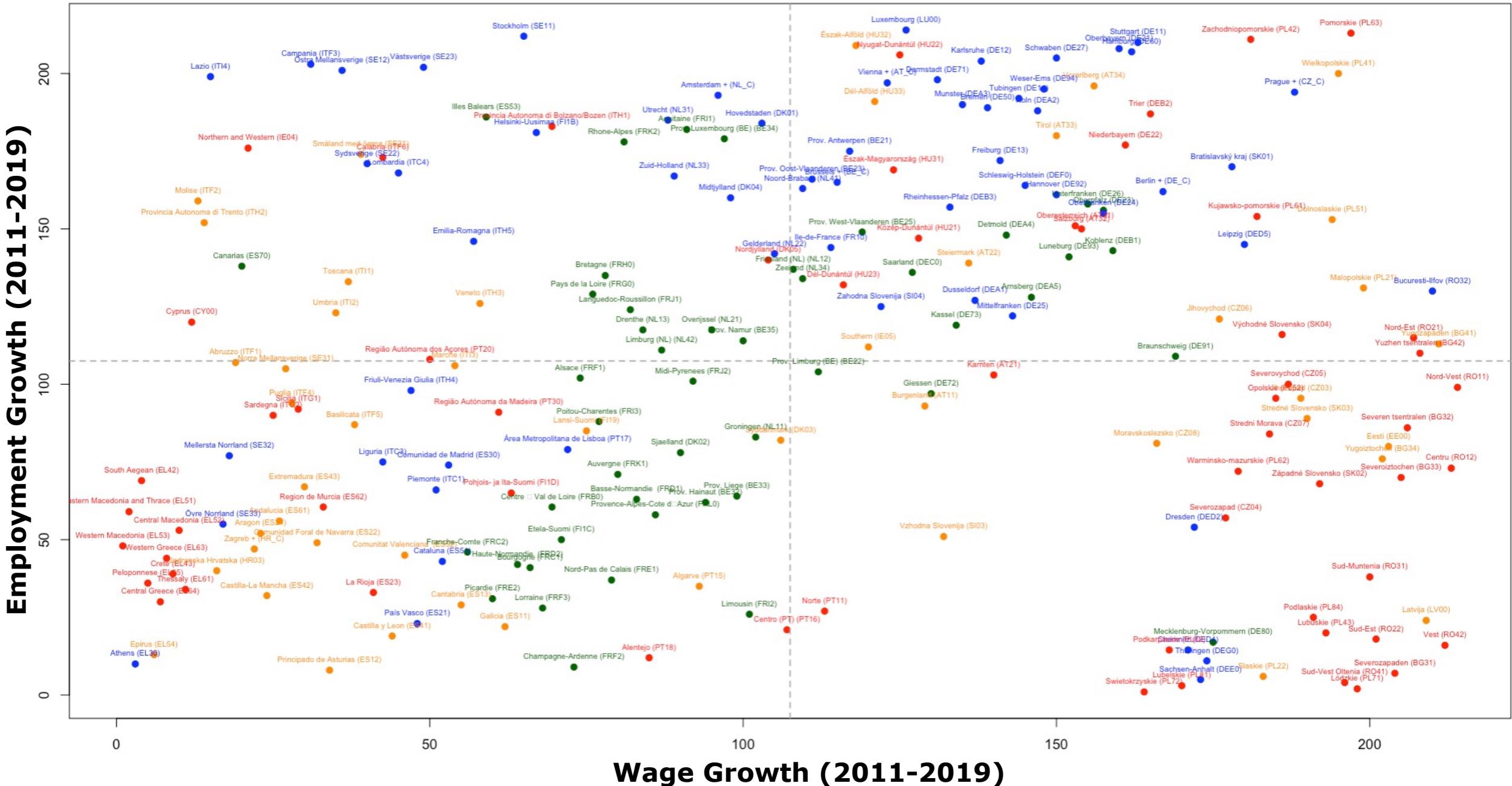


**CAN (INDUSTRY)
STRUCTURAL TRAPS
EXPLAIN REGIONAL
DEVELOPMENT?**

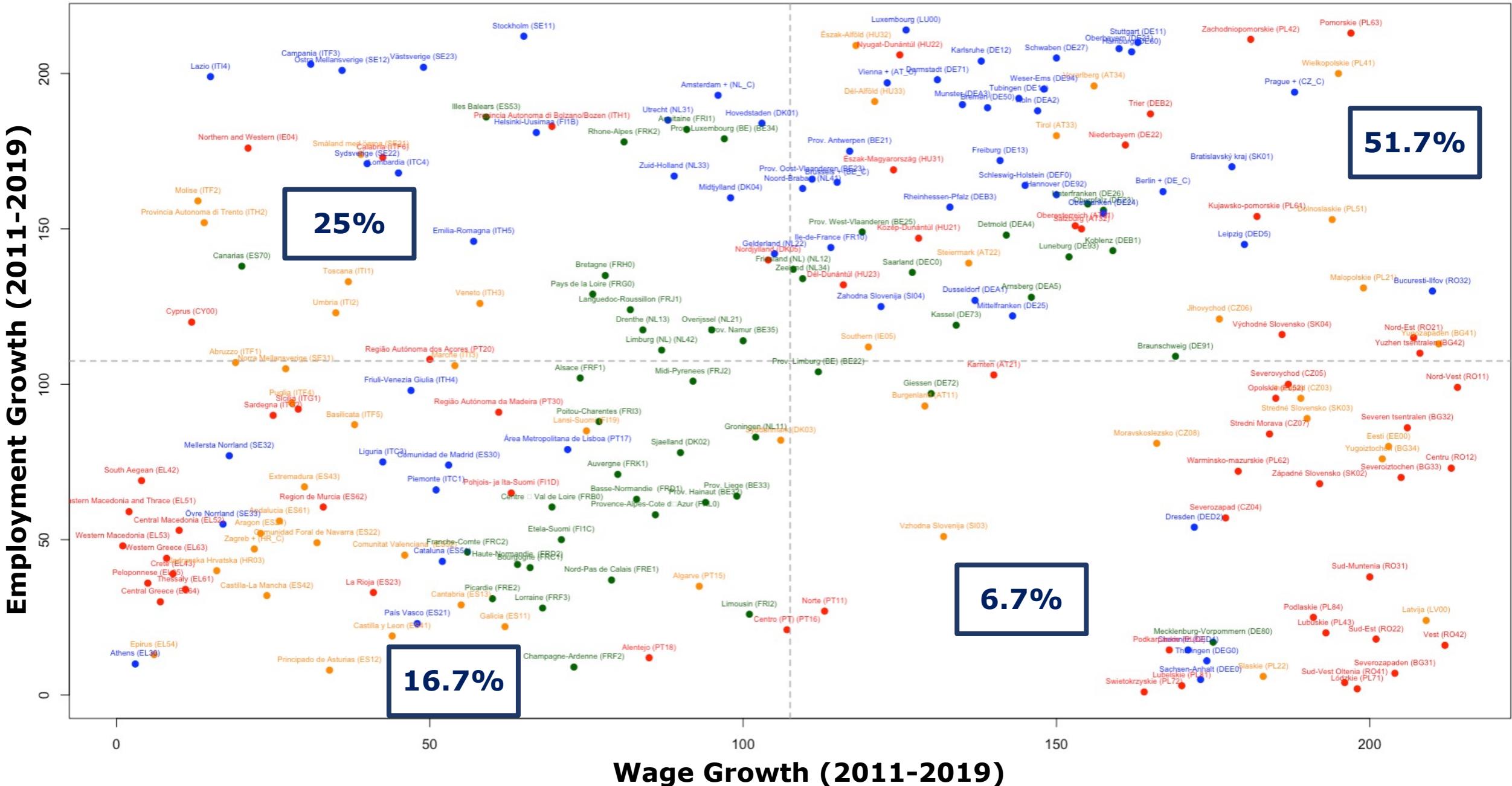
A Simple Evaluation Framework



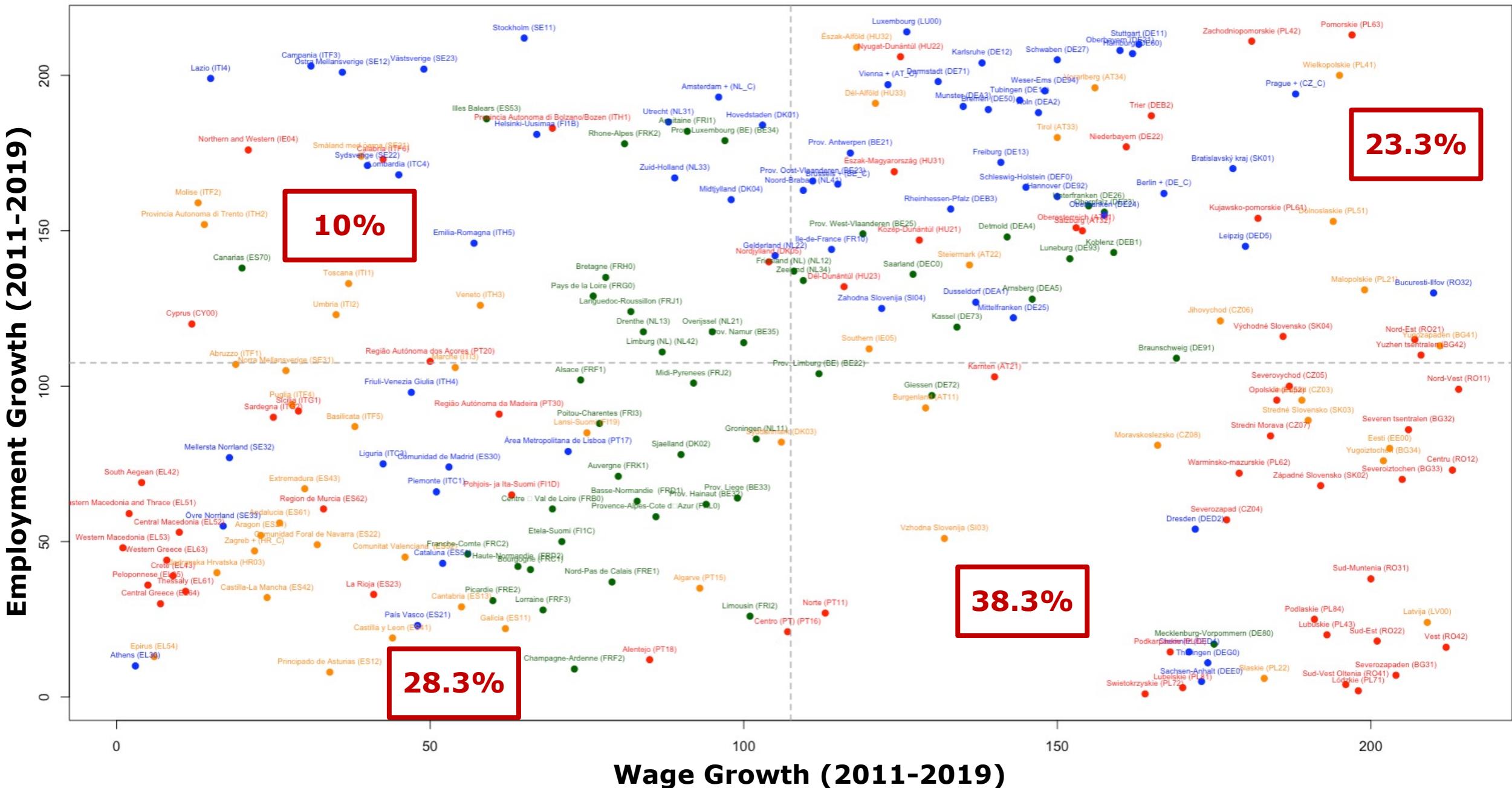
Complexity Loop, Structural Traps and Employment Dynamics



Regions in complexity loops → employment growth + wage growth



Regions in structural traps → employment decline



Employment Dynamics Summary Per Group – Industries

| | E+W+ | E+W- | E-W+ | E-W- | E+ | E- | W+ | W- |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|
| blue | 51.67 | 25.00 | 6.67 | 16.67 | 76.67 | 23.33 | 58.33 | 41.67 |
| darkgreen | 25.53 | 25.53 | 6.38 | 42.55 | 51.06 | 48.94 | 31.91 | 68.09 |
| darkorange | 23.40 | 12.77 | 19.15 | 44.68 | 36.17 | 63.83 | 42.55 | 57.45 |
| red | 23.33 | 10.00 | 38.33 | 28.33 | 33.33 | 66.67 | 61.67 | 38.33 |

Baseline Employment and Wage Growth Models

| | <i>Dependent variable:</i> | | | | | |
|--------------------------------|----------------------------|--------------------------------|----------------------|--------------------------|-----------------------|-----------------------|
| | Employment Growth | Employment Growth (Rank) | Wage Growth | Wage Growth (Rank) | Both (Rescaled) | Both (Rank) |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| emplevel | -0.104 (0.577) | 3.444 (5.557) | 5.591*** (1.556) | 15.139*** (4.381) | 4.252** (1.848) | 18.583** (8.044) |
| wagelevel | 0.124** (0.055) | 0.888* (0.527) | -1.272*** (0.148) | -4.136*** (0.415) | -0.774*** (0.175) | -3.248*** (0.763) |
| GERD_PCT_GDP | 1.480*** (0.515) | 15.609*** (4.963) | 1.383 (1.389) | 8.632** (3.913) | 3.955** (1.650) | 24.241*** (7.185) |
| GVA_IND_SHARE | -0.026 (0.058) | -0.217 (0.557) | 0.359** (0.156) | 1.477*** (0.439) | 0.236 (0.185) | 1.260 (0.806) |
| SHARE_HIGH_EDUC | -0.100 (0.068) | -1.176* (0.650) | 0.235 (0.182) | -0.169 (0.513) | -0.006 (0.216) | -1.344 (0.941) |
| EQI | 0.230 (0.697) | 6.508 (6.712) | 5.392*** (1.879) | 32.709*** (5.292) | 4.738** (2.232) | 39.216*** (9.715) |
| Constant | 0.381 (4.606) | 68.764 (44.352) | 3.025 (12.416) | 86.557** (34.969) | 72.685*** (14.748) | 155.321** (64.203) |
| Observations | 214 | 214 | 214 | 214 | 214 | 214 |
| R ² | 0.173 | 0.183 | 0.429 | 0.492 | 0.179 | 0.240 |
| Adjusted R ² | 0.149 | 0.160 | 0.413 | 0.478 | 0.156 | 0.218 |
| Residual Std. Error (df = 207) | 5.895 | 56.761 | 15.890 | 44.753 | 18.875 | 82.166 |
| F Statistic (df = 6; 207) | 7.202*** | 7.747*** | 25.971*** | 33.461*** | 7.537*** | 10.916*** |

Note:

*p**p***p<0.01

Industry - Employment and Wage Growth Models

| | <i>Dependent variable:</i> | | | | | |
|--------------------------------|----------------------------|--------------------------------|----------------|--------------------------|--------------------|----------------|
| | Employment Growth | Employment Growth (Rank) | Wage Growth | Wage Growth (Rank) | Both (Rescaled) | Both (Rank) |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| emplevel | -0.927* | -4.978 | 5.543*** | 11.936*** | 2.627 | 6.958 |
| | (0.546) | (5.548) | (1.606) | (4.565) | (1.848) | (8.074) |
| wagelevel | 0.055 | 0.220 | -1.276*** | -4.390*** | -0.910*** | -4.171*** |
| | (0.051) | (0.519) | (0.151) | (0.427) | (0.174) | (0.755) |
| GERD_PCT_GDP | 0.901* | 10.139** | 1.350 | 6.551 | 2.812* | 16.690** |
| | (0.482) | (4.842) | (1.419) | (3.983) | (1.633) | (7.045) |
| GVA_IND_SHARE | 0.006 | -0.088 | 0.361** | 1.526*** | 0.300* | 1.438* |
| | (0.053) | (0.529) | (0.157) | (0.435) | (0.181) | (0.770) |
| SHARE_HIGH_EDUC | -0.208*** | -2.042*** | 0.228 | -0.498 | -0.219 | -2.540*** |
| | (0.064) | (0.642) | (0.189) | (0.528) | (0.218) | (0.935) |
| EQI | 0.105 | 6.771 | 5.385** | 32.809*** | 4.491** | 39.580*** |
| | (0.640) | (6.369) | (1.884) | (5.240) | (2.169) | (9.269) |
| REL + COMP (RS) | 0.195*** | | 0.011 | | 0.386*** | |
| | (0.031) | | (0.091) | | (0.105) | |
| REL + COMP (Rank) | | 0.439*** | | 0.167** | | 0.606*** |
| | | (0.090) | | (0.074) | | (0.131) |
| Constant | -1.364 | 124.468*** | 2.924 | 107.743*** | 69.241*** | 232.210*** |
| | (4.237) | (43.608) | (12.472) | (35.877) | (14.354) | (63.457) |
| Observations | 214 | 214 | 214 | 214 | 214 | 214 |
| R ² | 0.306 | 0.268 | 0.430 | 0.505 | 0.230 | 0.312 |
| Adjusted R ² | 0.283 | 0.243 | 0.410 | 0.488 | 0.203 | 0.289 |
| Residual Std. Error (df = 206) | 5.411 | 53.866 | 15.928 | 44.316 | 18.331 | 78.384 |
| F Statistic (df = 7; 206) | 12.985*** | 10.780*** | 22.157*** | 29.976*** | 8.770*** | 13.347*** |

Note:

*p**p***p<0.01

MEASURING STRUCTURAL TRAPS WITH TECHNOLOGY DATA (REGPAT)

| tech | compTCI | |
|------|---|--------|
| 342 | Digital communication | 1.272 |
| 257 | Telecommunications | 1.115 |
| 1027 | Computer technology | 1.099 |
| 1406 | IT methods for management | 0.790 |
| 1366 | Audio-visual technology | 0.775 |
| 721 | Optics | 0.512 |
| 1037 | Pharmaceuticals | 0.481 |
| 338 | Biotechnology | 0.443 |
| 483 | Measurement | 0.325 |
| 941 | Basic communication processes | 0.298 |
| 115 | Control | 0.261 |
| 1317 | Organic fine chemistry | 0.244 |
| 156 | Food chemistry | 0.198 |
| 477 | Micro-structural and nano-technology | 0.174 |
| 766 | Semiconductors | 0.131 |
| 355 | Medical technology | 0.096 |
| 1074 | Environmental technology | 0.017 |
| 1153 | Chemical engineering | -0.125 |
| 649 | Materials, metallurgy | -0.143 |
| 1236 | Electrical machinery, apparatus, energy | -0.145 |
| 1039 | Green technologies | -0.157 |
| 39 | Macromolecular chemistry, polymers | -0.192 |
| 78 | Basic materials chemistry | -0.207 |
| 404 | Textile and paper machines | -0.312 |
| 824 | Civil engineering | -0.377 |
| 373 | Furniture, games | -0.400 |
| 703 | Thermal processes and apparatus | -0.401 |
| 26 | Surface technology, coating | -0.496 |
| 360 | Other special machines | -0.500 |
| 1345 | Engines, pumps, turbines | -0.506 |
| 1380 | Handling | -0.546 |
| 931 | Transport | -0.593 |
| 1208 | Other consumer goods | -0.639 |
| 758 | Mechanical elements | -0.704 |
| 167 | Machine tools | -0.787 |

Tech Complexity Rankings (2011)

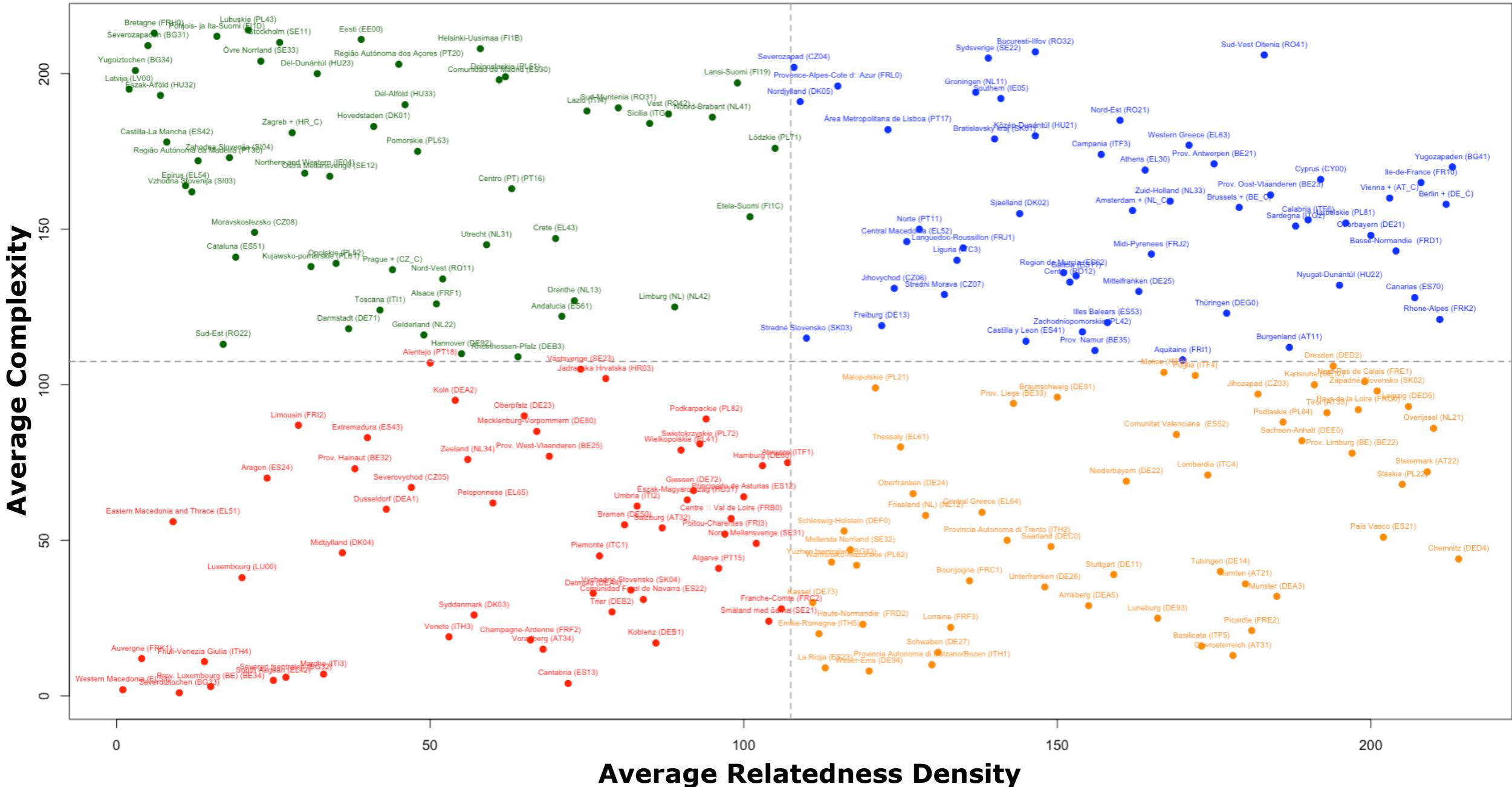
DATA:

- REGPAT, August 2023 version. Source of data: Organisation for Economic Co-operation and Development (OECD).

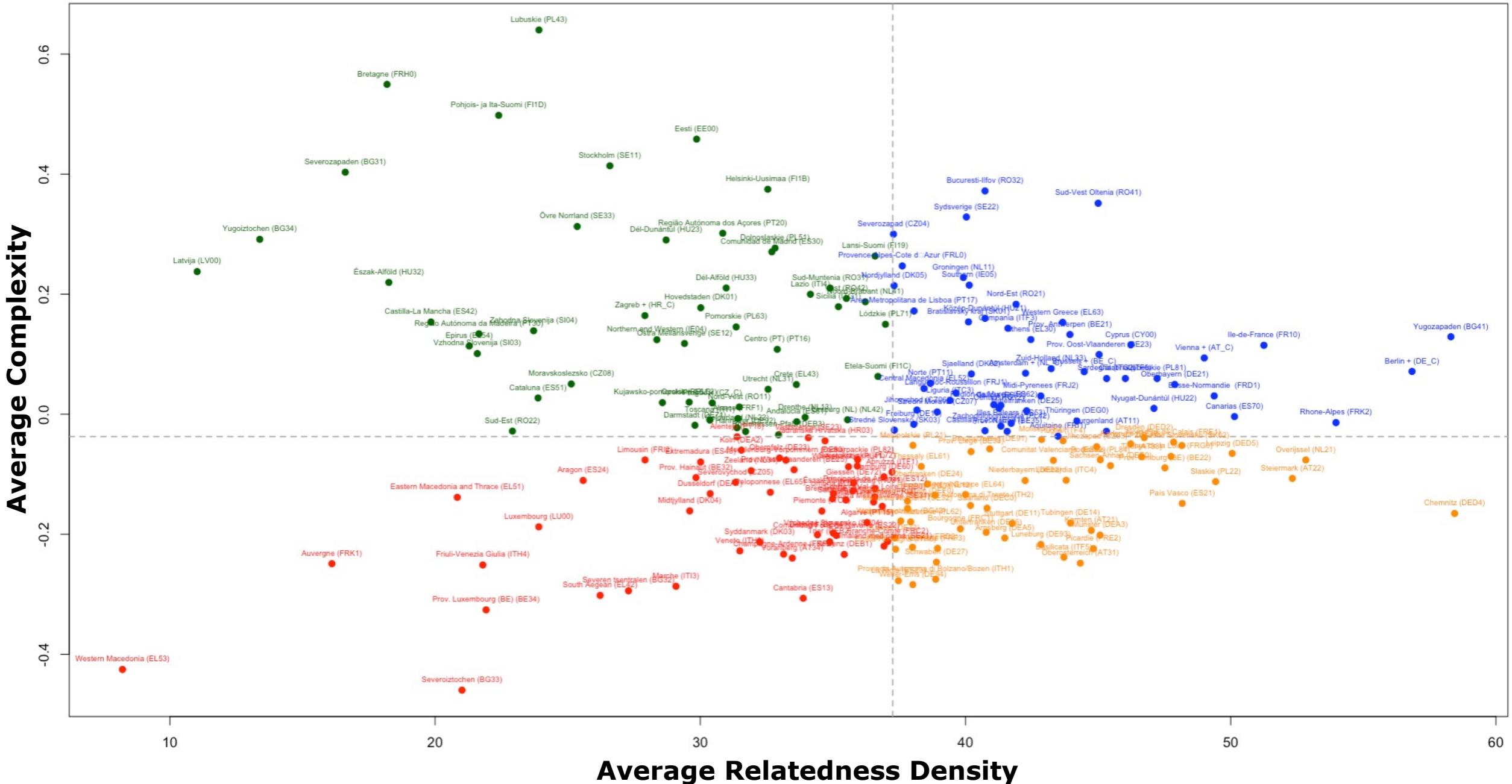
METHODOLOGICAL NOTE:

- Complexity scores are computed following the eigenvector reformulation. See Hidalgo & Hausman (2009) and for a more recent discussion of economic complexity indicators Balland et al. (2022).

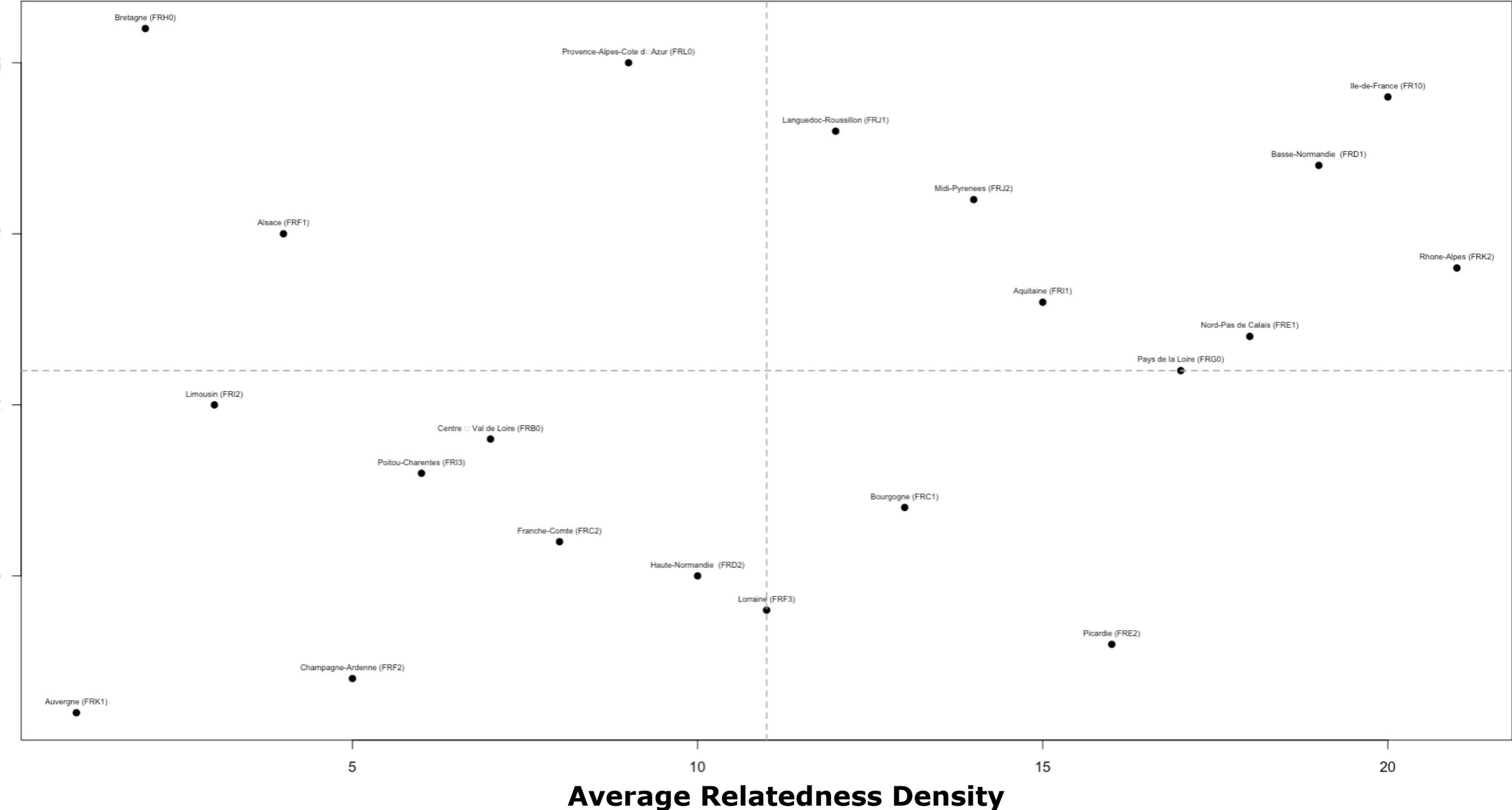
Complexity Loops & Structural Traps – Technologies (rank)



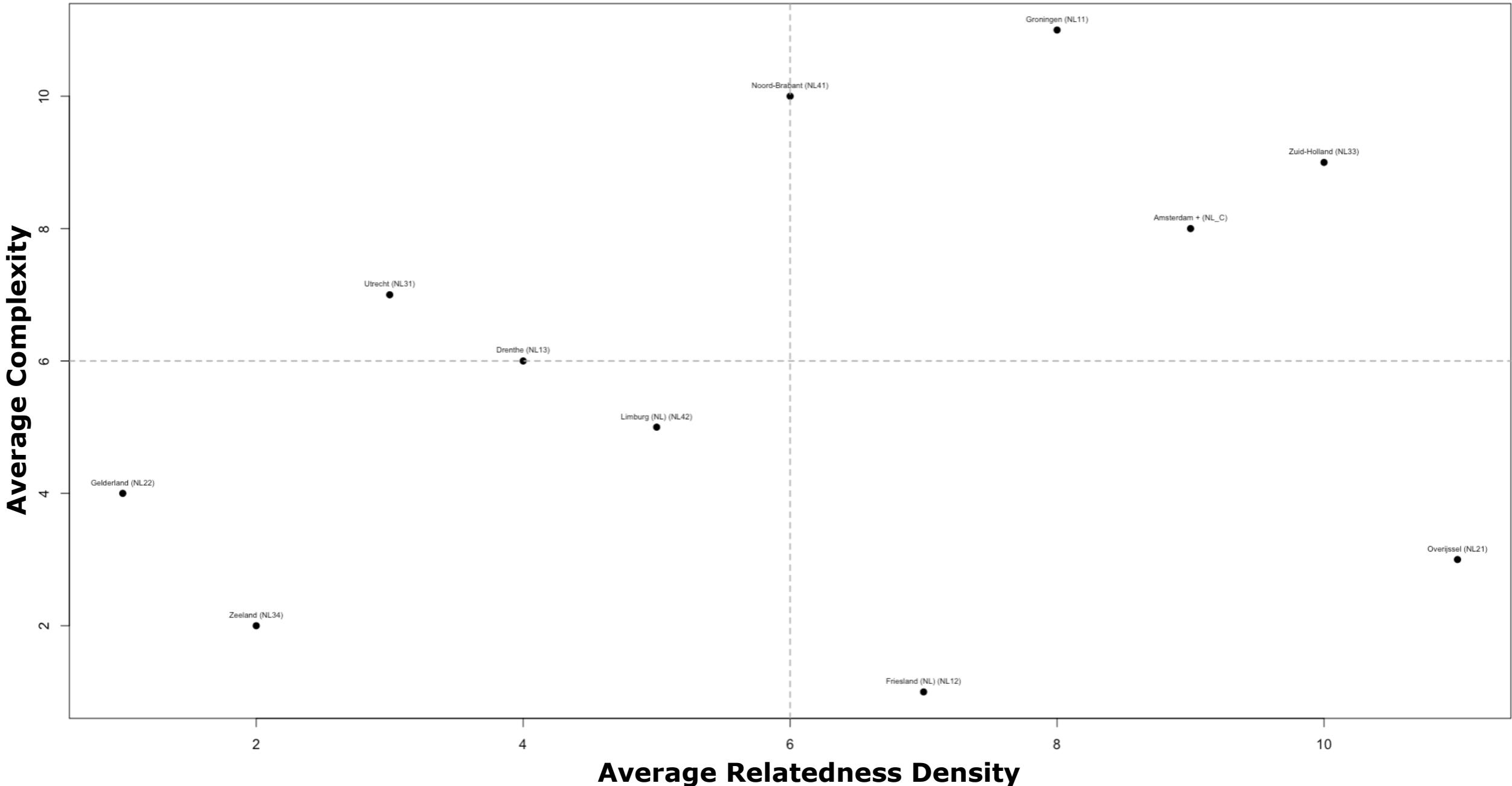
Complexity Loops & Structural Traps – Technologies (values)



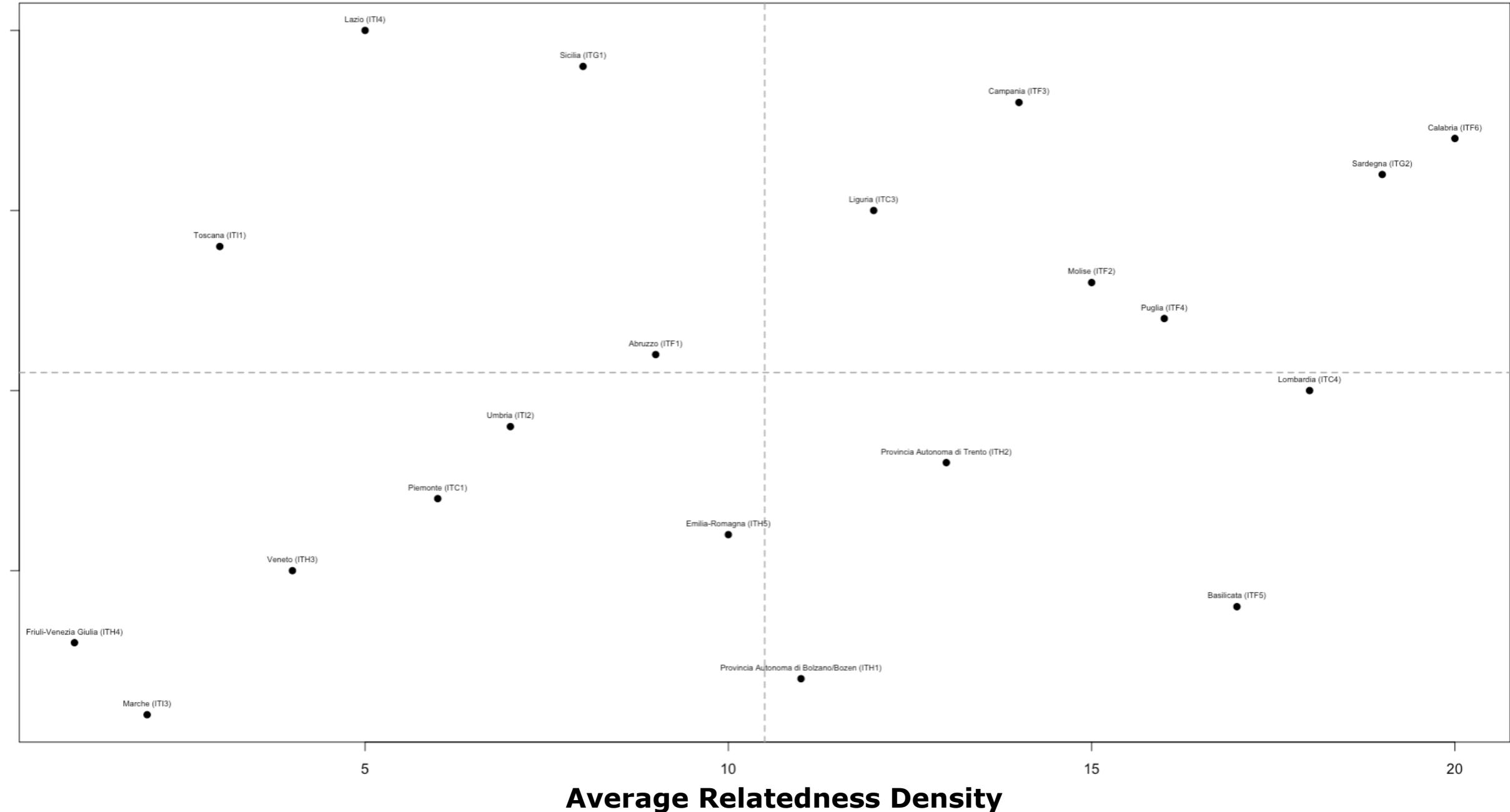
Complexity Loops & Structural Traps for France – Techs (rank)



Complexity Loops & Structural Traps for the NL – Techs (rank)

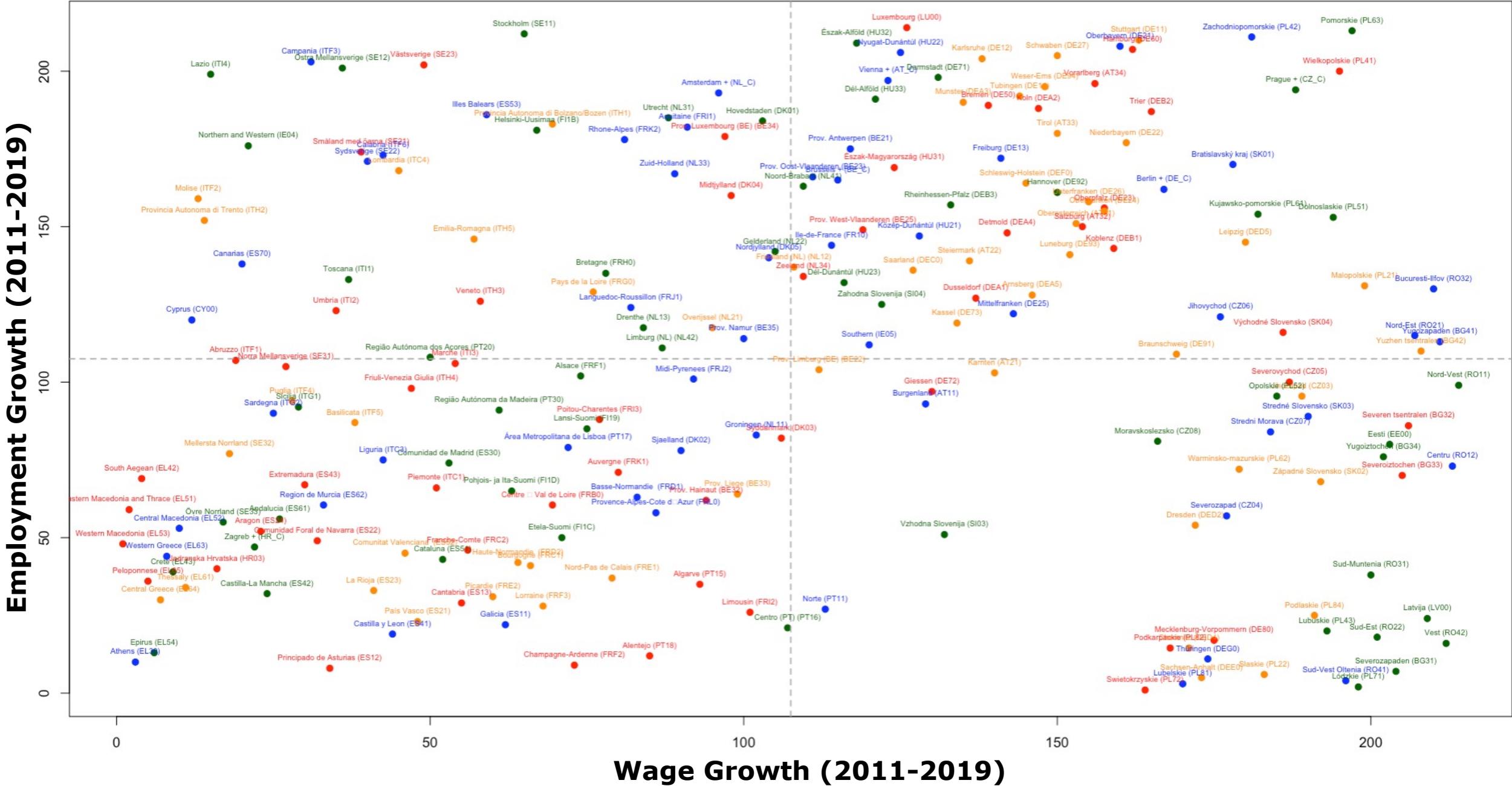


Complexity Loops & Structural Traps for Italy – Techs(rank)



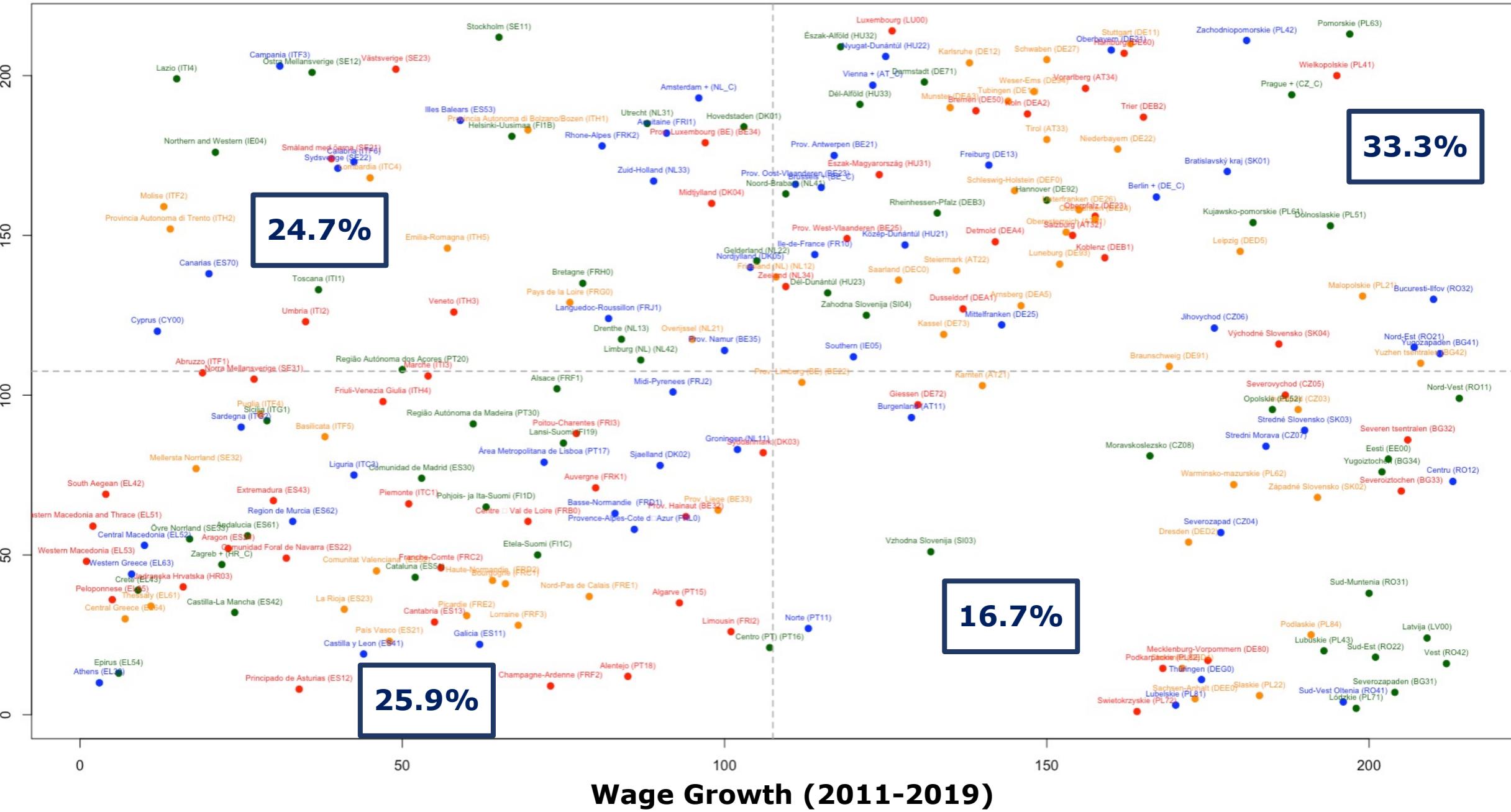
**CAN (TECHNOLOGY)
STRUCTURAL TRAPS
EXPLAIN REGIONAL
DEVELOPMENT?**

Complexity Loop, Structural Traps and Employment Dynamics



Regions in complexity loops → employment + wage growth

Employment Growth (2011-2019)



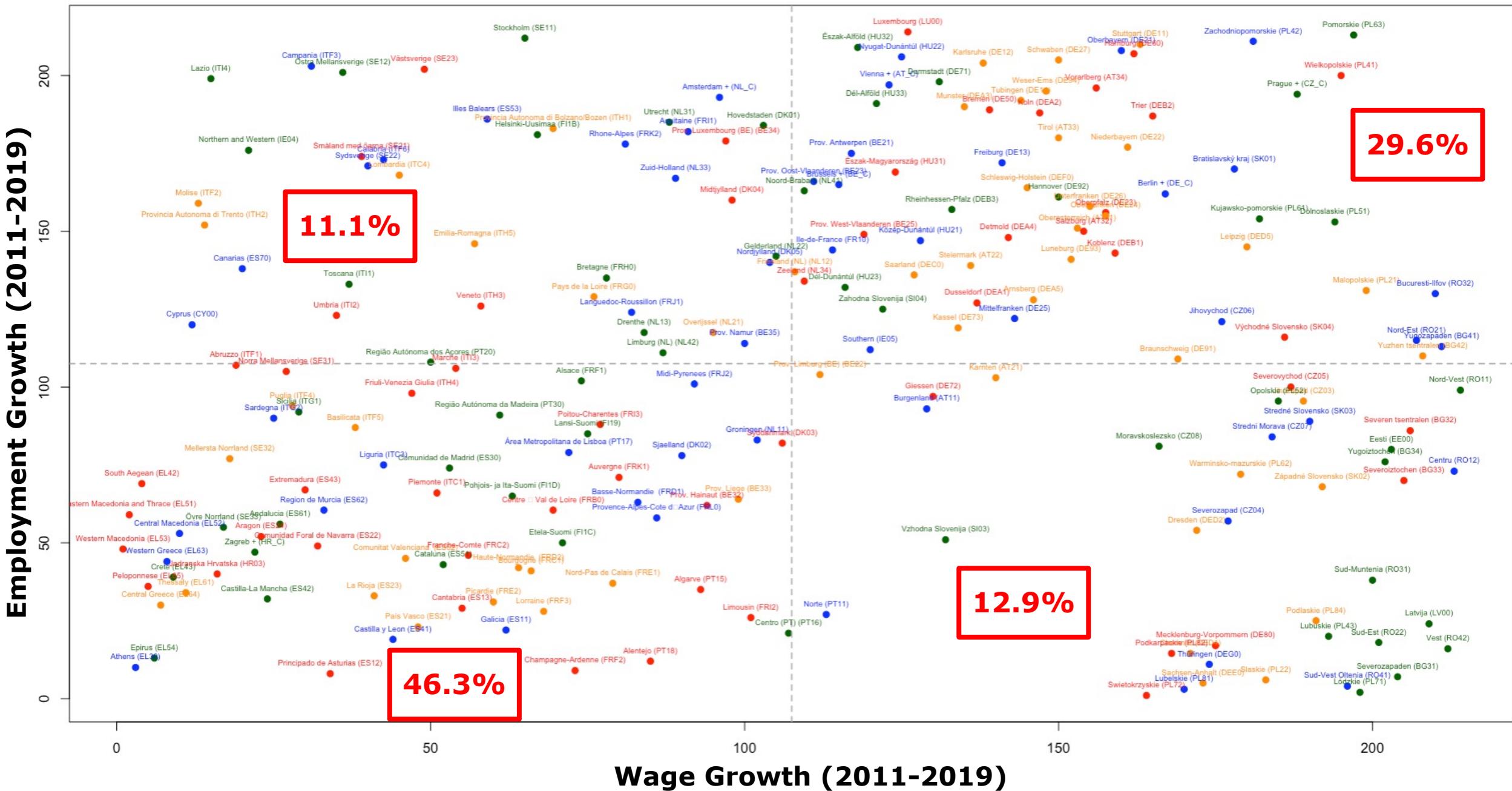
24.7%

25.9%

16.7%

33.3%

Regions in structural traps → employment decline



Employment Dynamics Summary Per Group – Technologies

| | E+W+ | E+W- | E-W+ | E-W- | E+ | E- | W+ | W- |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|
| blue | 33.33 | 24.07 | 16.67 | 25.93 | 57.41 | 42.59 | 50.00 | 50.00 |
| darkgreen | 22.64 | 24.53 | 24.53 | 28.30 | 47.17 | 52.83 | 47.17 | 52.83 |
| darkorange | 41.51 | 13.21 | 18.87 | 26.42 | 54.72 | 45.28 | 60.38 | 39.62 |
| red | 29.63 | 11.11 | 12.96 | 46.30 | 40.74 | 59.26 | 42.59 | 57.41 |

Technology - Employment and Wage Growth Models

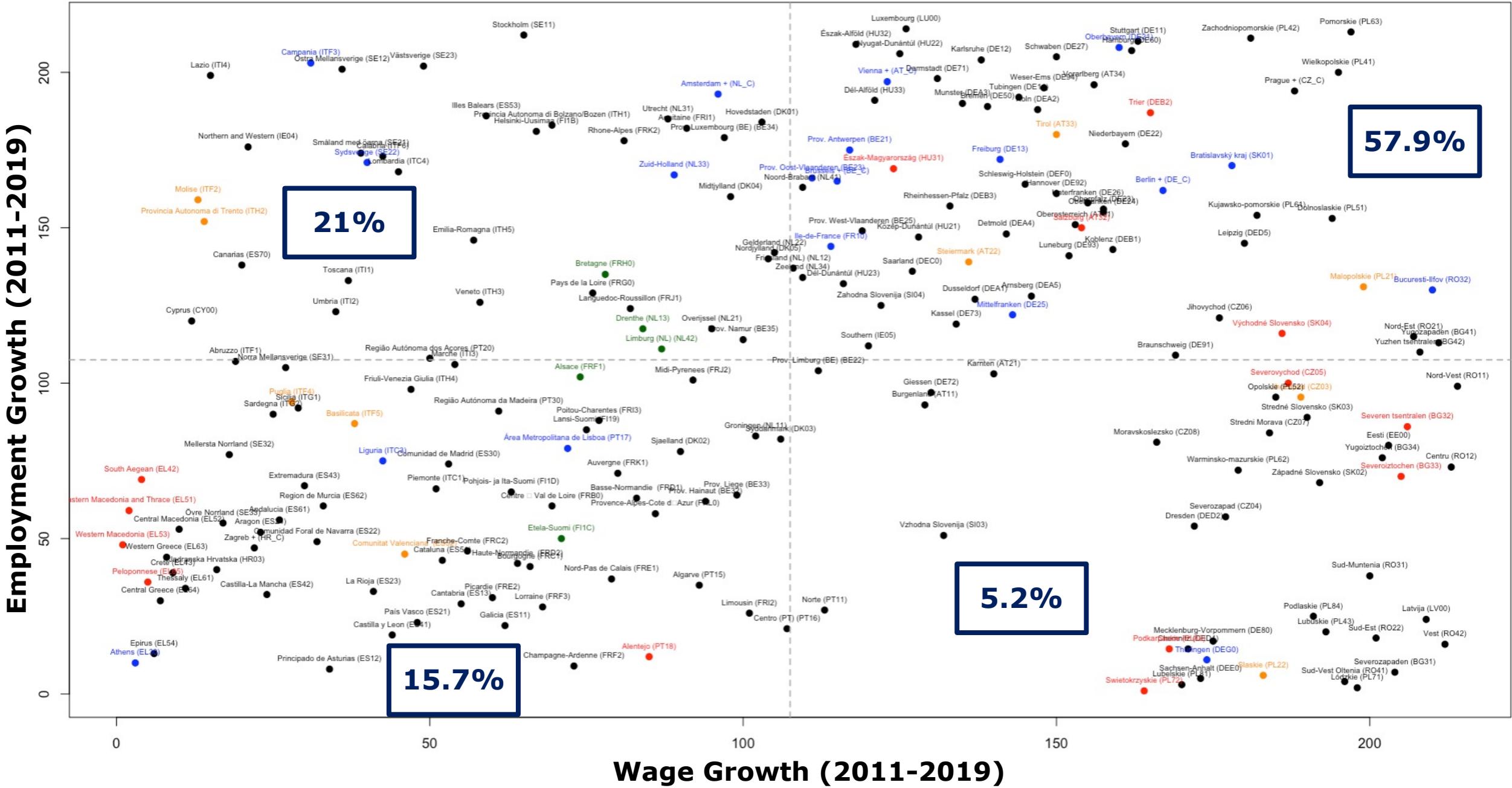
| | <i>Dependent variable:</i> | | | | | |
|--------------------------------|----------------------------|--------------------------------|----------------------|--------------------------|-----------------------|-----------------------|
| | Employment Growth | Employment Growth (Rank) | Wage Growth | Wage Growth (Rank) | Both (Rescaled) | Both (Rank) |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| emplevel | -0.091 (0.599) | 2.814 (5.688) | 5.346*** (1.613) | 14.254*** (4.478) | 4.082** (1.917) | 17.068** (8.224) |
| wagelevel | 0.123** (0.056) | 0.927* (0.533) | -1.256*** (0.150) | -4.082*** (0.419) | -0.763*** (0.179) | -3.155*** (0.770) |
| GERD_PCT_GDP | 1.487*** (0.523) | 15.126*** (5.053) | 1.253 (1.409) | 7.952** (3.978) | 3.865** (1.675) | 23.077*** (7.305) |
| GVA_IND_SHARE | -0.027 (0.059) | -0.179 (0.562) | 0.372** (0.158) | 1.529*** (0.442) | 0.245 (0.187) | 1.350* (0.813) |
| SHARE_HIGH_EDUC | -0.099 (0.069) | -1.237* (0.662) | 0.218 (0.185) | -0.255 (0.521) | -0.018 (0.219) | -1.493 (0.956) |
| EQI | 0.229 (0.699) | 6.939 (6.771) | 5.405*** (1.882) | 33.315*** (5.330) | 4.747** (2.237) | 40.255*** (9.789) |
| REL + COMP (RS) | -0.003 (0.030) | | 0.048 (0.082) | | 0.033 (0.097) | |
| REL + COMP (Rank) | | 0.037 (0.069) | | 0.052 (0.055) | | 0.090 (0.100) |
| Constant | 0.465 (4.719) | 69.132 (44.433) | 1.478 (12.711) | 87.074** (34.980) | 71.615*** (15.107) | 156.205** (64.242) |
| Observations | 214 | 214 | 214 | 214 | 214 | 214 |
| R ² | 0.173 | 0.185 | 0.430 | 0.495 | 0.180 | 0.243 |
| Adjusted R ² | 0.145 | 0.157 | 0.411 | 0.477 | 0.152 | 0.218 |
| Residual Std. Error (df = 206) | 5.909 | 56.859 | 15.915 | 44.761 | 18.915 | 82.206 |
| F Statistic (df = 7; 206) | 6.145*** | 6.659*** | 22.240*** | 28.802*** | 6.450*** | 9.462*** |

Note:

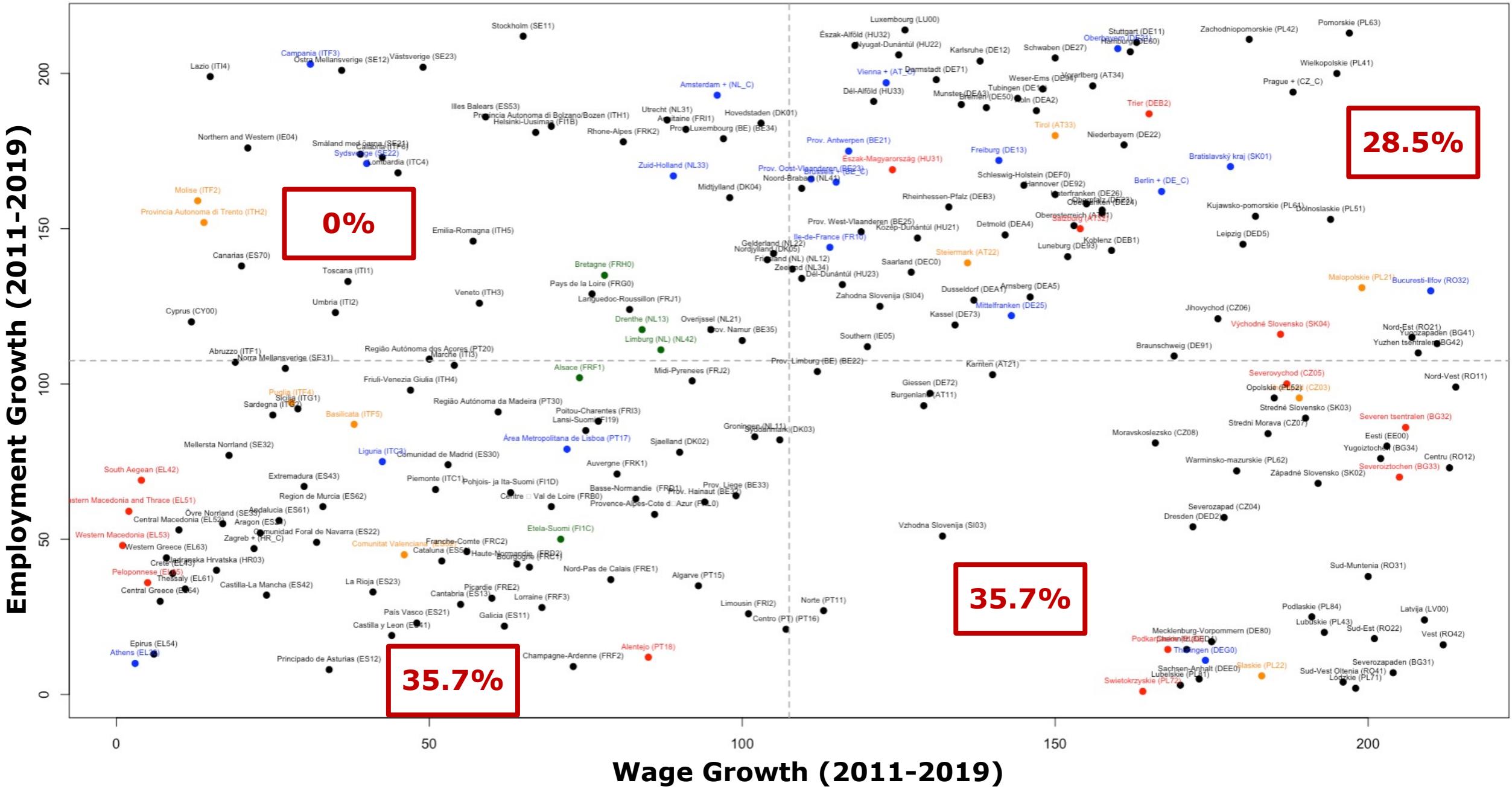
*p **p ***p < 0.01

COMBINING INDUSTRY AND TECHNOLOGY DATA

Combining industry and technology structures



Combining industry and technology structures



Structural Traps and Employment Dynamics – Industries & Techs

| | E+W+ | E+W- | E-W+ | E-W- | E+ | E- | W+ | W- |
|------------|-------|-------|-------|-------|-------|-------|-------|--------|
| blue | 57.89 | 21.05 | 5.26 | 15.79 | 78.95 | 21.05 | 63.16 | 36.84 |
| darkgreen | 0.00 | 60.00 | 0.00 | 40.00 | 60.00 | 40.00 | 0.00 | 100.00 |
| darkorange | 30.00 | 20.00 | 20.00 | 30.00 | 50.00 | 50.00 | 50.00 | 50.00 |
| red | 28.57 | 0.00 | 35.71 | 35.71 | 28.57 | 71.43 | 64.29 | 35.71 |

TRANSITIONING IN/OUT OF STRUCTURAL TRAPS

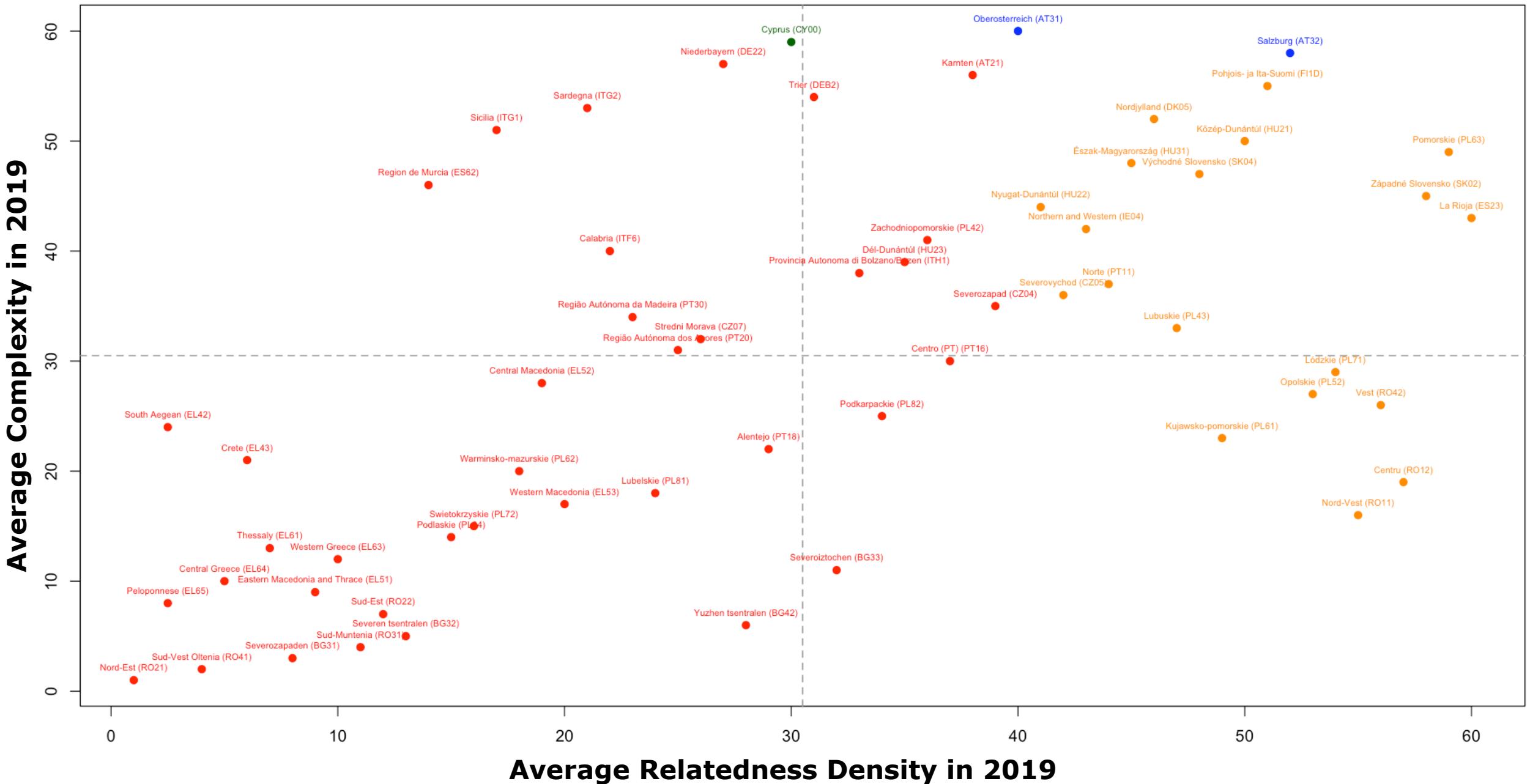
Structural traps transition matrix for industries

| | blue | darkgreen | darkorange | red |
|------------|------|-----------|------------|-----|
| blue | 46 | 12 | 1 | 1 |
| darkgreen | 5 | 36 | 1 | 5 |
| darkorange | 5 | 0 | 33 | 9 |
| red | 2 | 1 | 19 | 38 |

Structural traps transition matrix for industries (%)

| | blue | darkgreen | darkorange | red |
|------------|-------|-----------|------------|-------|
| blue | 76.67 | 20.00 | 1.67 | 1.67 |
| darkgreen | 10.64 | 76.60 | 2.13 | 10.64 |
| darkorange | 10.64 | 0.00 | 70.21 | 19.15 |
| red | 3.33 | 1.67 | 31.67 | 63.33 |

Structural Traps Dynamics 2011-19 for Industries (rank)



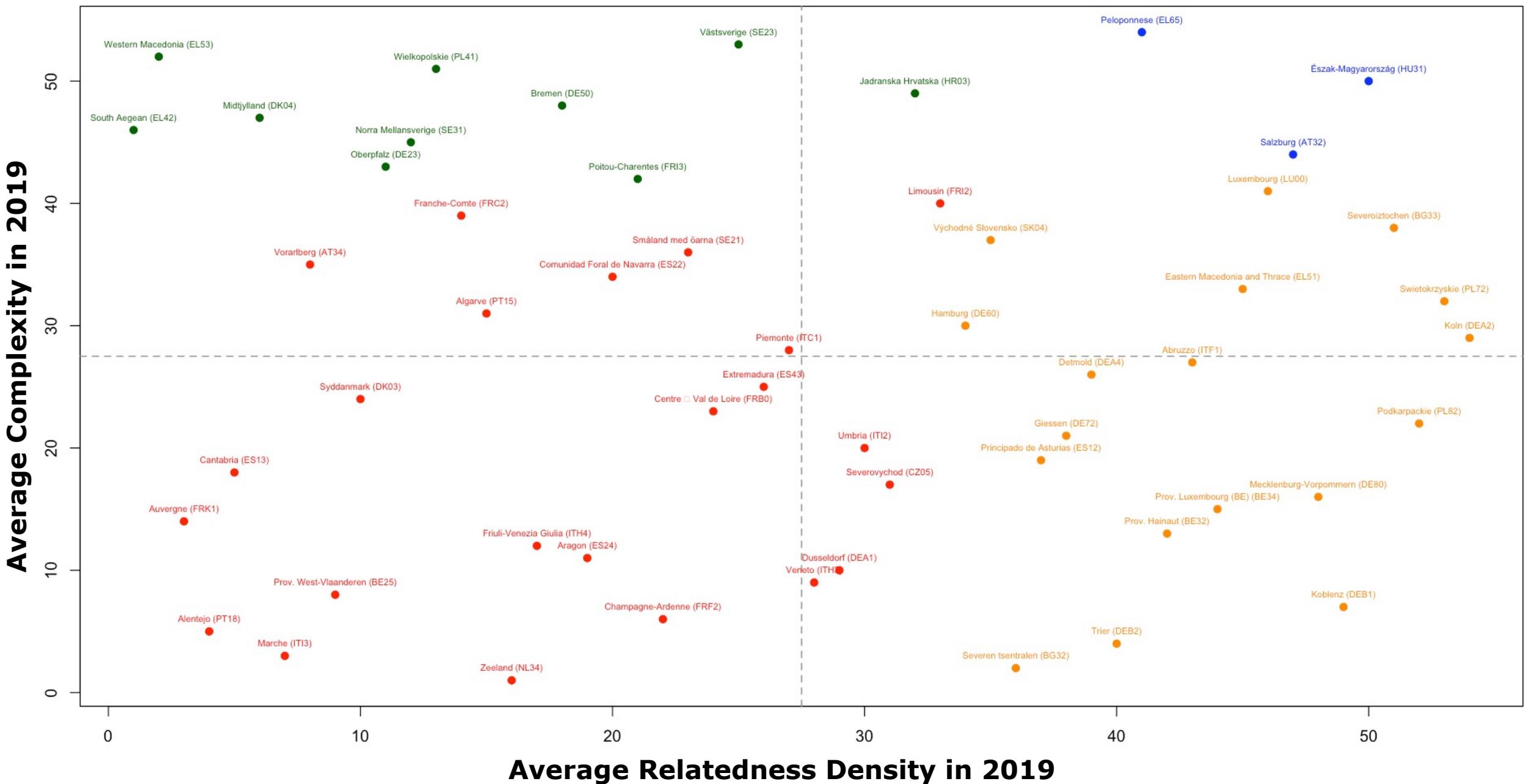
Structural traps transition matrix for technologies

| ▲ blue | blue | darkgreen | darkorange | red |
|------------|------|-----------|------------|-----|
| blue | 22 | 16 | 11 | 5 |
| darkgreen | 14 | 26 | 5 | 8 |
| darkorange | 10 | 2 | 26 | 15 |
| red | 3 | 10 | 18 | 23 |

Structural traps transition matrix for technologies (%)

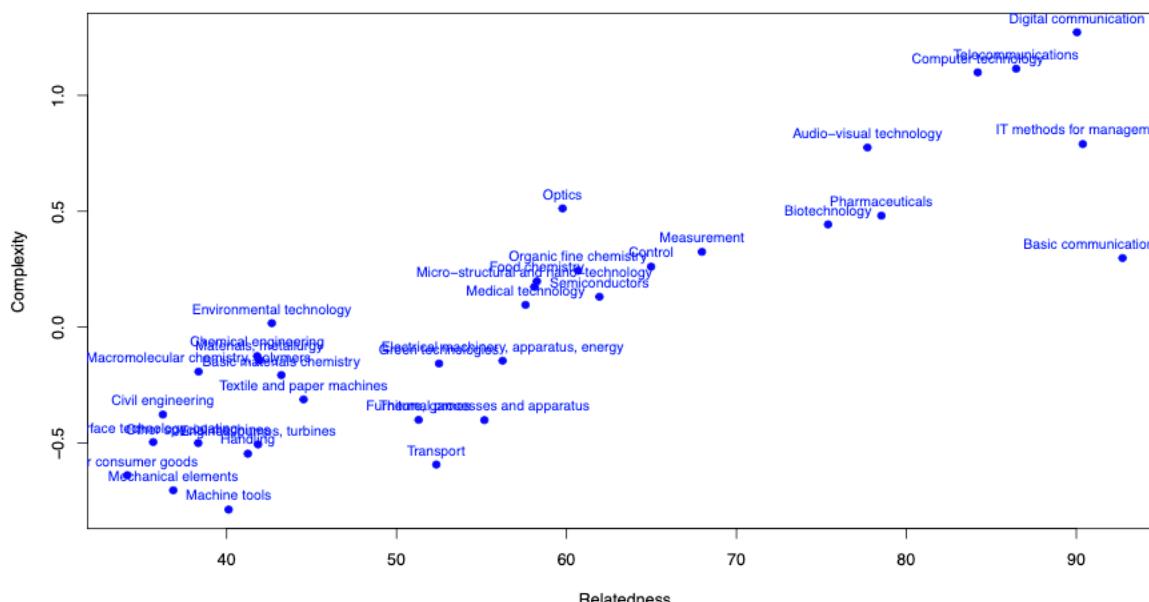
| | blue | darkgreen | darkorange | red |
|-------------------|-------------|------------------|-------------------|------------|
| blue | 40.74 | 29.63 | 20.37 | 9.26 |
| darkgreen | 26.42 | 49.06 | 9.43 | 15.09 |
| darkorange | 18.87 | 3.77 | 49.06 | 28.30 |
| red | 5.56 | 18.52 | 33.33 | 42.59 |

Structural Traps Dynamics 2011-19 for Technologies (rank)

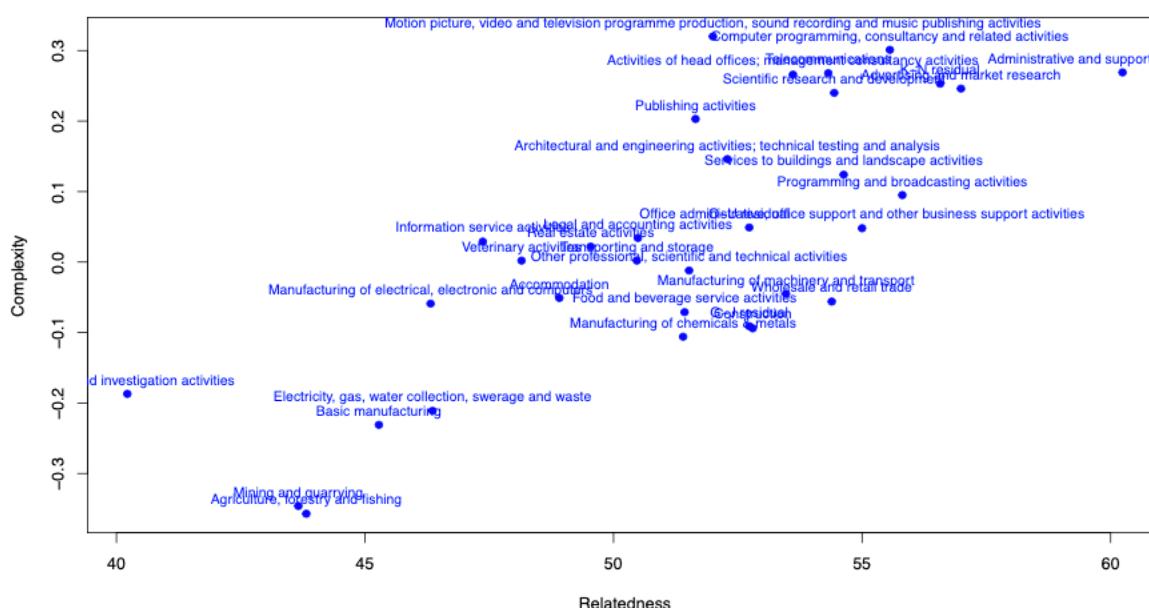


**ESCAPING STRUCTURAL
TRAPS BY PRIORITIZING
THE RIGHT TECH/IND
SPECIALIZATIONS**

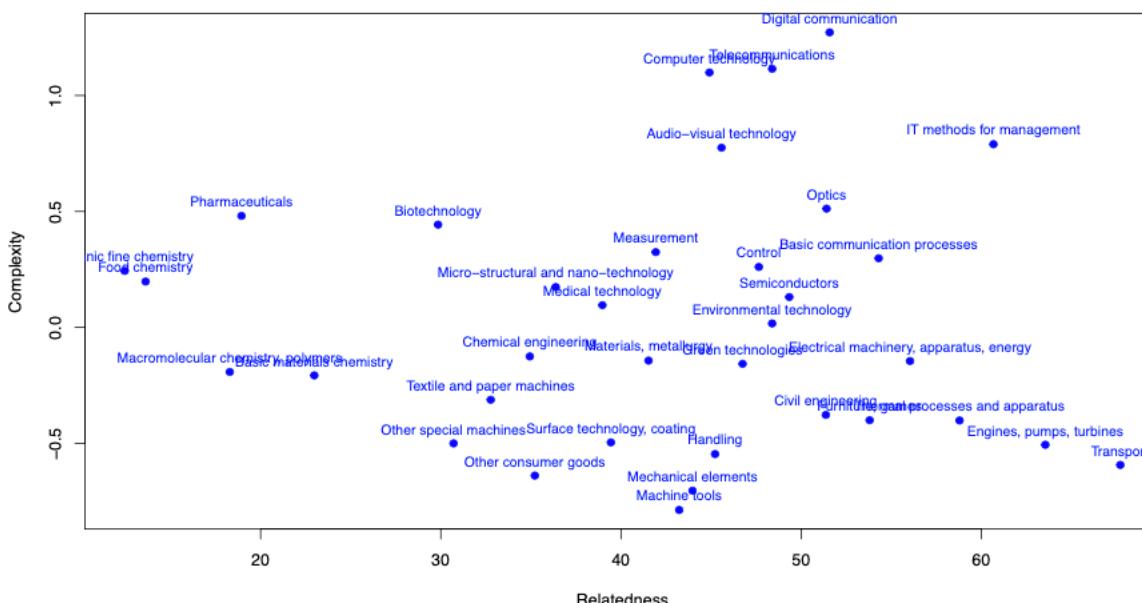
Berlin + (DE_C) – Patents [cor = 0.884]



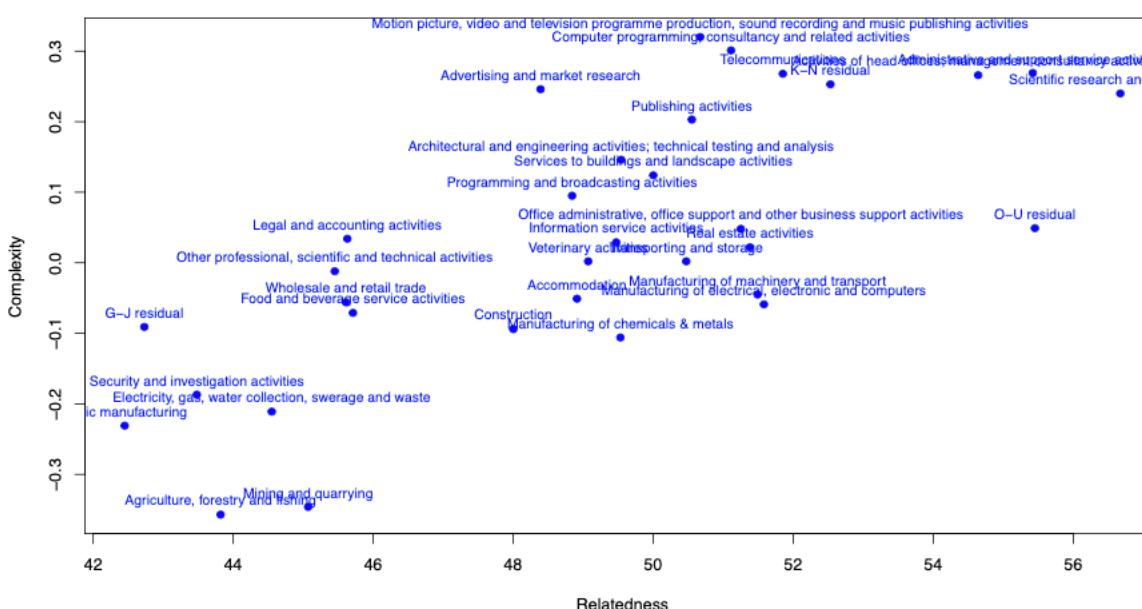
Berlin + (DE_C) – Industries [cor = 0.764]

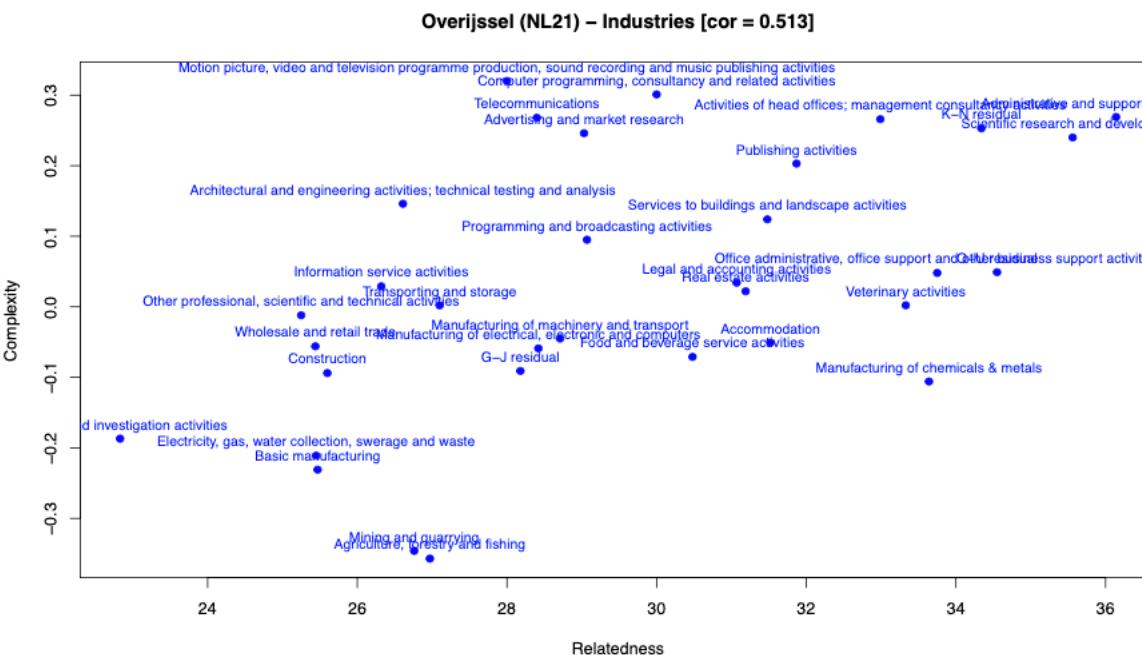
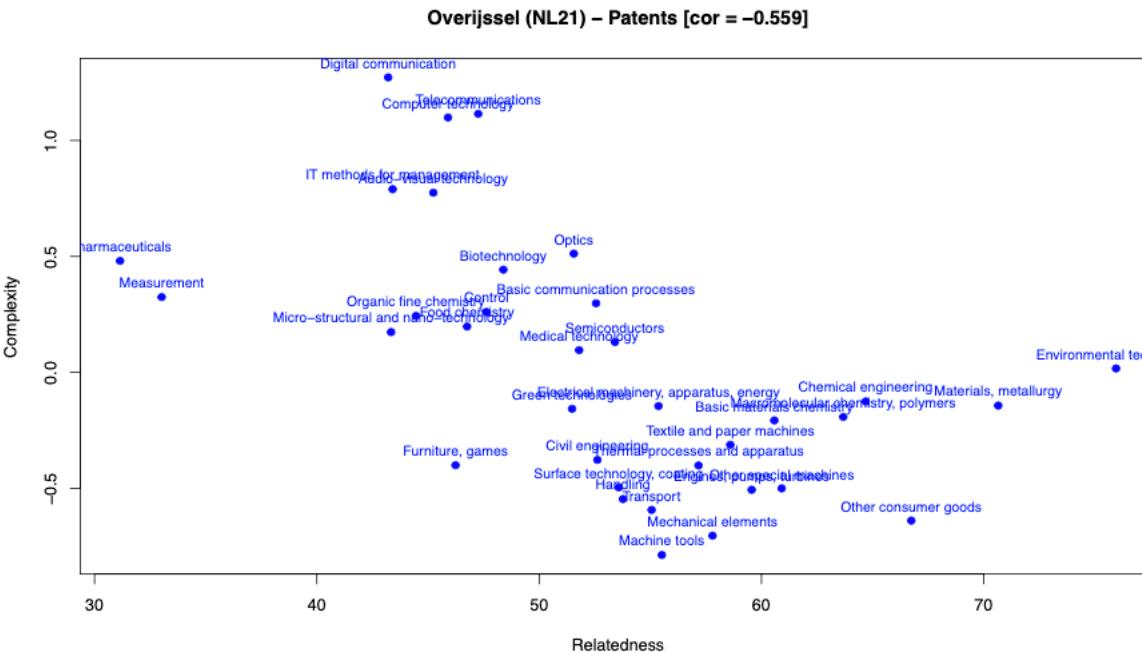


Mittelfranken (DE25) – Patents [cor = -0.017]

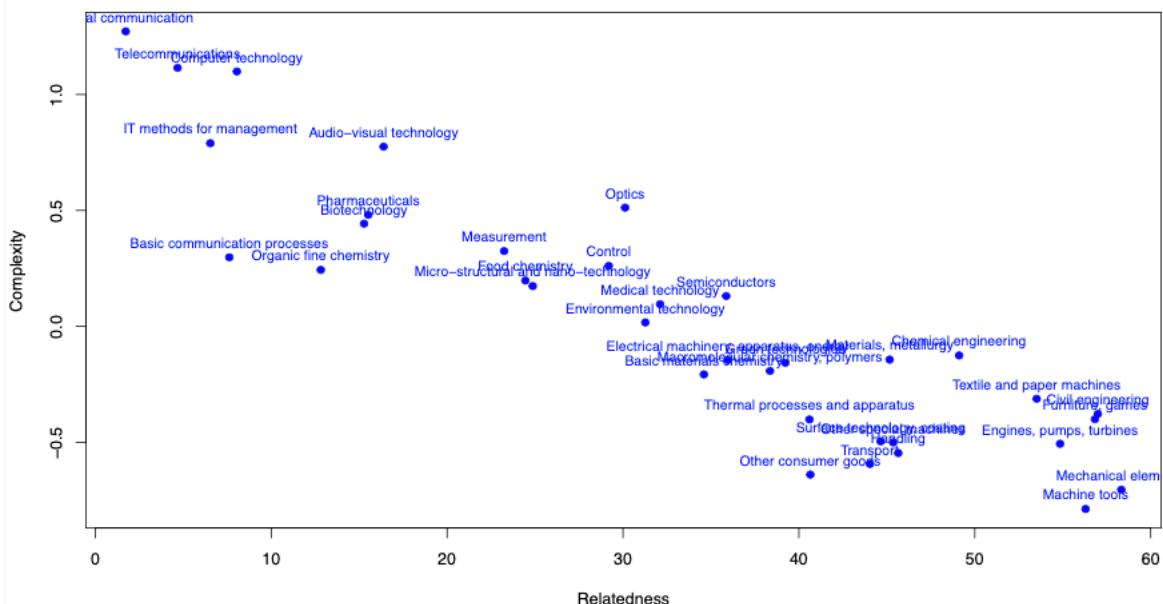


Mittelfranken (DE25) – Industries [cor = 0.724]

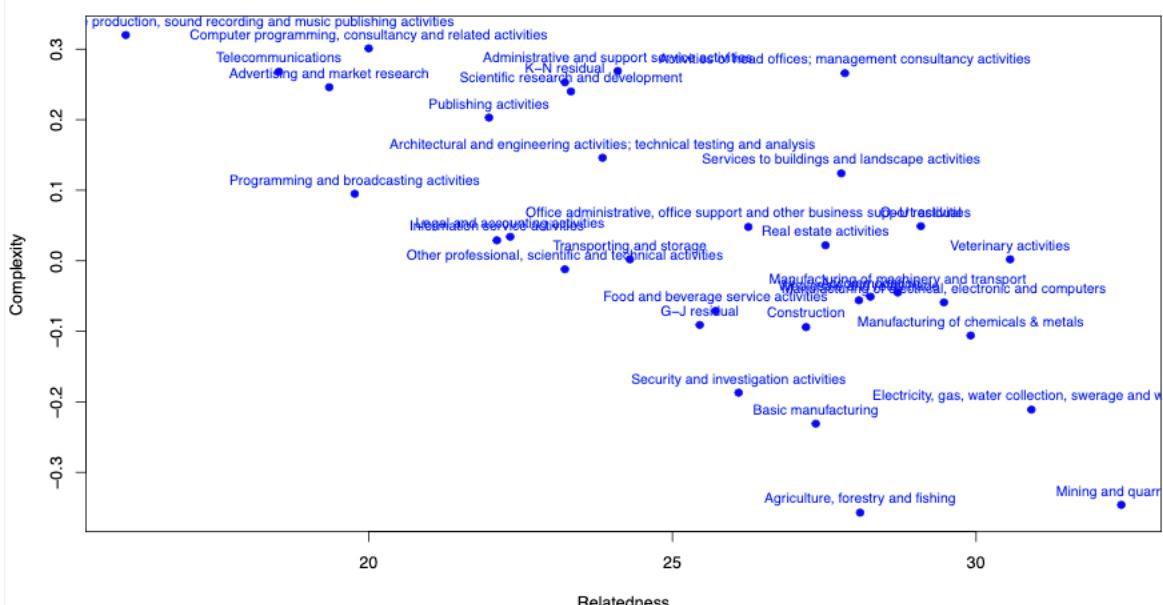




Champagne-Ardenne (FRF2) – Patents [cor = -0.904]



Champagne-Ardenne (FRF2) – Industries [cor = -0.702]



THANKS!

APPENDIX

DEVELOPMENT TRAPS (DT1)

