Appendix to:

Cluster Presence and Economic Performance:

A New Look Based on European Data

Table A1. Allocations of 4-digit NACE industries to cluster categories

| CLUSTER                              | NACE CODES |
|--------------------------------------|------------|
| Aerospace Vehicles and Defense       | 30.30      |
| Agricultural Inputs and Services     | 01.61, 01.62, 01.63, 01.64, 20.15 |
| Apparel                              | 14.11, 14.12, 14.13, 14.14, 14.19, 14.20 |
| Appliances                           | 27.51, 27.52 |
| Automotive                           | 24.53, 24.54, 28.13, 29.10, 29.20, 29.31, 29.32, 30.40 |
| Biopharmaceuticals                   | 21.10, 21.20 |
| Business Services                    | 49.32, 62.01, 62.02, 62.03, 62.09, 63.11, 64.20, 70.10, 70.22, 71.11, 71.12, 71.20, 74.30, 74.90, 77.12, 77.40, 78.10, 78.30, 81.10, 82.20, 82.30 |
| Coal Mining                          | 05.10, 05.20, 09.90 |
| Communications Equipment and Services| 26.30, 61.20, 61.30, 61.90 |
| Construction Products and Services   | 23.14, 23.51, 23.52, 23.61, 23.62, 23.64, 23.65, 23.70, 23.99, 24.21, 24.25, 25.30, 35.30, 42.12, 42.22, 42.91 |
| Distribution and Electronic Commerce | 46.11, 46.12, 46.13, 46.14, 46.15, 46.16, 46.17, 46.18, 46.19, 46.21, 46.22, 46.23, 46.24, 46.31, 46.32, 46.34, 46.35, 46.38, 46.41, 46.42, 46.43, 46.44, 46.45, 46.46, 46.47, 46.48, 46.49, 46.51, 46.52, 46.61, 46.62, 46.63, 46.64, 46.65, 46.66, 46.69, 47.91, 52.10, 77.31, 77.32, 77.33, 77.34, 77.35, 77.39, 82.92 |
| Downstream Chemical Products         | 20.12, 20.30, 20.41, 20.42, 20.51, 20.52, 20.53, 20.59 |
| Downstream Metal Products            | 25.29, 25.40, 25.71, 25.72, 25.91, 25.92, 25.99 |
| Education and Knowledge Creation     | 72.11, 72.19, 72.20, 85.41, 85.42, 85.52, 85.59, 85.60, 94.12 |
| Electric Power Generation and Transmission | 35.11, 35.12 |
| Environmental Services               | 36.00, 38.12, 38.22, 38.32 |
| Industry                              | Codes                        |
|---------------------------------------|------------------------------|
| Financial Services                    | 64.11, 64.30, 64.91, 64.92, 64.99, 66.11, 66.12, 66.19, 66.30 |
| Fishing and Fishing Products          | 03.11, 03.12, 10.20          |
| Food Processing and Manufacturing     | 10.31, 10.32, 10.39, 10.41, 10.42, 10.51, 10.52, 10.61, 10.62, 10.72, 10.73, 10.81, 10.82, 10.83, 10.84, 10.85, 10.86, 10.89, 10.91, 10.92, 11.01, 11.02, 11.03, 11.04, 11.05, 11.06, 11.07 |
| Footwear                              | 15.20, 15.11                 |
| Forestry                              | 02.10, 02.20, 02.30, 02.40    |
| Furniture                             | 31.01, 31.02, 31.03, 31.09    |
| Hospitality and Tourism              | 01.70, 55.10, 55.20, 55.30, 55.90, 77.21, 79.11, 79.12, 79.90, 91.02, 91.03, 91.04, 92.00, 93.11, 93.12, 93.19, 93.21, 93.29 |
| Information Technology and Analytical Instruments | 26.11, 26.12, 26.20, 26.40, 26.51, 26.52, 26.80, 58.21, 58.29, 26.70 |
| Insurance Services                    | 65.11, 65.12, 65.20, 66.21, 66.29 |
| Jewelry and Precious Metals           | 32.11, 32.12, 32.13           |
| Leather and Related Products          | 15.12                        |
| Lighting and Electrical Equipment     | 27.11, 27.12, 27.20, 27.31, 27.32, 27.33, 27.40, 27.90 |
| Livestock Processing                  | 10.11, 10.12, 10.13           |
| Marketing, Design, and Publishing     | 58.11, 58.12, 58.14, 58.19, 63.12, 63.91, 63.99, 70.21, 73.11, 73.12, 73.20, 74.10, 91.01 |
| Medical Devices                       | 26.60, 32.50                  |
| Metal Mining                          | 07.10, 07.21, 07.29           |
| Metalworking Technology               | 23.91, 25.11, 25.61, 25.62, 25.73, 25.94, 28.41, 28.91, 25.12 |
| Music and Sound Recording             | 59.20                        |
| Nonmetal Mining                       | 08.11, 08.12, 08.91, 08.92, 08.93, 08.99 |
| Oil and Gas Production and Transportation | 06.10, 06.20, 09.10, 19.10, 19.20, 49.50 |
| Paper and Packaging                   | 17.11, 17.12, 17.21, 17.22, 17.23, 17.24, 17.29 |
| Performing Arts                       | 90.01, 90.02, 90.03, 90.04    |
| Plastics                              | 20.16, 22.21, 22.22, 22.23, 22.29, 28.96 |
| Printing Services                     | 18.11, 18.12, 18.13, 18.14    |
| Production Technology and Heavy Machinery | 25.21, 28.11, 28.12, 28.14, 28.15, 28.21, 28.22, 28.24, 28.25, 28.29, 28.30, 28.49, 28.92, 28.93, 28.94, 28.95, 28.99, 30.20, 30.99 |
| Category                                      | Codes                              |
|----------------------------------------------|------------------------------------|
| Recreational and Small Electric Goods        | 28.23, 30.91, 30.92, 32.20, 32.30, 32.40, 32.91, 32.99 |
| Textile Manufacturing                         | 13.10, 13.20, 13.30, 13.91, 13.92, 13.93, 13.94, 13.95, 13.96, 13.99, 14.31, 14.39, 20.60 |
| Tobacco                                      | 12.00                              |
| Transportation and Logistics                 | 33.16, 51.10, 49.39, 49.41, 51.21, 51.22, 52.21, 52.23, 52.24, 52.29 |
| Upstream Chemical Products                   | 20.11, 20.13, 20.14, 20.17, 20.20 |
| Upstream Metal Manufacturing                 | 24.10, 24.31, 24.32, 24.33, 24.34, 24.41, 24.42, 24.43, 24.44, 24.45, 24.46, 24.51, 24.52, 25.50, 25.93 |
| Video Production and Distribution            | 18.20, 59.11, 59.12, 59.13         |
| Vulcanized and Fired Materials               | 22.11, 22.19, 23.11, 23.12, 23.13, 23.19, 23.20, 23.31, 23.32, 23.41, 23.43, 23.44, 23.49 |
| Water Transportation                         | 30.11, 30.12, 33.15, 50.10, 38.31, 50.20, 50.30, 50.40, 52.22 |
| Wood Products                                | 16.10, 16.21, 16.22, 16.23, 16.24, 16.29 |
Table A2: Regional clusters by cluster categories; Descriptive statistics

| Cluster                                | Size (Employment) | Specialization (LQ) | Wage level |
|----------------------------------------|-------------------|---------------------|------------|
|                                        | Average | Median | Max     | Median | Min | Max   | Median | Min   |
| Aerospace Vehicles and Defence          | 1405     | 205    | 19.44   | 0.21   | 0.00 | 120   | 207    | 37461 | 3001 |
| Agricultural Inputs and Services        | 422      | 165    | 7.35    | 0.77   | 0.01 | 78    | 314    | 24001 | 2812 |
| Apparel                                | 2821     | 613    | 14.70   | 0.32   | 0.01 | 55    | 1715   | 16560 | 1080 |
| Automotive                             | 9578     | 4146   | 9.71    | 0.54   | 0.00 | 63    | 334    | 30221 | 2245 |
| Biopharmaceuticals                      | 2117     | 1000   | 25.87   | 0.50   | 0.00 | 206   | 994    | 34518 | 2776 |
| Business Services                       | 32347    | 18620  | 2.42    | 0.73   | 0.13 | 76    | 738    | 25463 | 2431 |
| Coal Mining                            | 1199     | 37     | 64.02   | 0.04   | 0.00 | 137   | 540    | 25750 | 3595 |
| Communications Equipment and Services   | 2856     | 1606   | 5.96    | 0.62   | 0.03 | 106   | 727    | 32862 | 2337 |
| Construction Products and Services      | 4245     | 3128   | 4.53    | 1.12   | 0.08 | 58    | 649    | 29742 | 3498 |
| Distribution and Electronic Commerce    | 23283    | 15210  | 2.50    | 0.89   | 0.24 | 67    | 514    | 25123 | 2788 |
| Downstream Chemical Products            | 2100     | 1185   | 5.74    | 0.73   | 0.00 | 73    | 528    | 31322 | 2101 |
| Downstream Metal Products               | 2587     | 1582   | 8.67    | 0.77   | 0.04 | 57    | 116    | 26916 | 2687 |
| Education and Knowledge Creation        | 7246     | 2684   | 4.18    | 0.79   | 0.07 | 82    | 891    | 29285 | 3338 |
| Electric Power Generation and Transmission | 1528    | 1042   | 10.62   | 0.80   | 0.03 | 94    | 994    | 40776 | 2086 |
| Environmental Services                  | 2250     | 1635   | 4.43    | 0.94   | 0.08 | 50    | 215    | 26194 | 3352 |
| Financial Services                      | 4838     | 1637   | 7.22    | 0.64   | 0.08 | 80    | 382    | 35505 | 3105 |
| Fishing and Fishing Products            | 547      | 135    | 15.24   | 0.32   | 0.00 | 59    | 168    | 20471 | 1985 |
| Food Processing and Manufacturing       | 7245     | 5537   | 3.87    | 1.03   | 0.02 | 58    | 124    | 28138 | 2643 |
| Industry                                    | Sales   | Profit  | Return on Sales | Dividend Yield | Share Price | P/E Ratio | PS Ratio |
|--------------------------------------------|---------|---------|-----------------|----------------|-------------|-----------|----------|
| Footwear                                   | 1,185   | 192     | 29.28           | 0.24           | 0.00        | 125,904   | 19,014   | 1,784   |
| Forestry                                   | 1,034   | 494     | 9.88            | 0.61           | 0.00        | 85,405    | 22,411   | 2,048   |
| Furniture                                  | 3,079   | 1,844   | 11.54           | 0.74           | 0.03        | 60,442    | 19,947   | 2,014   |
| Hospitality and Tourism                    | 11,275  | 7,139   | 6.24            | 0.83           | 0.23        | 47,397    | 13,231   | 2,390   |
| Information Technology and Analytical Instruments | 4,145  | 2,287   | 8.05            | 0.65           | 0.03        | 76,086    | 32,031   | 2,422   |
| Insurance Services                         | 4,577   | 1,986   | 5.04            | 0.67           | 0.01        | 80,982    | 36,720   | 4,944   |
| Jewellery and Precious Metals              | 298     | 99      | 26.27           | 0.44           | 0.01        | 60,992    | 15,818   | 1,402   |
| Leather and Related Products               | 314     | 73      | 26.65           | 0.28           | 0.00        | 53,423    | 18,215   | 1,594   |
| Lighting and Electrical Equipment          | 3,679   | 2,305   | 5.18            | 0.77           | 0.01        | 77,419    | 28,591   | 3,152   |
| Livestock Processing                       | 3,070   | 2,196   | 8.42            | 0.83           | 0.06        | 58,209    | 20,639   | 2,414   |
| Marketing, Design, and Publishing          | 5,509   | 2,370   | 4.58            | 0.63           | 0.06        | 64,655    | 19,065   | 2,029   |
| Medical Devices                            | 1,700   | 927     | 7.67            | 0.66           | 0.02        | 65,578    | 24,120   | 1,965   |
| Metal Mining                               | 271     | 23      | 148.02          | 0.21           | 0.00        | 70,567    | 18,933   | 4,319   |
| Metalworking Technology                    | 8,439   | 5,988   | 3.69            | 0.88           | 0.03        | 59,361    | 26,746   | 3,089   |
| Music and Sound Recording                  | 118     | 30      | 6.75            | 0.35           | 0.00        | 70,062    | 19,066   | 854     |
| Non-metal Mining                           | 813     | 560     | 9.74            | 0.95           | 0.02        | 96,738    | 26,373   | 3,059   |
| Oil and Gas Production and Transportation   | 1,268   | 440     | 43.14           | 0.47           | 0.00        | 517,015   | 37,741   | 4,287   |
| Paper and Packaging                        | 2,201   | 1,670   | 8.63            | 0.91           | 0.00        | 60,503    | 28,919   | 2,172   |
| Performing Arts                            | 1,747   | 961     | 5.24            | 0.67           | 0.04        | 74,570    | 19,367   | 1,809   |
| Plastics                                   | 5,065   | 3,684   | 5.10            | 0.87           | 0.01        | 69,653    | 25,935   | 2,075   |
| Printing Services                          | 2,377   | 1,633   | 2.63            | 0.89           | 0.05        | 58,104    | 24,409   | 2,149   |
| Production Technology and Heavy Machinery  | 8,862   | 5,210   | 6.07            | 0.75           | 0.01        | 65,832    | 31,394   | 3,638   |
| Recreational and Small Electric Goods      | 1,511   | 861     | 11.47           | 0.71           | 0.03        | 58,899    | 23,504   | 1,936   |
| Industry                        | Total Value | Direct Value | Foreign Direct Investment | Total Direct Investment | Local Value | Local Indirect Value | Total Value |
|--------------------------------|-------------|--------------|---------------------------|-------------------------|-------------|----------------------|------------|
| Textile Manufacturing          | 2 720       | 1 196        | 10.44                     | 0.62                    | 66 350      | 21 659               | 2 526      |
| Tobacco                        | 295         | 135          | 32.92                     | 1.05                    | 94 419      | 34 571               | 2 364      |
| Appliances                     | 864         | 255          | 14.69                     | 0.42                    | 70 161      | 27 621               | 2 077      |
| Transportation and Logistics   | 17 759      | 13 071       | 2.71                      | 0.97                    | 57 894      | 21 452               | 2 596      |
| Upstream Chemical Products     | 1 169       | 545          | 17.39                     | 0.58                    | 96 136      | 38 690               | 3 189      |
| Upstream Metal Manufacturing   | 4 164       | 2 219        | 8.77                      | 0.71                    | 71 134      | 29 724               | 3 145      |
| Video Production and Distribution | 805     | 208          | 9.57                      | 0.37                    | 71 103      | 19 645               | 1 998      |
| Vulcanized and Fired Materials | 3 069       | 1 787        | 9.49                      | 0.73                    | 60 491      | 27 154               | 2 885      |
| Water Transportation           | 2 214       | 976          | 76.65                     | 0.50                    | 90 894      | 28 236               | 1 666      |
| Wood Products                  | 3 086       | 2 158        | 6.17                      | 0.84                    | 58 733      | 21 036               | 1 784      |
| Local Industries               | 232 807     | 174 176      | 1.40                      | 1.00                    | 49 442      | 16 925               | 2 951      |
Data processing and specifications

The underlying data on cluster presence includes employment and wages by detailed 4-digit industries in NUTS 2 regions in countries we analyse. In Croatia, Ireland, and Slovenia, each consisting of two NUTS 2 regions according to the official classification, the data available on NUTS 1 level (equivalent to the whole country) was much richer, so we opted to analyse these countries as single units. The data we used in all countries is the latest available, between 2011 and 2014.

The majority of the data comes from local statistical offices and is based on annual enterprise surveys, censuses, and registers (Structural Business Statistics, SBS). While usually this data provides the best industry detail and all the necessary indicators, it often does not cover some sectors of economy such as agriculture, financial services and some public services. To estimate values for those sectors, as well as for the three countries where enterprise statistics were missing (Czech Republic, Greece and the Netherlands), we used Eurostat’s Labour Force Survey data that has full coverage across Europe, though only using 3-digit industries. Where there was no 4-digit industry value, but some values on higher level of aggregation, we imputed the 4-digit numbers using the shares based on a) the same region in past years, b) regions in the same country, and c) based on all regions in Europe. A similar procedure was performed for countries where the data was available on a different classification from NACE revision 2.0 (most commonly older versions of NACE or national adaptations). In this paper we only use the latest available data and the only country not available using NACE revision 2.0 is Iceland.

Two key variables are number of employees in full-time equivalents and average wages per full-time equivalent. Full-time equivalents (FTE) are the best measure of labour input by cluster as it corrects for part-time work and seasonality patterns; however, it was not available universally. To make the numbers more comparable across regions and industries, we applied FTE adjustments to the countries that only supplied the data on number of employees (Austria, Czech Republic, Finland, Greece, Hungary, Italy, Portugal, and the United Kingdom). We obtained the coefficients using the national SBS data from Eurostat (where the number of employees and FTE was available per 4-digit industry, or sometimes on a more aggregate level). A similar procedure was applied to obtain the average wages: we

\[1\] We only did the estimation in case there was no data in any descendants of a given 2-digit code. E.g. the data for forestry industries was estimated in case there was not a single data point for any of the forestry industries in a given region/year.

\[2\] The wages are measured net of all social security contributions paid by employers. Including the social security contributions could in general change the relative performance of countries, however all of our models include regional or national fixed or random effects which capture these differences. Since the regional data from Eurostat only provides wages net of social security contributions we are using this measure throughout.
first deflated all numbers to adjust for inflation and then imputed the numbers for the countries using the 2-digit regional SBS and 4-digit national SBS data from Eurostat.\(^3\)

We also have access to a commercial firm-level database that has been used for the latest analysis done on behalf of the European Commission. This data has some benefits in terms of quality but is not freely available to other researchers. We have run the analysis on this data as well, with findings matching what we report in this paper. To make our results reproducible with the existing raw data we have decided to report here only the results of the analysis with the publicly available data.

**Additional predictors in section “Cluster portfolios and regional prosperity”**

All models in section “Cluster portfolios and regional prosperity” control for standard regional characteristics such as population size and area. After studying the non-random spatial patterns of regression residuals we also included a few additional controls: First, capital regions tend to do systematically better than other regions. Second, the data reveals a very strong spatial structure with similar signs and magnitudes in neighbouring regions. And third, the regions in Eastern Europe have consistently negative residuals (suggesting lower performance than expected from our model). The literature identifies social capital and institutions, broadly defined, as potent drivers of prosperity, and the measures on skill and trust included in our composite indicator of business environment quality might not pick the differences related to Eastern Europe’s past up sufficiently. We experimented with several ways of tackling this issue and settled on including indicators for capitals, and for the regions from the Eastern European countries, and a spatially lagged dependent variable to account for spatial autocorrelation.\(^4\)\(^5\)

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\(^3\) This imputation was done for Czech Republic, Germany, Greece, Italy, Netherlands, Norway, Poland and United Kingdom. In Spain we did this for all non-manufacturing industries. To check robustness, we also repeated the relevant analyses using only the data for countries where we did no wage imputations and the results are qualitatively similar, they usually show slightly stronger effects of localisation. Using the same technique for the countries where the data was actually available on regional 4-digit level, we checked that the correlation between the estimated data and the actual figures is 0.85.

\(^4\) We conducted a series of Lagrange Multiplier diagnostic tests that all showed the same conclusion: spatially correlated errors, but no spatially lagged omitted variable. We used both the adjacency matrix accounting only for a region’s neighbours, and an inverse-distance-weighted dependence matrix to achieve similar results. We only report the inverse-distance based results.

\(^5\) For robustness we have also done all of these models using the HLM approach while also including the country-level random effect. The results for all the key coefficients remained similar with cluster
Additional considerations on the relationship between localization and business environment

In model 6 we then test whether the specialization-wage relationship is affected by the quality of the business environment. The small and insignificant interaction term between these two variables shows that there is almost no relationship between the two factors beyond their direct effects; hypothesis 3 is rejected. These effects can be seen more clearly from Figure A1, which is based on Model 6. The top part of the figure depicts the expected average wages in a region versus regional business environment quality. Note the clear pattern that regions with better business environments also have higher wages (the average Europe-wide effect is shown by the solid line). Conversely, when plotting business environment against the effect of localization on wages within each respective region (the bottom part of Figure 1), there is no pattern among the coefficients. There are some regions scoring low on both, and some scoring high on both, but overall the effect is not dependent on business environment and we can see that it is between 0.01 and 0.04 across all regions the average being close to 0.023.

While we have seen that both narrow and broad specialization are associated with higher wages, the broader effects tended to be stronger. The situation is similar when it comes to the joint effects of cluster-level localization and business environment. From Model 7 we see that there is a significant positive interaction effect of broader specialization combined with attractive business environment. The effect is not large in quantitative terms, but hints at a possibility of an additional channel for the impact of cluster-level localization on wages.

Figure A1. Relationship between business environment and localization

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portfolio strength coefficients unaffected and cluster mix coefficients consistently lower than in the OLS results.
The plots represent the estimates from Models 6 and 7 on the regional level. Top: estimates ± standard errors of the regional intercepts (fitted log(average wage)) plotted versus the region’s business environment. Middle: estimates ± standard errors of the regional slopes (effect of log(localization) on log(avg wage)) plotted versus the region’s business environment. Bottom: estimates ± standard errors of the regional slopes (effect of log(cluster localization) on log(avg wage)) plotted versus the region’s business environment. All figures include the multilevel regression line corresponding to the average estimate across all regions.

There is a strong pattern among the intercepts, suggesting regional business environment has very strong effect on wages. The combined effect of business environment with industry localization is negligible suggesting these two factors operate separately from each other. The relationship between cluster localization effect and business environment is positive, although there is a lot uncertainty in the estimates.