Birth of scientists and inventors

HISTORICAL FACTORS

Attitude towards science

Development of a community of scientists

Foundation of universities

Culture and norms of behaviour

Innovation

Entrepreneurship

* Local autonomy
* Importance of the church
* Religious and social tolerance

Technology

Scientific knowledge

Mentality of artisans and

of intellectual elite groups

Growth

Fig. 1. The theoretical framework of this paper

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Spain | Italy | Germany | France | Great Britain | SIs in Spain and Italy as a proportion of total SIs | Variance of SIs between countries |
| *11th–15th centuries* |  |  |  |  |  |  |  |
| SIs | 3 | 4 | 0 | 2 | 4 | 0.53 | 2.8 |
| *15th century* |  |  |  |  |  |  |  |
| SIs | 0 | 3 | 6 | 1 | 0 | 0.30 | 6.5 |
| GDP p.c. | 661 | 1,100 | 688 | 727 | 714 |  |  |
| *16th century* |  |  |  |  |  |  |  |
| SIs | 0 | 6 | 6 | 5 | 2 | 0.31 | 7.2 |
| GDP p.c. | 853 | 1,100 | 791 | 841 | 974 |  |  |
| *17th century* |  |  |  |  |  |  |  |
| SIs | 0 | 7 | 7 | 13 | 15 | 0.17 | 34.8 |
| GDP p.c. | 853 | 1,100 | 910 | 910 | 1,250 |  |  |
| *18th century* |  |  |  |  |  |  |  |
| SIs | 0 | 7 | 16 | 31 | 36 | 0.08 | 235.5 |
| GDP p.c. | 1008 | 1,117 | 1,077 | 1,135 | 1,706 |  |  |
| *19th century* |  |  |  |  |  |  |  |
| SIs | 1 | 5 | 44 | 11 | 37 | 0.06 | 382.8 |
| GDP p.c. | 1,207 | 1,499 | 1,839 | 1,876 | 3,190 |  |  |

Tab. 1. Number of scientists and inventors (SIs) and GDP per capita (p.c.) from the eleventh to nineteenth centuries(Notes: GDP per capita is in 1959 international dollars. Sources of data were Singer (1959) for SIs and Maddison Contours of the World Economy 1-2018 for GDP per capita)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Mean | Std. Dev. | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| (1) Innovative\_SMEs | 6.77 | 14.8 |  |  |  |  |  |  |  |  |  |  |  |
| (2) Innovative\_firms | 15.95 | 27.4 | 0.75\* |  |  |  |  |  |  |  |  |  |  |
| (3) Patents | 335.5 | 529.2 | 0.60\* | 0.57\* |  |  |  |  |  |  |  |  |  |
| (4) Inventions | 52.68 | 417.9 | 0.09\* | 0.12\* | 0.14\* |  |  |  |  |  |  |  |  |
| (5) SI\_Singer | 0.34 | 1.13 | 0.23\* | 0.40\* | 0.36\* | 0.05 |  |  |  |  |  |  |  |
| (6) SI\_Wikidata | 2.10 | 5.29 | 0.40\* | 0.55\* | 0.51\* | 0.06 | 0.80\* |  |  |  |  |  |  |
| (7) SI\_Wikidata\_HS | 1.79 | 4.44 | 0.38\* | 0.53\* | 0.50\* | 0.06 | 0.79\* | 0.99\* |  |  |  |  |  |
| (8) SI\_Wikidata\_SS | 0.34 | 0.98 | 0.42\* | 0.56\* | 0.45\* | 0.07 | 0.71\* | 0.88\* | 0.83\* |  |  |  |  |
| (9) University | 0.73 | 2.37 | 0.48\* | 0.65\* | 0.40\* | 0.08 | 0.61\* | 0.72\* | 0.72\* | 0.63\* |  |  |  |
| (10) Population | 361,507 | 392,650 | 0.63\* | 0.64\* | 0.58\* | 0.05 | 0.30\* | 0.42\* | 0.41\* | 0.39\* | 0.57\* |  |  |
| (11) Density | 815.7 | 1,757 | 0.11\* | 0.38\* | 0.39\* | 0.05 | 0.34\* | 0.38\* | 0.38\* | 0.30\* | 0.32\* | 0.20\* |  |
| (12) GDP p.c. | 37,241 | 24,706 | 0.19\* | 0.47 | 0.41\* | 0.10\* | 0.42\* | 0.45\* | 0.44\* | 0.41\* | 0.41 | 0.03 | 0.46 |

Tab. 2. Descriptive statistics and correlations(Notes: N = 737. \* Statistically significant at the 5% level)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Singer | 0.173\*\*\*(0.062) | 0.152\*\*\*(0.047) | 0.129\*\*(0.064) | 0.124\*(0.054) |
| University | 0.131\*\*\*(0.047) | 0.177\*\*\*(0.036) | 0.093\*(0.054) | 0.351\*\*\*(0.076) |
| Population  | 0.785\*\*\*(0.050) | 0.905\*\*\*(0.041) | 1.292\*\*\*(0.047) | 1.070\*\*\*(0.080) |
| Density | 0.048\*(0.025) | 0.047\*\*(0.022) | 0.054\*\*(0.027) | 0.090\*(0.048) |
| GDP p.c. | 0.623\*\*\*(0.110) | 0.632\*\*\*(0.097) | 0.338\*\*\*(0.107) | 1.120\*\*\*(0.212) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.81 | 0.85 | 0.88 | 0.64 |

Tab. 3. The historical determinants of current entrepreneurship and innovation. Data from Singer (1959).(Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SI\_Wikidata  | 0.016\*\*\*(0.003) | 0.010\*\*\*(0.002) | 0.003(0.004) | 0.006(0.006) |
| University | 0.091\*\*(0.046) | 0.163\*\*\*(0.037) | 0.124\*\*(0.055) | 0.346\*\*\*(0.082) |
| Population  | 0.794\*\*\*(0.047) | 0.913\*\*\*(0.040) | 1.307\*\*\*(0.046) | 1.077\*\*\*(0.080) |
| Density | 0.049\*\*(0.024) | 0.049\*\*(0.022) | 0.058\*\*(0.028) | 0.091\*(0.048) |
| GDP p.c. | 0.602\*\*\*(0.107) | 0.620\*\*\*(0.097) | 0.330\*\*\*(0.108) | 1.115\*\*\*(0.221) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.81 | 0.84 | 0.87 | 0.63 |

Tab. 4. The historical determinants of current entrepreneurship and innovation. Data from Wikidata (Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Wikidata\_HS | 0.021\*\*\*(0.004) | 0.013\*\*\*(0.003) | 0.010\*\*(0.005) | 0.007\*(0.004) |
| University | 0.084\*(0.046) | 0.156\*\*\*(0.037) | 0.117\*\*(0.055) | 0.349\*\*\*(0.081) |
| Population  | 0.793\*\*\*(0.048) | 0.913\*\*\*(0.040) | 1.306\*\*\*(0.046) | 1.077\*\*\*(0.080) |
| Density | 0.048\*\*(0.024) | 0.048\*\*(0.022) | 0.057\*\*(0.028) | 0.091\*(0.048) |
| GDP p.c. | 0.615\*\*\*(0.105) | 0.635\*\*\*(0.096) | 0.365\*\*\*(0.107) | 1.116\*\*\*(0.220) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.81 | 0.84 | 0.88 | 0.64 |

Tab. 5. The historical determinants of current entrepreneurship and innovation considering SIs in hard science fields(Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Wikidata\_SS | 0.086\*\*\*(0.022) | 0.060\*\*\*(0.016) | 0.33(0.029) | 0.035(0.036) |
| University | 0.103\*\*(0.045) | 0.164\*\*\*(0.036) | 0.130\*\*(0.053) | 0.352\*\*\*(0.078) |
| Population  | 0.797\*\*\*(0.048) | 0.916\*\*\*(0.040) | 1.309\*\*\*(0.046) | 1.079\*\*\*(0.080) |
| Density | 0.054\*\*(0.024) | 0.052\*\*(0.022) | 0.056\*\*(0.027) | 0.093\*(0.048) |
| GDP p.c. | 0.605\*\*\*(0.104) | 0.628\*\*\*(0.096) | 0.365\*\*\*(0.107) | 1.112\*\*\*(0.221) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.81 | 0.84 | 0.86 | 0.60 |

Tab. 6. The historical determinants of current entrepreneurship and innovation considering SIs in soft sciences. (Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis).

**Appendix**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Singer | 0.213\*\*\*(0.062) | 0.137\*\*\*(0.042) | 0.134\*\*(0.061) | 0.188\*(0.112) |
| University | 0.118\*\*\*(0.047) | 0.157\*\*\*(0.032) | 0.095\*(0.052) | 0.312\*\*\*(0.081) |
| Population  | 1.070\*\*\*(0.044) | 1.046\*\*\*(0.032) | 1.286\*\*\*(0.045) | 1.176\*\*\*(0.092) |
| Density | 0.043(0.029) | 0.050\*\*(0.019) | 0.066\*\*\*(0.026) | 0.144\*\*\*(0.051) |
| GDP p.c. | 0.728\*\*\*(0.113) | 0.764\*\*\*(0.086) | 0.314\*\*\*(0.097) | 1.548\*\*\*(0.215) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| Pseudo R2 | 0.31 | 0.38 | 0.39 | 0.15 |

Tab. A1. Negative binomial regressions on the historical determinants of current entrepreneurship and innovation. Data from Singer (1959). (Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Wikidata  | 0.016\*\*\*(0.002) | 0.011\*\*\*(0.002) | 0.003(0.003) | 0.001(0.008) |
| University | 0.058(0.046) | 0.122\*\*\*(0.031) | 0.128\*\*(0.051) | 0.343\*\*\*(0.083) |
| Population  | 1.089\*\*\*(0.043) | 1.058\*\*\*(0.031) | 1.301\*\*\*(0.045) | 1.190\*\*\*(0.091) |
| Density | 0.042(0.029) | 0.050\*\*\*(0.019) | 0.072\*\*\*(0.026) | 0.146\*\*\*(0.051) |
| GDP p.c. | 0.743\*\*\*(0.110) | 0.760\*\*\*(0.085) | 0.345\*\*\*(0.099) | 1.562\*\*\*(0.217) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| Pseudo R2 | 0.31 | 0.36 | 0.38 | 0.15 |

Tab. A2. Negative binomial regressions on the historical determinants of current entrepreneurship and innovation. Data from Wikidata (Notes: \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Singer | 0.592\*\*\*(0.218) | 2.154\*(1.220) | 16.82\*(10.01) | 10.36\*(0.611) |
| University | 0.247\*\*(0.115) | 0.177\*(0.968) | 0.488\*(0.052) | 0.660\*\*(0.312) |
| Population  | 0.006(0.177) | 0.798(0.647) | 2.106\*\*\*(0.730) | 1.737(1.533) |
| Density | 0.223\*\*(0.097) | 0.027(0.261) | 1.214\*\*\*(0.437) | 1.165(1.145) |
| GDP p.c. | 1.827\*\*\*(0.486) | 6.434\*\*\*(1.996) | 6.003\*\*(2.291) | 4.984\*(3.063) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.58 | 0.65 | 0.65 | 0.29 |

Tab. A3. Historical determinants of current entrepreneurship and innovation. Data from Singer (1959). (Notes: The dependent variables are scaled by population (100,000 inhabitants). \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | Innovative SMEs | Innovative firms | Patents | Inventions |
| SI\_Wikidata  | 0.051\*\*(0.025) | 0.378\*(0.216) | 0.650\*(0.350) | 0.413\*(0.224) |
| University | 0.140(0.139) | 0.476\*(0.257) | 0.430(0.743) | 0.230(1.283) |
| Population  | 0.038(0.169) | 0.729(0.492) | 2.220\*\*\*(0.707) | 2.606\*(1.526) |
| Density | 0.228\*\*(0.096) | 0.052(0.206) | 1.232\*\*\*(0.446) | 1.234(1.156) |
| GDP p.c. | 1.836\*\*\*(0.474) | 5.85\*\*\*(1.764) | 6.205\*\*\*(0.302) | 4.465(3.015) |
| Regional fixed effects | YES |
| Observations | 737 | 737 | 683 | 737 |
| R2 | 0.57 | 0.69 | 0.65 | 0.29 |

Tab. A4. The historical determinants of current entrepreneurship and innovation. Data from Wikidata (Notes: The dependent variables are scaled by population (100,000 inhabitants). \*\*\*, \*\*, and \* show statistical significance at the 1, 5 and 10% levels. Robust standard errors in parenthesis)