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)