

## EUROPEAN POLICY

# Is Europe Evolving Toward an Integrated Research Area?

A. Chessa, A. Morescalchi, F. Pammolli,\* O. Penner, A. M. Petersen, M. Riccaboni\*

Efforts toward European research and development (R&D) integration have a long history, intensifying with the Fifth Framework Programme (FP) in 1998 (1–3) and the launch of the European Research Area (ERA) initiative at the Lisbon European Council in 2000. A key component of the European Union (EU) strategy for innovation and growth (4, 5), the ERA aims to overcome national borders through directed funding, increased mobility, and streamlined innovation policies.

To assess the rate of progress toward this ERA vision, we analyzed the evolution of geographical collaboration networks constructed from patent and scientific publication data. Although these data may not capture every facet of the ERA, they are widely accepted measures of R&D output, and the European Commission considers them crucial for the evaluation of the Horizon 2020 FP (6). All in all, we find no evidence since 2003 that EU innovation policies aimed at promoting an integrated research and innovation system have corresponded to intensified cross-border R&D activity in Europe vis-à-vis other Organization for Economic Cooperation and Development (OECD) countries.

We exploited the June 2012 release of the OECD REGPAT database (7) and analyzed all  $\sim 2.4 \times 10^6$  patent applications filed with the European Patent Office (EPO) over the period 1986–2010. For comparison with scientific publications, we take a random sample of

$\sim 2.6 \times 10^5$  records from the Thomson ISI Web of Science over the period 1991–2009. We geographically coded each data set at the NUTS3 region level [see supplemental materials (SM)].

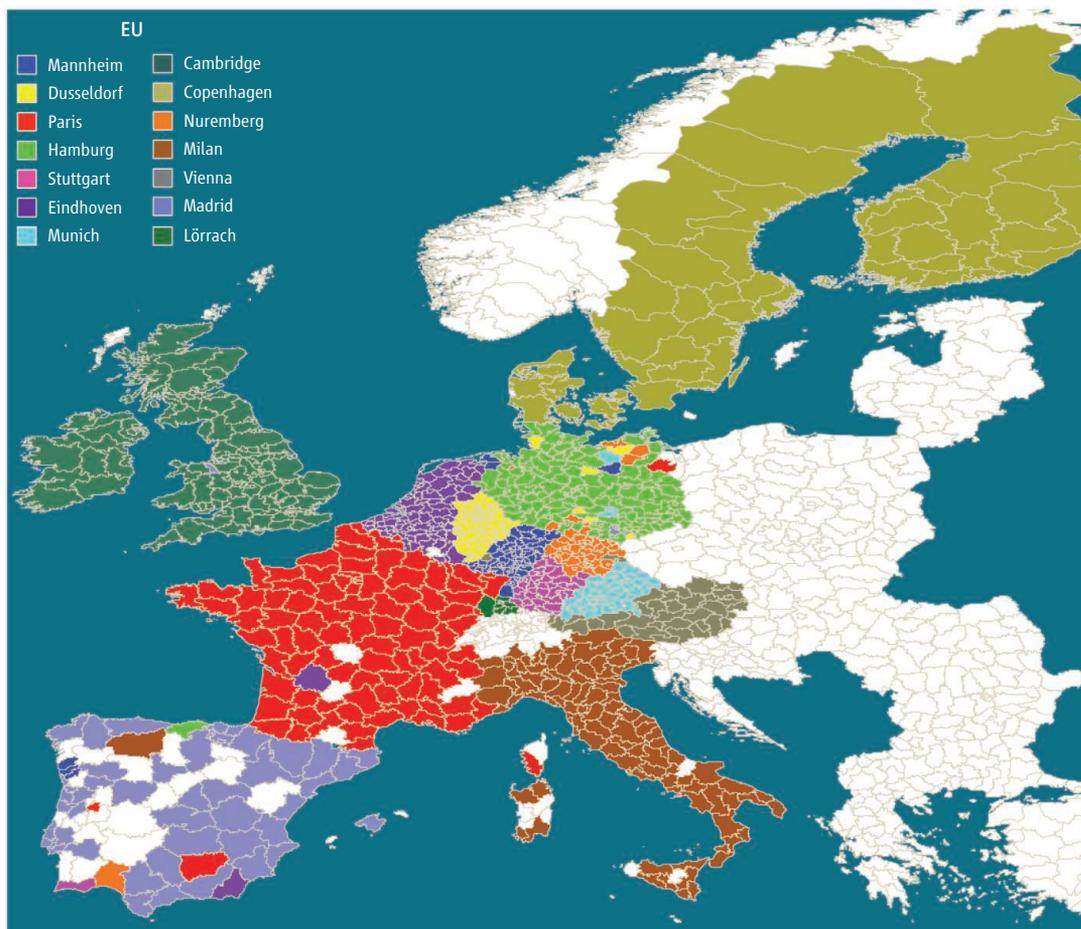
Using the data, we constructed five networks, which provide different perspectives into EU R&D integration. In our networks, nodes correspond to NUTS3 regions and links represent collaboration and/or mobility measures. Specifically, (i) the patent coinventor network and (ii) the publication coauthor network measure the intensity of interregional collaboration at the individual level; (iii) the coapplicant patent network measures the collaboration between institutions (“applicants”) located in different regions; (iv) the patent

Despite efforts to integrate across borders, Europe remains a collection of national innovation systems.



citation network indirectly measures scientific integration by following the flow of citations from patents in one region to patents in another; and (v) the patent mobility network measures the mobility of inventors from one region to another by tracking their location in subsequent patents.

We use a standard network-clustering algorithm to identify communities, i.e., subsets of nodes more strongly linked to one another than to nodes outside, to compare geopolitical borders and R&D networks. Regional integration is shown in the first figure in the purple community, centered on Eindhoven, which is composed of strongly



**Community structure of the 2009 EU-15 coinventor network.** Communities (color blocs) are labeled by their most-central region and were generated by iteratively aggregating them into clusters of increasing size (see SM). Blank regions, no ties in 2009.

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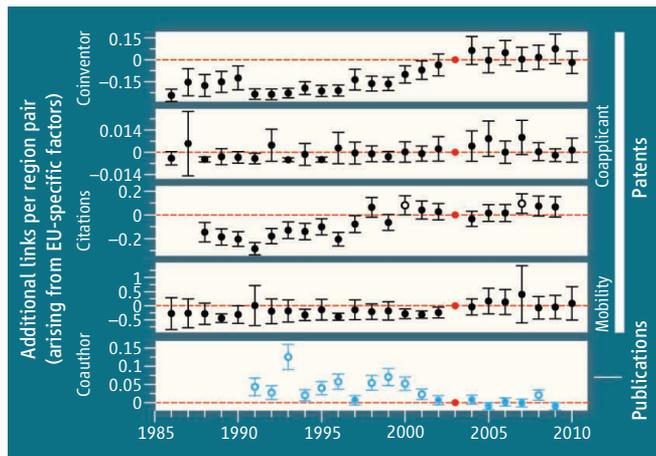
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collaborating regions in the Benelux, and in the international Nordic community with its center in Copenhagen. Despite these exceptions, coinventorship in Europe continues to be largely shaped by national borders, in contrast to the community structure of the highly dispersed “coast-to-coast” U.S. coinventor network (see SM for comparison) (8).

Europe is shown in the figure to be a collection of regional and national innovation communities. However, that does not necessarily mean that integration efforts have been unsuccessful. The more relevant question is at what rate is Europe evolving toward an integrated research system relative to the rate of cross-border R&D collaboration observed in non-EU OECD countries?

As shown elsewhere (3, 9–11), we observe a significant increase in the total number of cross-border research collaborations, both within and outside Europe (see fig. S1). To assess the role of EU-specific factors, we compared relative changes in cross-border collaboration between European countries (e.g., distinguishing German-French, from German-German and French-French collaborations) with changes in cross-border collaboration between non-European OECD countries. We did not analyze collaborations between EU and non-EU regions.

For each network, our econometric model performs three quantitative differences and controls for the size of regions, geographic distance, and time effects (see SM). First, the difference between cross-border and intra-border average number of links is computed, both for EU and non-EU OECD nations. Second, the difference between these two estimates isolates the impact of EU-specific factors on R&D integration. Finally, comparison with a baseline year yields the quantitative output of the model, i.e., the expected number of additional links between regions resulting from EU-specific factors. This quantity is shown in the second figure. Comparing data points from two different years, a higher y-axis value indicates a greater impact of EU-specific factors upon integration among EU nations. Choice of the baseline year does not alter our results. A positive (or negative)



**Evolution of European integration in five R&D networks.** The y axis reports the additional number of cross-border links for an average pair of regions (i) relative to within-border links, (ii) due to EU-specific factors as compared with non-EU OECD countries, and (iii) relative to 2003 baseline year. Error bars indicate 95% confidence intervals for four different patent networks (black circles) and a scientific publication network (green circles). Open circles indicate statistically significant (0.05 level) positive deviations from the baseline year. See SM.

slope indicates Europe is integrating faster (or slower) than non-EU OECD countries.

Since the late 1990s, signs of integration in European patent statistics are often seen. In the patent coinventor network, cross-border collaboration in Europe have increased vis-à-vis other OECD countries. This effect was relatively pronounced from 1998 to 2002 but stalled in 2003. Since then, additional links for an average pair of regions due to Europe-specific factors has never been significantly larger than zero. The patent coapplicant network exhibits no significant increase since 1996. The citation network shows a temporary bump in integration in the late '90s, then fluctuates around that level. Finally, the inventors' mobility network shows almost no progress in the last decade, confirming a slow pace of integration for the European high-skill labor market.

The scientific publication coauthorship network shows a negative trend since 1999, indicating that cross-border links among non-EU OECD countries grew faster than European cross-border links. These results are striking and deserve further investigation given the amount of resources the EU has committed to promote cross-border scientific collaboration through programs like FPs, European Cooperation in Science and Technology, Networks of Excellence, Marie Curie Actions, and so on.

In sum, our analysis of R&D patent and publication networks shows that Europe remains a collection of loosely coupled national innovation systems (12). Furthermore, since 2003, cross-border collaborations in Europe have developed no faster than in the

rest of the OECD countries.

Several ongoing initiatives seek to address general shortcomings that have affected previous integration efforts (5). The European Institute of Innovation and Technology's (EIT) Knowledge and Innovation Communities are long-term (7 to 15 years) collaboration networks spanning all aspects of the R&D ecosystem. To foster synergetic interaction between national funding bodies, Science Europe, an association of national research organizations, was founded in 2011 (14).

The European Research Council (ERC) has taken steps toward cross-border mobility by making grants competitive and portable. Likewise, a memorandum of understanding signed by the European Commission and the League of European Research Universities (13) pushes for pension unification and transparency in hiring and tenure decisions.

Despite these initiatives to increase competition within the system, monitoring and evaluation must drastically change if Europe is to accomplish its ambitious goals in science and technology. Evidence-based evaluation focused on output and impact is crucial, as recognized in the plans for the Horizon 2020 FP (6). Our methodology promotes this vision by combining interdisciplinary expertise with data relevant to impact analysis.

#### References and Notes

1. H. Delanghe, U. Muldur, L. Soete, *European Science and Technology Policy: Towards Integration or Fragmentation?* (Edward Elgar, Cheltenham, UK, 2009).
2. T. Scherngell, M. J. Barber, *Ann. Reg. Sci.* **46**, 247 (2011).
3. T. Scherngell, R. Lata, *Pap. Reg. Sci.* (2012). 10.1111/j.1435-5957.2012.00419.x
4. M. Nedevea, M. Stampfer, *Science* **336**, 982 (2012).
5. ERA, <http://ec.europa.eu/research/era>.
6. Commission Staff Working Paper, Impact Assessment; [http://ec.europa.eu/research/horizon2020/pdf/proposals/horizon\\_2020\\_impact\\_assessment\\_report.pdf](http://ec.europa.eu/research/horizon2020/pdf/proposals/horizon_2020_impact_assessment_report.pdf).
7. S. Maraut *et al.*, The OECD REGPAT Database: a Presentation (STI Working Paper 2008/2, OECD, Paris, 2008); [www.oecd.org/science/innovationiniscienceandindustry/40794372.pdf](http://www.oecd.org/science/innovationiniscienceandindustry/40794372.pdf).
8. J. Owen-Smith *et al.*, *Manage. Sci.* **48**, 24 (2002).
9. S. Breschi, L. Cusmano, *Int. J. Technol. Manag.* **27**, 747 (2004).
10. J. Hoekman *et al.*, *J. Econ. Geogr.* **13**, 23 (2013).
11. National Science Board, *Science and Engineering Indicators 2012* (NSB 12-01, National Science Foundation, Arlington, VA, 2012).
12. R. R. Nelson, *National Innovation Systems: A Comparative Analysis* (Oxford Univ. Press, New York, 1993).
13. Memorandum of Understanding on ERA, (July 2012); [www.leru.org/files/publications/ERA\\_Final\\_MoU\\_LERU.pdf](http://www.leru.org/files/publications/ERA_Final_MoU_LERU.pdf).

**Acknowledgments:** Authors acknowledge funding from the National Research Program of Italy (PNR) project “CRISIS Lab” and thank M. Buchanan and F. Cerina for comments. M.R. acknowledges funding from the Italian Ministry of Education, University, and Research (MIUR) [Progress in Research of Interest (PRIN) project 2009Z3E2BF] and the Research Foundation of Flanders (FWO) (G073013N). O.P. acknowledges funding from the Social Sciences and Humanities Research Council of Canada.

#### Supplementary Materials

[www.sciencemag.org/cgi/content/full/339/6120/650/DC1](http://www.sciencemag.org/cgi/content/full/339/6120/650/DC1)

10.1126/science.1227970

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*Science* **339** (6120), 650-651.  
DOI: 10.1126/science.1227970

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