



HAL
open science

Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial Concentration and Mobility Patterns

Michaela Tripl

► **To cite this version:**

Michaela Tripl. Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial Concentration and Mobility Patterns. *Regional Studies*, 2011, pp.1. 10.1080/00343404.2011.556613 . hal-00680012

HAL Id: hal-00680012

<https://hal.science/hal-00680012>

Submitted on 17 Mar 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial Concentration and Mobility Patterns

| | |
|------------------|--|
| Journal: | <i>Regional Studies</i> |
| Manuscript ID: | CRES-2010-0056.R1 |
| Manuscript Type: | Special Issue Paper |
| JEL codes: | J61 - Geographic Labor Mobility Immigrant Workers < J6 - Mobility, Unemployment, and Vacancies < J - Labor and Demographic Economics, O10 - General < O1 - Economic Development < O - Economic Development, Technological Change, and Growth, R10 - General < R1 - General Regional Economics < R - Urban, Rural, and Regional Economics |
| Keywords: | islands of innovation, location of star scientists, scientific mobility |
| | |

SCHOLARONE™
Manuscripts

1
2
3 Islands of Innovation as Magnetic Centres of Star Scientists? Empirical Evidence on Spatial
4
5 Concentration and Mobility Patterns
6
7
8
9

10 Michaela Tripl

11
12 Institute for Regional Development and Environment, Vienna University of Economics and
13
14 Business, Nordbergstrasse 15, A-1090 Vienna, Austria
15

16
17 Email: michaela.trippl@wu.ac.at
18
19

20
21
22 (Received February 2010; in revised form January 2011)
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Abstract
4

5 Drawing on the results of a survey of 720 'star scientists' this paper seeks to analyse the role
6 of islands of innovation in the United States and Europe in providing educational and
7 employment opportunities for such stars and in attracting internationally mobile members of
8 the scientific elite. It is shown that the US and to a lesser extent European islands of
9 innovation are at the forefront when it comes to employing stars and exchanging them with
10 other places. Furthermore, the paper provides evidence for the formation of a network among
11 islands of innovation based on international movements of top researchers.
12
13
14
15
16
17
18
19
20
21
22
23

24 Keywords: islands of innovation, location of star scientists, scientific mobility
25
26
27
28

29 JEL classification: J61, O30, R10
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45

46 1. Introduction
47

48 There is a growing awareness in both academic and policy circles that highly-qualified
49 scientists and top researchers are crucial drivers of regional high-tech development and
50 science-based innovation. Elite scientists make major and exceptional contributions to the
51 advancement of science and to technological breakthroughs, which can form an essential
52 basis for the emergence and dynamic evolution of new science-based sectors and innovative
53 regional development (ZUCKER et al., 2002). Given the key role that is potentially played by
54 top scientists in fuelling regional high-tech dynamics, their location pattern and international
55
56
57
58
59
60

1
2
3 movements are issues of essential importance. The literature suggests that the scientific elite
4
5 is highly mobile (MEYER et al., 2001) and tends to concentrate geographically in only a few
6
7 places worldwide (MAHROUM, 2003; LAUDEL, 2005; ZUCKER and DARBY, 2007).
8
9
10 Despite an increasing interest in these issues, empirical evidence about the spatial movements
11
12 of the best and brightest scientists remains scarce (see also LAUDEL, 2005; HUNTER et al.,
13
14 2009). Furthermore, apart from a few notable exceptions (see, for instance, ZUCKER and
15
16 DARBY, 2007) hardly any attempts have been made so far to identify those regions where the
17
18 scientific elite can be found.
19
20
21

22
23
24 This paper seeks to fill this research gap. It focuses on so-called 'star scientists' who are
25
26 identified by the number of citations they generated in journals in the ISI databases in the
27
28 period 1981 to 2002. Using data from a worldwide survey of 720 stars, the key aim of the
29
30 paper is to investigate and compare the role of 'islands of innovation' in the United States and
31
32 Europe in producing (i.e. educating) and employing top scientists and to track international
33
34 movements of these stars. The motivation for so doing is that these islands of innovation have
35
36 been identified as advanced centres of industrial and scientific expertise (see the introduction
37
38 to this special issue and HILPERT, 1992, 2009). Star scientists can be expected to work at
39
40 particular places only when appropriate jobs and favourable working conditions are available.
41
42 There are strong reasons to assume that islands of innovation offer such unique conditions and
43
44 are, thus, highly attractive to star scientists. Furthermore, since stars indicate a propensity to
45
46 be internationally mobile, it can be expected that they move between such places, giving rise
47
48 to the formation and reproduction of a global network between islands of innovation. Finally,
49
50 inspired by the literature on national innovation systems and the 'varieties of capitalism'
51
52 approach, the paper deals with the hypothesis that the wider institutional context has an
53
54 impact on the capacity of regions to perform as major educational and location centres of the
55
56 star scientists. It is supposed that compared with Europe the United States benefits from more
57
58
59
60

1
2
3 deregulated and mobile science labour markets and a common institutional set-up and thus
4 offers better conditions for the formation of strong islands of innovation with high capacities
5
6 to educate, employ, attract and retain star scientists. In summary, this article addresses the
7
8 following research questions:
9
10

- 11
12
13
14
15 • To what extent are star scientists spatially concentrated in US and European islands of
16 innovation and what is the role of these regions in educating and attracting internationally
17 mobile members of the scientific elite? What are the key differences in this regard between
18 the United States and Europe?
19
20
21
22
23
24
25
26
- 27 • What is the geography of international movements of the best and brightest scientific
28 minds in the world? Do members of the scientific elite mainly move between islands of
29 innovation, thus contributing to the networking and exchange of expertise among islands
30 of innovation?
31
32
33
34
35
36
37
38

39 The remainder of this paper is organised in four sections. Section 2 examines in more detail
40 the role of star scientists in regional development and provides a short literature review on
41 scientific mobility, islands of innovation and the institutional context conditions in the US and
42 in Europe. Section 3 describes the data of the study and contains some methodological notes.
43 Results on the location and education of star scientists in islands of innovation and flows of
44 stars to and from these advanced regional centres are presented in section 4. The final section
45 summarises the key results of the paper and outlines further research perspectives.
46
47
48
49
50
51
52
53
54
55
56
57

58 2. Conceptual Considerations and Literature Review

59 This chapter provides the conceptual background for the empirical analyses presented in
60 section 4. It brings together different strands of literature, reviewing in particular recent work

1
2
3 on the role of (star) scientists in regional development, contributions to migration studies, and
4 findings from research on 'islands of innovation'. Furthermore, to provide a framework for
5 comparing the United States and Europe, arguments derived from the national innovation
6 system (NIS) concept and the 'varieties of capitalism' approach are taken into account.
7
8
9
10
11

12
13
14
15 A growing body of work suggests that regional high-tech development and science-based
16 innovation critically depend on the provision of employment opportunities for outstanding
17 researchers. Several authors have shown that in the emerging knowledge-based economy top
18 researchers and highly-qualified scientists play a central role in innovation and regional
19 growth (ZUCKER et al., 2002; FURUKAWA and GOTO, 2006; BABA et al., 2009; TRIPPL,
20 forthcoming). These individuals represent a small but decisive and highly influential group of
21 the research community. The literature suggests that elite scientists are an essential element of
22 the strength of a region's and nation's science base (MULKAY, 1976; ZUCKERMAN, 1977;
23 LAUDEL, 2005). They are acknowledged to be possessors and carriers of unique cutting-
24 edge knowledge and they make major and exceptional contributions to the advancement of
25 science and technology. The excellence of top scientists, however, is not limited to academia.
26
27 Employment of outstanding scientists can potentially contribute to regional development and
28 innovation. This may hold particularly true for science-based industries (PAVITT, 1984) or
29 sectors with an analytical knowledge base (ASHEIM and GERTLER, 2005; COOKE et al.,
30 2007) which rely heavily on scientific knowledge inputs during the innovation process.
31
32 Recent work on star scientists provided support for this view. Zucker and her colleagues
33 (ZUCKER et al., 1998, 2002) demonstrated that direct involvement of star scientists in
34 commercialisation activities of scientific discoveries plays a crucial role in the formation or
35 transformation of biotech and other high-tech industries. In a similar vein, SCHILLER and
36 REVILLA-DIEZ (2010) and TRIPPL (forthcoming) have recently shown that star scientists
37 tend to embed themselves in their current location of work by creating multiple forms of
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 knowledge linkages to regional firms, research institutes and policy actors. Given the
4
5 importance of stars to both scientific progress and regional economic development their
6
7 spatial pattern of employment and their movements to specific places matter fundamentally.
8
9

10
11
12 Migration studies have provided some interesting insights in this regard, pointing to an
13
14 increase of the global mobility of highly-skilled people in general (OECD, 2008; SKELDON,
15
16 2009) and scientists and academics in particular (MEYER et al., 2001). The literature
17
18 suggests that there are enormous imbalances in the geography of flows of scientists, resulting
19
20 in an uneven distribution of scientific capabilities. Generally, the United States seems to
21
22 benefit rather strongly from the inflow of researchers from abroad (STEPHAN and LEVIN,
23
24 2001). There is only scanty empirical evidence on international movements of star scientists.
25
26
27 A recent study of 158 of the world's most highly-cited physicists (HUNTER et al., 2009)
28
29 pointed to outstandingly high levels of international movements and migration. No fewer than
30
31 50% of these stars were found to work outside their country of birth. International mobility is
32
33 regarded as a normal phenomenon in the academic world and as a precondition for
34
35 progression in science careers (MAHROUM, 2000). MAHROUM (2000) noted that through
36
37 their mobility scientists form global spaces that stitch specific scientific places together. In
38
39 these global spaces, scientists are attracted to the centres of their respective spaces where their
40
41 peers reside. Indeed, there is a strong claim in the literature that top scientists concentrate
42
43 geographically in only a few places worldwide (MAHROUM, 2003; LAUDEL, 2005). They
44
45 tend to go where the best facilities are, i.e. they are attracted by global centres of excellence
46
47 and the presence of other outstanding researchers (MAHROUM, 2000, 2003; ZUCKER and
48
49 DARBY, 2007). According to MAHROUM (2000) there is a reciprocal relationship between
50
51 mobility and excellence. 'Highly talented scientists flow to scientific sites that have a high
52
53 reputation for excellence, while at the same time those sites increase their credibility and
54
55 capabilities through hosting such top scientists' (MAHROUM, 2000, p. 518). This leads to
56
57
58
59
60

1
2
3 the formation and further strengthening of a few world poles of science which are more
4
5 successful than other regions and scientific sites in attracting and hosting top scientists
6
7
8 (MAHROUM, 2000).
9

10
11
12 In this paper it is suggested that islands of innovation represent such world poles of science by
13
14 educating, attracting and retaining star scientists. The islands of innovation concept was
15
16 introduced by HILPERT (1992) and represents an interesting contribution to a well-known
17
18 phenomenon, i.e. the strong clustering of science, research and innovation in particular
19
20 geographical areas. At the core of HILPERT's (1992) identification of islands of innovation
21
22 was an analysis of the geographic distribution of research organizations and firms which
23
24 received public funding for R&D projects in different areas such as biotechnology, artificial
25
26 intelligence, etc. A strong spatial concentration of publicly-funded R&D projects in a few
27
28 regions in the United States and Europe was found. Island of innovation, however, not only
29
30 represent strong research clusters. Other indicators, including size of the research
31
32 infrastructure, number of firms in respective industries and dynamics of new firm formation
33
34 were used to show that in islands of innovation a strong relationship between research and its
35
36 industrial exploitation exists (see the introduction to this special issue and HILPERT, 1992).
37
38 Thus, islands of innovation are essential nuclei of science-based innovation, attracting a high
39
40 proportion of public R&D expenditures and hosting not only many excellent research
41
42 institutions but also enterprises with strong abilities to make use of the scientific knowledge
43
44 available in the region. Consequently, islands of innovation are identified by the co-existence
45
46 of scientific and industrial expertise. HILPERT (1992) has shown that only a few places in the
47
48 United States and in Europe are characterised by such unique conditions and could thus be
49
50 classified as islands of innovation. Importantly, this phenomenon seems to be rather stable
51
52 over time. Although some framework conditions have changed considerably since the 1990s
53
54 today it is still the same regions which perform as islands of innovation (HILPERT, 2009).
55
56
57
58
59
60

1
2
3 Their strong role as core centres of science-based innovation continued largely unaltered for
4
5 over a quarter of a century. This is also reflected in the outstanding position taken by these
6
7 regions in international scientific and industrial collaborations. Islands of innovation act as
8
9 key nodes in such international networks and they are often strongly connected to each other
10
11 via scientific and industrial co-operative linkages (HILPERT, 2009). There are good reasons
12
13 to assume that these islands of innovation are highly attractive to star scientists. Their
14
15 strengths in both scientific and industrial capabilities constitute an environment that is
16
17 conducive to scientific breakthroughs and provides top scientists with attractive conditions to
18
19 apply their knowledge and participate in the commercialisation of their research findings.
20
21
22
23
24
25

26
27 Finally, research on national innovation systems (see, for example, LUNDVALL, 1992) and
28
29 varieties of capitalism (HALL and SOSKICE, 2001) implies that the capacity of regions to
30
31 perform as an island of innovation and to educate, employ and exchange star scientists is – at
32
33 least to some extent – shaped by the wider institutional context in which these regions are
34
35 embedded. Such a perspective is highly relevant for an international comparison between US
36
37 islands and those in Europe. The United States and European countries differ quite strongly in
38
39 terms of essential institutional structures that may influence scientists' choices of places to
40
41 work and willingness to move. Compared with Europe, the United States is characterised by
42
43 more liberal market structures and more deregulated and mobile science and technology
44
45 labour markets. Furthermore, the United States benefits from the existence of a common
46
47 institutional setting and language, whereas European countries differ quite strongly from each
48
49 other in terms of culture, language, the working of labour markets, national science and
50
51 technology policies, education systems, regulation of research and its commercialisation,
52
53 intellectual property rights, etc. This leads to the hypothesis that the United States offers more
54
55 favourable institutional conditions for the formation of strong islands of innovation with high
56
57 capacities to employ, attract and retain star scientists than does Europe.
58
59
60

3. Data and Methodology

The empirical results reported in this paper stem from a worldwide web-based survey (conducted in August and September 2008) of so-called star scientists, i.e. the world's top and most renowned scientists and research professionals. More precisely, making use of the database "ISI Highly Cited", the paper refers to star scientists as authors of highly cited research papers. ISI Highly Cited is an online information service provided by the Institute for Scientific Information (ISI), a subsidiary of Thomson Incorporated. With this freely accessible website (<http://isihighlycited.com/>) one can identify individuals, departments, and laboratories that have made important contributions to the advancement of science and technology in recent decades. The importance of contributions is identified by the number of citations they generated in journals in the ISI databases. ISI Highly Cited distinguishes between 21 different areas of research (subject categories) such as clinical medicine, engineering, physics or social sciences and identifies approximately the 250 most cited individuals in each category. The information in ISI Highly Cited is based on publications and citations from the period 1981 to 2002. Use of this database, however, is not without its shortcomings. Two are particularly notable. First, the identification of stars based on the quantitative approach and the extensive but not very current observation period represents a limitation. Older researchers with an extensive publication record may have better chances of being classified as star scientists because of the extensive observation period. Younger researchers and scientists who are at the very top of their class may not be included because they have not accumulated enough publications and citations yet. Table 1 confirms this objection, showing that the stars included in the database are on average 65 years old. ISI Highly Cited data are therefore useful for a study of older, established, top researchers who are at a relatively mature stage of their professional careers. It is less adequate for dealing with younger outstanding scientists and potential members of the scientific elite. Second,

1
2
3 there is a bias towards English-language journals. This leads to an ‘undercounting’ of top
4
5 scientists who publish their research results in other languages.
6
7
8
9

10 The database includes approximately 5,600 star scientists, comprising less than 0.5% of all
11
12 worldwide publishing researchers. All 3,274 star scientists who provide their contact
13
14 information (email address) in the database have been contacted and invited to fill in the
15
16 questionnaire. Only 433 of them were not reachable owing to invalid email addresses. Out of
17
18 the remaining 2,841 star scientists, 720 stars replied. This corresponds to a response rate of
19
20 25.34%.
21
22
23
24
25
26

27 [Table 1 about here]
28
29
30

31 Table 1 provides an overview on the average age (year of birth), research discipline¹ and
32
33 current location (world region) of the total population of stars included in the database, those
34
35 who have been contacted and reached (i.e. those who provided a valid email address), and the
36
37 responding stars. As shown in Table 1, the group of stars who provide valid contact
38
39 information is rather similar to the total population. There is hardly any age, discipline or
40
41 regional bias when it comes to the provision of and accessibility by email addresses.
42
43 Comparing the respondents with the total population reveals that the sample is not fully
44
45 representative. The responding stars are slightly younger than the total population of stars
46
47 included in the database. Natural Sciences, as well as Engineering and Technology are
48
49 somewhat overrepresented whilst Social Sciences and particularly Agricultural Science are
50
51 underrepresented in the sample. Looking at the current location of stars at the level of world
52
53 regions it becomes clear that star scientists working in the US are underrepresented; those
54
55 employed in other world regions are slightly overrepresented in the sample. In comparison of
56
57 the United States with Europe (Section 4) this finding will have to be born in mind. The
58
59
60

1
2
3 results reported below may underestimate the role of the United States and their islands of
4 innovation in providing jobs for stars as well as in attracting internationally mobile members
5 of the scientific elite.
6
7
8
9

10
11
12 [Table 2 about here]
13
14

15
16
17 Table 2 shows some further characteristics of the responding star scientists. The
18 overwhelming majority of responding star scientists is male (93%). A vast majority of the
19 sampled scientists (70%) is employed by universities. About 18% are working for non-
20 university research institutions, whereas the proportion of star scientists from the corporate
21 sector is negligible (2%). Under the category 'other' the respondents have indicated that they
22 are retired, have founded their own company, work for the government, or do non-profit
23 research or consulting. Finally, data on the mobility background of the surveyed star scientists
24 were collected. Almost 48% of them can be classified as 'non-movers'. This group includes
25 those star scientists who indicated they have not relocated internationally so far. Apart from
26 short-term travelling they have not been substantially mobile for professional purposes but
27 have stayed in their home countries. Arguably, this does not mean that they have not been
28 mobile at all. They might have moved within their home countries between scientific sites or
29 organisations. More than half of the respondents (52%) have an international mobility
30 background. Here a distinction can be drawn between expatriates on the one hand and
31 returnees on the other. Expatriates are defined as researchers who have left their home
32 countries and now live and work in a foreign location. Their proportion in the sample is 25%.
33 On average they have already spent 30 years away from home. Returnees (i.e. scientists who
34 have moved back to their home countries after living abroad for a substantial period of time)
35 represent 27% of all sampled stars. They have spent on average six years abroad before
36 relocating back home.
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

4. Empirical Part: Islands of Innovation and Star Scientists

This section presents the results of the empirical analysis of the location pattern, educational origins and spatial movements of the surveyed star scientists and it compares the role of US and European islands of innovation in this regard. As noted above, top researchers have the potential to be key drivers of science-based innovation, as their excellence and specialised knowledge could form essential inputs for the rise and dynamic evolution of new industries. Consequently, in a first step it is intriguing to explore where the best and brightest researchers in their respective disciplines are located.

4.1. Islands of Innovation as Location of Choice of Star Scientists

The surveyed star scientists are unevenly distributed across space. The United States is clearly in the lead, hosting no fewer than 57% of the top researchers included in the sample. Europe accounts for 28% of all responding star scientists, whereas Asia (7%), Canada (4%), Oceania (4%) and other parts of the world (1%) show a rather low ability in comparison to attract or retain top researchers (see Table 1). Together, the United States and Europe provide employment opportunities for about 85% of all star scientists included in the sample. Taking a closer view on the location pattern of stars in the United States and in Europe reveals that the majority of these highly-skilled individuals are strongly concentrated in a few places, pointing to the dominating role and attractiveness of islands of innovation.

US Islands of Innovation

In the United States, no fewer than 230 top researchers (representing 66% of the scientific elite located in the United States) are working in an island of innovation (Table 3). For the United States there is thus confirmation of the assumption that islands of innovation are the favourite workplaces of elite scientists. Given the fact that stars who are currently employed

1
2
3 in the United States are underrepresented in the sample, this finding may even underestimate
4
5 the real concentration of top researchers in US islands of innovation.
6
7
8
9

10 In the United States there is a clear hierarchy of the core regions. The top eight US islands of
11
12 innovation provide employment opportunities for no fewer than 55% of all US-based stars.
13
14 Other US islands of innovation account for 39 stars (11% of the US-based scientific elite)
15
16 whereas other US regions host 120 stars (34% of all stars located in the US). As shown in
17
18 Table 3, the top eight locations are the New York region (made up of New York, Ithaca and
19
20 places like Princeton, New Brunswick, Newark, etc. in New Jersey), Los Angeles-San Diego,
21
22 San Francisco Bay Area (covering amongst others famous places such as Stanford, Berkeley,
23
24 etc.), Washington-Baltimore, Boston (Boston and Cambridge, MA), Chicago/Milwaukee and
25
26 Raleigh Durham. The group of other US islands of innovation includes regions such as Ann
27
28 Arbor, Philadelphia and Seattle. Apart from one region (Dayton, OH) all US islands of
29
30 innovation identified by HILPERT (1992, 2009) host at least one star scientist. In the United
31
32 States, there are only a few hotspot locations of stars that are not islands of innovation. Key
33
34 places in this respect are Boulder, CO (employment of eight stars), Atlanta, GA (employment
35
36 of seven stars), Charlottesville, VA (employment of six stars) and Bloomington, IN, Madison,
37
38 WI and Nashville, TN, each of which hosts four stars.
39
40
41
42
43
44
45
46
47
48
49
50
51
52

[Table 3 about here]

53 Importantly, the strong role of US islands of innovation as core regions of star scientists is not
54
55 restricted to a specific scientific field. On the contrary, the islands of innovation are major
56
57 locations of stars working in very different scientific disciplines. This holds particularly true
58
59 for the top islands of innovation. Although some of these areas seem to be more specialised in
60
a certain research field than other regions (measured by the number of stars active in a

1
2
3 specific science field employed in the region), they all provide employment opportunities for
4 stars from at least four science fields. This finding points to their generally high attraction for
5 top researchers and their strong capacity to recruit or retain the best and brightest scholars in
6 various research disciplines.
7
8
9
10
11

12 13 14 15 European Islands of Innovation

16
17 Table 4 presents data about the regional distribution of star scientists in Europe. Nearly 55%
18 of the surveyed European-based star scientists (a number of 103 top researchers) are
19 employed in an island of innovation. The top eight European islands of innovation account for
20 almost 40% of all European-based stars, whereas other European islands of innovation and
21 the rest of European regions host 15% and 46% respectively. Key places in Europe are the
22 London region (London and Oxford), East Anglia (Cambridge, Norwich), Munich,
23 Copenhagen, Glasgow-Edinburgh, Paris, Amsterdam/Rotterdam and Milan/Turin. The
24 empirical findings for Europe thus also provide some support for the assumption that islands
25 of innovation are major workplaces of stars, although in Europe the location pattern is more
26 complex than in the United States. In Europe we find a few non-islands of innovation that
27 provide jobs for stars. Zurich in Switzerland (employment of six stars) and Leuven in
28 Belgium (employment of five stars) represent key examples in this regard. At the same time
29 one could identify several islands of innovation that do not host any of the responding star
30 scientists. These include the German regions of Hamburg and Frankfurt, Toulouse (Mini-
31 Pyrénées) in France, Barcelona (Spain), as well as Rome and Livorno/Pisa (Tuscany) in Italy.
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54

55 [Table 4 about here]
56
57
58
59

60 To summarise, there is an enormous spatial concentration of the investigated top researchers
in a few islands of innovation in the United States and Europe. Obviously, these few top

1
2
3 places have an enormous magnetic power and constitute main agglomeration centres of the
4
5 scientific elite. There is thus evidence that islands of innovation represent world poles of
6
7 science (or islands of science) by hosting a large number of stars. The analysis also showed
8
9 that some islands of innovation (particularly European ones) do not provide employment
10
11 opportunities for the responding stars, indicating that their innovation capacity may rest on
12
13 other key assets such as high levels of R&D expenditures or patenting activities, skilled
14
15 workforce concentration, etc. At the same time a few hotspots of stars in the United States and
16
17 Europe were found that could not be categorised as islands of innovation. Obviously, these
18
19 places miss other key ingredients for successful innovation processes. It is beyond the scope
20
21 of this paper to analyse which factors need to be combined with the presence of stars to
22
23 enhance the innovation capacity of regions. This is an important issue for future research (see
24
25 section 5).
26
27
28
29
30
31
32
33

34 The results reported above confirm the hypothesis (see section 2) that the concentration of
35
36 stars in a few islands of innovation is stronger in the United States than in Europe. The
37
38 hypothesis that the distributions of stars across top islands, other islands and other regions in
39
40 the US and in Europe are the same was tested by a Chi-square test and rejected at the 1 per
41
42 cent level of significance. These differences between the United States and Europe might
43
44 result from the specific institutional contexts prevailing in these areas. The United States are
45
46 characterised by a rather homogeneous institutional set-up and a common research area. The
47
48 European countries, in contrast, differ strongly in terms of language, culture and research
49
50 systems, leading to a lower degree of intra-European mobility of scientists and a more
51
52 decentralised distribution of outstanding researchers across the continent.
53
54
55
56
57
58
59
60

4.2. Islands of Innovation as Educational Centres of Star Scientists

1
2
3 Looking at the places where the scientific elite examined here were educated again highlights
4 and confirms the key role of islands of innovation. The regional distribution of 'star
5 production' is given in Table 4. Not fewer than 69% (or 201 individuals) of all stars scientists
6 who received their education in the United States have studied in an US island of innovation.
7
8 It is particularly the top US islands of New York, Boston, the San Francisco Bay Area and
9
10 Los Angeles/San Diego which appear to be the major centres of star production in the United
11
12 States. In Europe, the respective proportion is lower, amounting to 52%. Here, a particularly
13
14 strong role of London and East Anglia can be observed. Obviously, the islands of innovation
15
16 not only provide employment opportunities for the large majority of star scientists worldwide
17
18 but are also key training places of top researchers, offering excellent educational opportunities
19
20 and attracting outstanding young scholars who later become star scientists. Arguably, the
21
22 educational role of these areas reproduces and further strengthens their capacity to perform as
23
24 key hotspots of stars.
25
26
27
28
29
30
31
32
33
34
35

36 [Table 5 about here]
37
38
39
40

41 In the United States there is less evidence of star production outside the islands of innovation
42 (31%) than in Europe (48%). A Chi-square test again indicated that these differences between
43 the United States and Europe are statistically significant at the 1 per cent level. This might
44 again reflect rather strong national differences between European countries regarding their
45 science and education systems, culture and language, leading to lower mobility of students for
46 educational purposes.
47
48
49
50
51
52
53
54
55

56
57 In a next step, it is intriguing to analyse in more detail the educational origins of star scientists
58 who currently work in the top US and European islands of innovation. Table 6 reveals the
59 respective pattern for the top places in the United States. Here, about 18% of the stars
60

1
2
3 scientists (continue to or have returned to) work in the innovation island where they received
4 their training. Some regions clearly exceed this average number, such as Boston (38% of stars
5 working there have also been educated there), New York (23%), Chicago/Milwaukee (21%),
6
7
8
9
10 whereas others rely heavily on stars educated elsewhere, like Raleigh Durham and
11
12 Washington/Baltimore. Another 35% have received their PhD in another US island of
13
14 innovation. This type of relationship – i.e. the migration of stars who have been educated in
15
16 one island of innovation to another island of innovation to take a job there – is the most
17
18 important one found for the United States. Only a small number of stars located in these US
19
20 islands of innovation received their doctoral training abroad.
21
22
23
24
25
26

27 [Table 6 about here]
28
29
30

31
32 The proportion of ‘own production’ (endogamy) is much higher in Europe than it is in the US
33
34 (35% in Europe compared with 18% in the United States). It is particularly high in
35
36 Copenhagen (57%), Milan/Turin (50%), and Glasgow/Edinburgh (43%), but below average in
37
38 East Anglia (25%) and Amsterdam-Rotterdam (20%). The top European islands of innovation
39
40 attracted 21% of stars from other European islands of innovation and another 31% from other
41
42 European regions. Only 8% of stars who work in a top European island have been educated in
43
44 the United States (Table 7). A Chi-square test showed that differences in educational origin
45
46 between stars working in US islands of innovation and those employed in European islands of
47
48 innovation are statistically significant at the 1 per cent level.
49
50
51
52
53
54

55 [Table 7 about here]
56
57
58
59

60 4.3. International Movements of Star Scientists and Linkages between Islands of Innovation

1
2
3 The evidence provided so far in this article clearly points to a pronounced concentration of
4 star scientists in a few places worldwide. Areas that provide employment opportunities for the
5 elite researchers possess a critical ingredient for future science-based innovation and may
6 represent key nodes in international network between regional scientific labour markets via
7 mobility of top researchers. Arguably, only those regions which host star scientists can take
8 part in the global exchange of these stars, acting as core centres in the international process of
9 scientific brain circulation.
10
11
12
13
14
15
16
17
18
19
20
21

22 Islands of Innovation as Sticky Places for Non-Movers and Key Destinations of 23 Internationally Mobile Star Scientists 24

25
26 In the following the importance of islands of innovation for attracting and retaining different
27 types of star scientists is explored. Given the international mobility background of the
28 surveyed top researchers, a distinction between 'non-movers', 'expatriates' and 'returnees'
29 can be drawn (see also section 3). This section also examines the role of islands of innovation
30 as 'sending regions' of expatriates and returnees and it investigates linkages between these
31 regions.
32
33
34
35
36
37
38
39
40
41
42

43 Which types of star scientists are to be found in the islands of innovation in the United States
44 and Europe? There are interesting differences in this regard between these two continents. No
45 fewer than 58% of all stars working in the US islands of innovation can be classified as non-
46 movers. This might reflect the superior working conditions for top researchers in the United
47 States, implying that stars are not forced to move away. At the same time these areas seem to
48 be highly attractive to expatriates. More than 30% (58 stars out of 191) of the surveyed stars
49 employed in these top regions fall into this category. The proportion of returnees (11%) is
50 comparatively low. Table 8 provides further details about the types of stars working in the top
51 US islands of innovation. There are some interesting variations between the areas belonging
52
53
54
55
56
57
58
59
60

1
2
3 to this group of places. Some regions have an extremely high proportion of non-movers,
4
5
6 whereas others rely more on the inflow of internationally mobile star scientists. Centres of
7
8 non-movers particularly comprise Washington/Baltimore (82.8%), Los Angeles/San Diego
9
10 (65.6%) and Dallas (63.2%). Regions with a high proportion of internationally mobile stars
11
12 include Chicago/Milwaukee (57.1%) and the San Francisco Bay area (55.2%).
13
14

15
16
17 In the European islands of innovation the situation is clearly different. Only 40% of all those
18
19 stars who are employed in these areas represent non-movers, whereas 19% could be classified
20
21 as expatriates. Returnees (42%) represent the most important group of stars working in the
22
23 European islands of innovation. Thus, the top regions in Europe are quite successful in luring
24
25 their best and brightest scientists back home. Among the leading European islands of
26
27 innovation it is only the London region and Milan/Turin, where the proportion of non-movers
28
29 is 50%. There are thus clear differences between US and European islands of innovation in
30
31 terms of the type of star scientists they host. The hypothesis that the proportions of non-
32
33 movers, expatriates and returnees are the same in the US and European islands of innovation
34
35 was tested by a Chi-square test and rejected at the 1 per cent level of significance.
36
37
38
39
40
41
42

43 Outflow of Mobile Star Scientists from Islands of Innovation

44
45 Generally, the islands of innovation investigated here not only provide significant
46
47 employment opportunities for both movers and non-movers but are also essential sending
48
49 regions of mobile star scientists. This statement, however, needs refining. Looking at the US
50
51 islands of innovation, hardly any outflow of US star scientists (i.e. US expatriates) can be
52
53 observed. There are only nine star scientists who have left the US islands of innovation and
54
55 now work and live abroad.
56
57
58
59
60

[Table 8 about here]

1
2
3
4
5 This finding might reflect the superiority of the labour markets of these areas, implying that
6
7 outstanding scientists are not forced to move abroad. As revealed in Table 8, however, the US
8
9 islands of innovation have lost 65 foreign star scientists who relocated back home after
10
11 working for a while in these areas. Obviously, the US islands of innovation are strong in
12
13 attracting this type of mobile scientists, but they cannot retain them.
14
15

16
17
18
19 In the European islands of innovation a different pattern is found (Table 9). These regions
20
21 have lost far more expatriates (34 stars) than the US islands of innovation. Furthermore, the
22
23 European islands of innovation experienced an outflow of 26 foreign researchers who have
24
25 returned to their home regions (returnees).
26
27

28
29
30
31 [Table 9 about here]
32
33

34 35 Linkages between Islands of Innovation through Movements of Star Scientists

36
37 The next step of the analysis is to examine international movements of star scientists and the
38
39 resulting pattern of linkages between the islands of innovation and their ties with other
40
41 regions of the world. Given the pronounced differences between expatriates and returnees in
42
43 terms of the period of time they have (already) been employed abroad, it seems reasonable to
44
45 suppose that they represent two very different types of mobile star scientists. Expatriates have
46
47 on average spent 30 years away from their home regions. This points to permanent migration
48
49 and it can be assumed that these star scientists are, indeed, 'lost' to their home regions.
50
51 Returnees, in contrast, seem to be better categorised as temporary migrants, as they have lived
52
53 and worked abroad for an average of six years before relocating back home. Thus, in the
54
55 following, the movements of expatriates and returnees will be analysed separately.
56
57
58
59
60

1
2
3 As mentioned above, the sample covers 181 expatriates. The overwhelming majority of them
4
5 (110 stars) have migrated to the United States. The key area for sending stars to the United
6
7 States is Europe (61 star scientists), followed by Asia (fifteen), Canada (eleven) and Oceania
8
9 (ten). Europe provides jobs for 40 expatriates. Most of the expatriates employed in Europe
10
11 come from European regions (26 stars), reflecting strong linkages between European
12
13 countries via mobility of top researchers. There is comparatively little inflow of expatriate star
14
15 scientists from outside Europe. Other world regions hardly play any role at all in attracting
16
17 expatriate top researchers.
18
19
20
21

22
23
24 Given the dominant role of the United States in providing jobs for expatriates, in the
25
26 following the analysis is mainly oriented on the US context, placing special emphasis on
27
28 movements of expatriates to the US islands of innovation. As shown above, the US islands of
29
30 innovation are major workplaces for expatriate star scientists, providing employment
31
32 opportunities for no fewer than 70 foreign top researchers. At the same time, these regions
33
34 hardly lose any native star scientists (see also Table 8). The European islands of innovation,
35
36 in contrast, provide jobs for only nineteen expatriate star scientists included in the sample.
37
38 Where do the foreign scientific elites employed in the top US regions come from? As
39
40 revealed in Figure 1, the US islands of innovation benefit from a rather strong inflow of
41
42 European star scientists. Twelve stars migrated from European islands of innovation to the top
43
44 US places, and movements of expatriates originating from other European regions are even
45
46 more intense (24 stars).
47
48
49
50
51
52
53
54

55 [Figure 1 about here]
56
57
58

59 To summarise, there is evidence of networking relations between the US and European
60 islands of innovation via mobile star scientists. At the same time rather strong flows of

1
2
3 migrants from other European regions, Asia, Oceania, Canada and other parts of the world to
4
5 the US islands of innovation could be observed. It is therefore fair to say that particular non-
6
7 islands of innovation seem to lose many stars to the top US regions. This pattern might be
8
9 explained with reference to the weak labour markets in these areas, which drive star scientists
10
11 to move away and seek new employment opportunities in the superior US locations.
12
13
14

15
16
17 [Figure 2 about here]
18
19
20
21

22 In a next step international movements of returnees are explored. As noted above, Europe in
23
24 general and European islands of innovation in particular seem to be quite successful in luring
25
26 top researchers back home. Out of 197 surveyed returnees no fewer than 88 stars (45% of all
27
28 returnees in the sample) could be found in Europe, whereas the United States provides
29
30 employment opportunities for 48 returnees, representing a proportion of 25% of all
31
32 investigated returnees worldwide. There are strong linkages between the US and European
33
34 regions via mobility of returnees. It is in particularly Europe which benefits strongly from an
35
36 inflow of returning stars who have been employed on a temporary basis in the US. Europe has
37
38 attracted 54 returnees from the US, whereas flows in the opposite direction are less intense
39
40 (21 returnees). Also, the exchange of returnees between European regions (eighteen stars)
41
42 plays a role.
43
44
45
46
47
48
49

50 Exploring the sending regions of returning European stars points to the high importance of US
51
52 islands of innovation. Very strong relations between these top places in the United States and
53
54 European islands of innovation were found. No fewer than 50% (22 stars) of the scientific
55
56 elite who have relocated back home to a European island of innovation have temporarily
57
58 worked in a US island of innovation (Figure 2). Obviously, these top regions in the United
59
60 States have an extraordinarily high attraction for distinguished researchers who decide to

1
2
3 move away on a temporary basis. At the same time, it is clear that the United States cannot
4 retain all foreign-born top researchers who flow in. A different picture is found for the the
5 main sending regions of US stars who return to a US island of innovation (Figure 2).
6
7 Returning US stars do not come mainly from European islands of innovation; there is a large
8 number of different sending areas.
9
10
11
12
13
14

15
16
17 Figure 3 shows the exchange of expatriates and returnees between the US islands of
18 innovation and their counterparts in Europe. Although it is based on a rather low number of
19 observations, some tentative remarks can be made. A few particular regions play an
20 outstanding role in this international network of innovative regions, acting as crucial sending
21 and receiving areas of mobile star scientists. They include San Francisco, Boston, MA,
22 London, East Anglia and Copenhagen. At the same time, it is clear that a relatively large
23 number of top US and European regions (such as Dallas/Houston/San Antonio, Raleigh
24 Durham, Ann Arbor, Madrid, Berlin, etc.) do not take part in the networking between islands
25 of innovation. These areas rely exclusively on linkages with regions outside the islands of
26 innovation. Finally, Figure 3 also reveals another key characteristic of the international
27 network of islands of innovation, that is, the very specific geography of linkages, which is
28 strongly transcontinental in nature. Indeed, the overwhelming majority of ties are between top
29 US and European places, whereas linkages between European islands of innovation are
30 almost negligible.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50

51
52
53 [Figure 3 about here]
54
55
56

57 5. Summary and Outlook

58 Star scientists play a pivotal role in regional development, growth and innovation. They make
59 major contributions to the advancement of science, thus potentially providing key inputs in
60

1
2
3 the rise of new science-based industries. Additionally, there is evidence that star scientists are
4 increasingly involved in the commercialisation of scientific breakthroughs, acting as what
5
6 ZUCKER and DARBY (2007) termed 'star innovators'. Given the crucial importance of these
7
8 outstanding individuals for the evolution of regional knowledge economies and the
9
10 development of science-based innovation, it is of the utmost significance to identify those
11
12 places and regions where star scientists are educated, move to, come from and stay. Areas
13
14 which provide employment opportunities for top researchers and take part in the international
15
16 exchange of the scientific elite have a good chance of being among those places where future
17
18 science-based innovation will occur. Despite a growing interest in these issues, surprisingly
19
20 little is known about the location pattern, educational origins and geography of international
21
22 movements of the very best and brightest scientific minds.
23
24
25
26
27
28
29
30

31 In this paper an attempt was made to analyse and compare the importance of US and
32
33 European islands of innovation in this context. It has been shown that star scientists are
34
35 strongly concentrated in a few places, highlighting the crucial role that is played by islands of
36
37 innovation in providing employment opportunities for these outstanding researchers.
38
39 Generally, this finding holds true for both the United States and Europe. In the United States
40
41 the pattern of geographical concentration of the surveyed members of the scientific elite is
42
43 even more intense, reflecting the existence of a rather homogeneous institutional set-up and a
44
45 common research area, whereas the comparatively more even distribution of stars in Europe is
46
47 probably the outcome of fairly strong differences between European nations in terms of
48
49 language, culture and research, education and science systems.
50
51
52
53
54
55
56

57 Islands of innovation do not only provide employment opportunities for many star scientists
58
59 but have also contributed to a large extent to the 'production' (i.e. education) of the surveyed
60
members of the scientific elite. Obviously, the educational role of these areas reproduces and

1
2
3 further strengthens their capacity to perform as islands of innovation. As major educational
4 centres the islands of innovation have a strong capacity to retain or re-attract stars educated
5 there. For the US islands it was also found that they succeed in attracting stars trained in other
6 US islands of innovation.
7
8
9
10
11

12
13
14
15 Furthermore, it was shown that islands of innovation act as major centres in the process of
16 international brain circulation, playing a key role in attracting internationally mobile star
17 scientists. There are, however, clear differences between the US and the European islands of
18 innovation. The US islands were found to be highly successful in attracting expatriates. At the
19 same time there is hardly any evidence that they lose native-born stars. Compared with the
20 United States, the European islands of innovation perform less well when it comes to
21 attracting foreign star scientists. They are, however, highly successful in luring returnees back
22 home.
23
24
25
26
27
28
29
30
31
32
33

34
35
36 Exploring the geography of movements of star scientists revealed a very specific pattern of
37 exchange relations between islands of innovation. The analysis pointed to linkages between
38 US and European islands of innovation via mobility of expatriates, uncovering pronounced
39 one-way flows from Europe to the United States. At the same time evidence was found for a
40 rather strong inflow of top scientists from other parts of the world to US islands of innovation.
41 Tracking the mobility of returnees identified strong exchange relations between US and
42 European islands of innovation. The net flow is biased in one direction, clearly favouring the
43 top regions in Europe.
44
45
46
47
48
49
50
51
52
53
54

55
56
57 Overall, a densely-knit web of linkages was detected between the islands of innovation
58 investigated here. It was shown that they form an international network via the exchange of
59 expatriates and returnees. Not all islands of innovation take part in this network, however.
60

1
2
3 Another key feature of the network is its highly transcontinental nature. The overwhelming
4 majority of linkages is between the US and European top places, and very few ties between
5
6 European islands of innovation were found.
7
8
9

10
11
12 The paper leaves a number of questions and issues for further research. First, the goal of this
13 paper was confined to identifying the location pattern, educational origins and international
14 movements of star scientists. Further analyses are required to provide explanations for the
15 patterns found. It will be a valuable issue for future research to examine why some islands of
16 innovation are more successful than others in hosting and attracting stars and why some
17 regions participate more than others in the international network between islands of
18 innovation formed by mobile top researchers. Moreover, the relationship between the location
19 of stars and classification of regions as islands of innovation needs closer scrutiny. The
20 analysis has identified some islands of innovation (particularly in Europe) that do not host any
21 stars and a few non-islands of innovation that provide employment opportunities for elite
22 researchers. Analysis of the influence of regional characteristics by using indicators on
23 highly-skilled labour concentration, R&D expenditures, R&D workforce concentration,
24 patenting activities, etc. seem to be required to enhance our understanding why some islands
25 are innovative without hosting many stars, and why some regions are not outstandingly
26 innovative despite the fact of employing a lot of elite researchers. Second, as noted in section
27 3, the use of ISI Highly Cited data led to a focus on older top researchers who are at a mature
28 stage in their career. The findings reported in this paper, therefore, reflect the location,
29 educational origins and international movements of older and established members of the
30 scientific elite. What remains unclear is whether similar patterns could be found for younger
31 outstanding researchers and potential stars who are not yet included in the ISI Highly Cited
32 database. The mobility pattern and location decisions of young scientists should receive due
33 attention in future work. Some authors assume that migration occurs more among potential
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 elites rather than among established elites and that the best young talents tend to go where
4 stars reside (MAHROUM, 2003; LAUDEL, 2005). This is said to increase the likelihood that
5 those scientists will later become members of the elite themselves. Exploring whether such an
6 autocatalytic character of 'elite production' exists in islands of innovation is a key issue for
7 future investigation. Third, international movements of star scientists should be tracked at the
8 discipline level to find out to what extent factors of mobility and spatial concentration of top
9 researchers differ between research areas. Fourth, given the paper's focus on the international
10 mobility of star scientists, the role of non-movers remains little understood. As noted in
11 Section 3, the term 'non-movers' was used to denote stars who have not yet been
12 internationally mobile but this does not mean that they have not been mobile at all. They
13 might have been substantially mobile within their home countries between various regions,
14 scientific sites and organisations. It will be an interesting issue for further research to explore
15 to what extent such internal migration processes contribute to the concentration of star
16 scientists in islands of innovation.
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

39 Acknowledgements – I would like to thank the two anonymous reviewers for their valuable
40 and constructive comments. I am also grateful to my colleague Gunther Maier and the guest
41 editors of this special issue, Helen Lawton Smith and Ulrich Hilpert for very helpful
42 comments on earlier versions of this paper. The usual disclaimer applies.
43
44
45
46
47
48
49

50 References

51
52 ASHEIM B. and GERTLER M. (2005) The geography of innovation: Regional innovation
53 systems, in FAGERBERG J., MOWERY D. and NELSON R. (Eds) The Oxford Handbook of
54 Innovation, pp. 291-317. Oxford University Press, Oxford.
55
56
57
58
59
60

1
2
3 BABA Y., SHICHIJO N. and SEDITA S. (2009) How do collaborations with universities
4 affect firms' innovative performance? The role of "Pasteur scientists" in the advanced
5 materials field, *Research Policy* 38, 756-64.
6
7

8
9
10
11
12 COOKE P., DE LAURENTIS C., TÖDTLING F. and TRIPPL M. (2007) *Regional*
13 *knowledge economies*. Edward Elgar, Cheltenham.
14
15

16
17
18
19
20 FURUKAWA R. and GOTO A. (2006) Core scientists and innovation in Japanese electronics
21 companies, *Scientometrics* 68, 227-40.
22
23

24
25
26
27 HALL P. and SOSKICE D. (Eds.) (2001) *Varieties of capitalism: The institutional*
28 *foundations of comparative advantage*. Oxford University Press, Oxford.
29
30

31
32
33
34 HILPERT U. (1992) *Archipelago Europe – Islands of Innovation*. Synthesis Report.
35
36 Prospective Dossier No 1: "Science, Technology and Social and Economic Cohesion in the
37 Community". Commission of the European Communities, Brussels.
38
39

40
41
42
43 HILPERT U. (2009) The virtualisation of proximity: Building networks among islands of
44 innovation in Europe and the US, Paper submitted to the *Journal of Economic Geography*.
45
46
47

48
49
50
51 HUNTER R., OSWALD A. and CHARLTON B. (2009) The elite brain drain, *The Economic*
52 *Journal* 119, 231-51.
53
54

55
56
57
58 LAUDEL G. (2005) Migration currents among the scientific elite, *Minerva* 43, 377-95.
59
60

1
2
3 LUNDVALL, B.-A. (Ed) (1992) National Systems of Innovation. Towards a Theory of
4
5 Innovation and Interactive Learning. Pinter, London.
6
7

8
9
10 MAHROUM S. (2000) Scientists and global spaces, *Technology in Society* 22, 513-23.
11
12

13
14
15 MAHROUM S. (2003) Brain gain, brain drain: an international overview. Paper presented to
16
17 the Austrian Ministry for Transport, Innovation and Technology Seminar, Alpbach, Austria,
18
19 22-23. August 2003.
20
21

22
23
24 MEYER J.-B., KAPLAN D. and CHARUM J. (2001) Scientific nomadism and the new
25
26 geopolitics of knowledge, *International Social Science Journal* 53, 309-21.
27
28

29
30
31 MULKAY M. (1976) The mediating role of the scientific elite, *Social Studies of Science* 6,
32
33 445-70.
34
35

36
37
38 OECD (2006) Revised field of science and technology (FOS) classification in the Frascati
39
40 manual. OECD, Paris.
41
42

43
44
45 OECD (2008) The global competition for talent. Mobility of the highly skilled. OECD, Paris.
46
47

48
49
50 PAVITT K. (1984) Sectoral patterns of technical change: towards a taxonomy and a theory,
51
52 *Research Policy* 13, 343-73.
53
54

55
56
57 SCHILLER D. and REVILLA DIEZ J. (2010) Local embeddedness of knowledge spillover
58
59 agents: Empirical evidence from German star scientists, *Papers in Regional Science* 89, 275-
60
94.

1
2
3
4
5 SKELDON R. (2009) Of skilled migration, brain drains and policy responses, *International*
6
7
8 *Migration* 47, 3-29.
9

10
11
12 STEPHAN P. and LEVIN S. (2001) Exceptional contributions to US science by the foreign-
13
14
15 born and foreign-educated, *Population Research and Policy Review* 20, 59-79.
16

17
18
19 TRIPPL M. (forthcoming) Scientific mobility and knowledge transfer at the interregional and
20
21
22 intraregional level, *Regional Studies*.
23

24
25
26 ZUCKER L. and DARBY M. (2007) Star Scientists, *Innovation and Regional and National*
27
28
29 *Immigration*, NBER Working Paper No. 13547, October 2007.
30

31
32
33 ZUCKER L., DARBY M. and ARMSTRONG J. (2002) Commercializing knowledge:
34
35
36 university science, knowledge capture, and firm performance in biotechnology, *Management*
37
38
39 *Science* 48, 138-53.
40

41
42
43 ZUCKER L., DARBY M. and BREWER M. (1998) Intellectual Human Capital and the Birth
44
45
46 of U.S. Biotechnology Enterprises, *American Economic Review* 88, 290-306.
47

48
49
50 ZUCKERMAN H. (1977) *Scientific Elite: Nobel Laureates in the United States*. Free Press,
51
52
53 New York.
54

Tables

Table 1: Sample characteristics I

| | Database | Valid Email Address | Responding |
|--------------------------------------|----------|------------------------|------------|
| Year of Birth (Mean) | 1945.1 | 1945.7 | 1946.5 |
| Research Discipline (% of stars) | | | |
| Natural Sciences | 49.2 | 47.6 | 54.7 |
| Agricultural Sciences | 10.2 | 9.9 | 3.1 |
| Engineering and Technology | 7.5 | 7.4 | 10.4 |
| Medical and Health Sciences | 23.5 | 24.7 | 23.9 |
| Social Sciences | 9.6 | 10.5 | 7.8 |
| Location (World Region) (% of stars) | | | |
| USA | 66.2 | 65.9 | 56.6 |
| Europe | 22.6 | 23.0 | 28.4 |
| Asia | 5.8 | 4.9 | 7.1 |
| Oceania | 2.1 | 2.6 | 3.8 |
| Canada | 3.0 | 3.4 | 3.9 |
| Rest World | 0.3 | 0.2 | 0.6 |

Table 2: Sample characteristics II (% of responding star scientists)

| | | Percentages |
|---|---------------------------------------|-------------|
| Gender (N=720) | Female | 5.6 |
| | Male | 92.6 |
| | Missing | 1.8 |
| Type of Institution (N=720) | University | 70.4 |
| | Non-university research entity | 18.3 |
| | Corporate research unit | 2.1 |
| | Other | 5.8 |
| | Missing | 3.3 |
| Mobility Background (N=720) | Non-Movers | 47.9 |
| | Expatriates | 25.1 |
| | Returnees | 26.9 |
| Year of Birth (Mean) | | |
| Non-Movers | 1946.9 | |
| Expatriates | 1946.7 | |
| Returnees | 1945.7 | |
| Expatriates: Years already spent abroad (N=181) | <u>Mean (Min. 0.7, Max. 60): 29.5</u> | |
| | 1 – 10 years | 11.6 |
| | 11 – 20 years | 8.8 |
| | 21 – 30 years | 29.8 |
| | 31 – 40 years | 30.9 |

| | | | |
|----|-------------------------------|--------------------------------------|------|
| 1 | | | |
| 2 | | | |
| 3 | | More than 40 years | 16.6 |
| 4 | | | |
| 5 | | Missing | 2.2 |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | Returnees: Years spent abroad | <u>Mean (Min. 0.5, Max. 40): 5.9</u> | |
| 10 | | | |
| 11 | (N=194) | Less than 1 year | 1.6 |
| 12 | | | |
| 13 | | 1 – 3 years | 49.0 |
| 14 | | | |
| 15 | | 4 – 10 years | 32.5 |
| 16 | | | |
| 17 | | More than 10 years | 12.9 |
| 18 | | | |
| 19 | | Missing | 4.1 |
| 20 | | | |
| 21 | | | |
| 22 | | | |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | | | |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | | | |
| 32 | | | |
| 33 | | | |
| 34 | | | |
| 35 | | | |
| 36 | | | |
| 37 | | | |
| 38 | | | |
| 39 | | | |
| 40 | | | |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | | | |
| 46 | | | |
| 47 | | | |
| 48 | | | |
| 49 | | | |
| 50 | | | |
| 51 | | | |
| 52 | | | |
| 53 | | | |
| 54 | | | |
| 55 | | | |
| 56 | | | |
| 57 | | | |
| 58 | | | |
| 59 | | | |
| 60 | | | |

For Peer Review Only

Table 3: Number of stars employed in US islands of innovation

| United States | Total | Natural Sciences | Medical & Health Sciences | Engineering & Technology | Social Sciences | Agricultural Sciences | Missing |
|-----------------------------|-------|------------------|---------------------------|--------------------------|-----------------|-----------------------|---------|
| Top Islands of Innovation | | | | | | | |
| New York | 35 | 14 | 10 | 4 | 6 | 0 | 1 |
| Los Angeles/San Diego | 32 | 13 | 8 | 7 | 2 | 1 | 1 |
| San Francisco Bay Area | 29 | 17 | 4 | 6 | 1 | 1 | 0 |
| Washington/Baltimore | 29 | 13 | 13 | 2 | 1 | 0 | 0 |
| Boston | 21 | 10 | 4 | 1 | 5 | 0 | 1 |
| Dallas/Houston/San Antonio | 19 | 10 | 4 | 2 | 3 | 0 | 0 |
| Chicago/Milwaukee | 14 | 7 | 3 | 2 | 2 | 0 | 0 |
| Raleigh Durham (RTP) | 12 | 7 | 2 | 2 | 1 | 0 | 0 |
| Total Top Islands | 191 | 91 | 48 | 26 | 21 | 2 | 3 |
| % of total US | 54.6 | 50.8 | 55.8 | 63.4 | 58.3 | 66.7 | |
| Other Islands of Innovation | | | | | | | |
| Ann Arbor, MI | 8 | 6 | 0 | 1 | 1 | 0 | 0 |
| Philadelphia, PA | 8 | 1 | 3 | 1 | 3 | 0 | 0 |
| Seattle, WA | 8 | 3 | 4 | 0 | 0 | 0 | 1 |
| New Haven/Hartford, CT | 5 | 2 | 2 | 0 | 1 | 0 | 0 |
| Columbus/Cincinnati, OH | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| NY-Upstate Network | 3 | 1 | 1 | 1 | 0 | 0 | 0 |
| Pittsburgh, PA | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| Minneapolis/St. Paul, MN | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Urbana, IL/Lafayette, IN | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Total Other Islands | 39 | 16 | 11 | 4 | 7 | 0 | 1 |
| % of total US | 11.1 | 8.9 | 12.8 | 9.8 | 19.4 | 0.0 | |
| Total all Islands | 230 | 107 | 59 | 30 | 28 | 2 | 4 |

| | | | | | | | |
|----|------------------|------|------|------|------|------|------|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | % of total US | 65.7 | 59.8 | 68.6 | 73.2 | 77.8 | 66.7 |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | Other US Regions | 120 | 72 | 27 | 11 | 8 | 1 |
| 8 | | | | | | | |
| 9 | % of total US | 34.3 | 40.2 | 31.4 | 26.8 | 22.2 | 33.3 |
| 10 | | | | | | | |
| 11 | | | | | | | |
| 12 | | | | | | | |
| 13 | Total US | 350 | 179 | 86 | 41 | 36 | 3 |
| 14 | | | | | | | |

| | | | | | | | |
|----|------------------------------------|-----|-----|----|----|----|---|
| 17 | Total US (including stars who | | | | | | |
| 18 | provided information about their | | | | | | |
| 19 | location at the national level but | 390 | 197 | 94 | 44 | 45 | 5 |
| 20 | | | | | | | 5 |
| 21 | not at the regional level) | | | | | | |
| 22 | | | | | | | |
| 23 | | | | | | | |
| 24 | | | | | | | |

Peer Review Only

Table 4: Number of stars employed in European islands of innovation

| Europe | Total | Natural Sciences | Medical & Health Sciences | Engineering & Technology | Social Sciences | Agricultural Sciences | Missing |
|-----------------------------|-------|------------------|---------------------------|--------------------------|-----------------|-----------------------|---------|
| Top Islands of Innovation | | | | | | | |
| London | 26 | 13 | 9 | 1 | 1 | 2 | 0 |
| East Anglia | 12 | 9 | 2 | 0 | 0 | 1 | 0 |
| Munich | 8 | 5 | 3 | 0 | 0 | 0 | 0 |
| Copenhagen | 7 | 3 | 1 | 2 | 1 | 0 | 0 |
| Glasgow/Edinburgh | 7 | 3 | 3 | 0 | 0 | 1 | 0 |
| Paris (Ile de France) | 6 | 4 | 0 | 1 | 0 | 0 | 1 |
| Amsterdam/Rotterdam | 5 | 3 | 2 | 0 | 0 | 0 | 0 |
| Milan/Turin | 4 | 2 | 2 | 0 | 0 | 0 | 0 |
| Total Top Islands | 75 | 42 | 22 | 4 | 2 | 4 | 1 |
| % of total Europe | 39.1 | 37.5 | 45.8 | 23.5 | 40.0 | 50.0 | |
| Other Islands of Innovation | | | | | | | |
| East Midlands | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| Heidelberg | 3 | 0 | 1 | 2 | 0 | 0 | 0 |
| Madrid | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| Rhein-Ruhr | 3 | 1 | 0 | 0 | 0 | 2 | 0 |
| Stuttgart | 3 | 2 | 0 | 1 | 0 | 0 | 0 |
| Bologna (Emilia Romagna) | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| Strasbourg (Alsace) | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| Wageningen (Oost-Nederland) | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| West Midlands | 2 | 0 | 1 | 0 | 1 | 0 | 0 |
| Berlin | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Bordeaux (Aquitaine) | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Kaiserslautern | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Lyon-Grenoble (Rhone-Alpes) | 1 | 1 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | |
|----|------------------------|------|------|------|------|------|------|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | Naples (Campania) | 1 | 0 | 0 | 1 | 0 | 0 |
| 4 | | | | | | | |
| 5 | Total Other Islands | 28 | 17 | 3 | 5 | 1 | 2 |
| 6 | | | | | | | |
| 7 | % of total Europe | 14.5 | 15.2 | 6.3 | 29.4 | 20.0 | 25.0 |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |
| 11 | Total All Islands | 103 | 59 | 25 | 9 | 3 | 6 |
| 12 | | | | | | | |
| 13 | % of total Europe | 53.6 | 52.7 | 52.1 | 52.9 | 60.0 | 75.0 |
| 14 | | | | | | | |
| 15 | | | | | | | |
| 16 | | | | | | | |
| 17 | Other European Regions | 89 | 53 | 23 | 8 | 2 | 2 |
| 18 | | | | | | | |
| 19 | % of total Europe | 46.4 | 47.3 | 47.9 | 47.1 | 40.0 | 25.0 |
| 20 | | | | | | | |
| 21 | | | | | | | |
| 22 | | | | | | | |
| 23 | Total Europe | 192 | 112 | 48 | 17 | 5 | 8 |
| 24 | | | | | | | |
| 25 | | | | | | | |

Total Europe (including stars

who provided information

about their location at the

national level but not at the

regional level)

| | | | | | |
|-----|-----|----|----|---|---|
| 197 | 113 | 51 | 17 | 5 | 9 |
|-----|-----|----|----|---|---|

Table 5: Education of star scientists in US and European islands of innovation

| | Number | | Number |
|---|----------|---|----------|
| United States | of stars | Europe | of stars |
| Top US Islands | | Top European Islands | |
| New York | 39 | London | 36 |
| Boston | 37 | East Anglia | 20 |
| San Francisco Bay Area | 28 | Glasgow/Edinburgh | 8 |
| Los Angeles/San Diego | 19 | Munich | 8 |
| Ann Arbor, MI | 14 | Paris (Ile de France) | 8 |
| Chicago/Milwaukee | 12 | Copenhagen | 5 |
| Washington/Baltimore | 12 | Madrid | 4 |
| New Haven/Hartford | 10 | Bologna (Emilia Romagna) | 3 |
| Dallas/Houston/San Antonio | 7 | Milan/Turin | 3 |
| Raleigh Durham (RTP) | 7 | Total Top Islands | 95 |
| Total Top Islands | 185 | | |
| % of total US | 63.4 | % of total Europe | 46.1 |
| Other US Islands | | Other European Islands | |
| | 16 | | 12 |
| % of total US | 5.4 | % of total Europe | 5.8 |
| Total US Islands | 201 | Total European Islands | 107 |
| % of total US | 68.8 | % of total Europe | 51.9 |
| Other US Regions | | Other European Regions | |
| | 91 | | 99 |
| % of total US | 31.2 | % of total Europe | 48.1 |
| Total US | 292 | Total Europe | 206 |
| Total US (including 54 stars who provided information about their educational origins at the national | 345 | Total Europe (including 31 stars who provided information about their educational origins at the national level | 237 |

Table 6: Educational origins of star scientists located in the top US islands of innovation

| | Number | | Places of Education | | | | |
|----------------------------|----------|---------|---------------------|---------|---------|--------|--------|
| | of stars | | | | | | |
| | working | Other | | | | | |
| | | in each | Endo- | US | Rest US | Europ. | Rest |
| region | gamy | Islands | Rest US | Islands | Europe | World | |
| Top Islands of Innovation | | | | | | | |
| New York | 35 | 8 | 12 | 7 | 2 | 2 | 4 |
| Los Angeles/San Diego | 32 | 5 | 16 | 7 | 2 | 0 | 2 |
| San Francisco Bay Area | 29 | 4 | 10 | 6 | 4 | 2 | 3 |
| Washington/Baltimore | 29 | 3 | 12 | 9 | 2 | 0 | 3 |
| Boston | 21 | 8 | 4 | 4 | 2 | 3 | 0 |
| Dallas/Houston/San Antonio | 19 | 4 | 4 | 5 | 1 | 1 | 4 |
| Chicago/Milwaukee | 14 | 3 | 4 | 1 | 1 | 1 | 4 |
| Raleigh Durham (RTP) | 12 | 0 | 5 | 5 | 0 | 1 | 1 |
| Total Top Islands | 191 | 35 | 67 | 44 | 14 | 10 | 21 |
| (in %) | (100) | (18.3) | (35.1) | (23.0) | (7.3) | (5.2) | (11.0) |

Table 7: Educational origins of star scientists located in the top European islands of innovation

| | Number of stars | Places of Education | | | | | |
|----------------------------|--------------------|---------------------|---------------|---------|-------------------|----------------|---------------|
| | | Endo- gamy | US Islands | Rest US | Europ. Islands | Rest Europe | Rest World |
| Top European Islands | | | | | | | |
| London | 26 | 8 | 1 | 0 | 7 | 8 | 2 |
| East Anglia | 12 | 3 | 1 | 0 | 2 | 5 | 1 |
| Munich | 8 | 3 | 1 | 0 | 2 | 1 | 1 |
| Copenhagen | 7 | 4 | 1 | 0 | 0 | 2 | 0 |
| Glasgow/Edinburgh | 7 | 3 | 1 | 0 | 3 | 0 | 0 |
| Paris (Ile de France) | 6 | 2 | 1 | 0 | 1 | 2 | 0 |
| Amsterdam/Rotterdam | 5 | 1 | 0 | 0 | 1 | 3 | 0 |
| Milan/Turin | 4 | 2 | 0 | 0 | 0 | 2 | 0 |
| Total Top European Islands | 75 | 26 | 6 | 0 | 16 | 23 | 4 |
| (in %) | (100) | (34.7) | (8.0) | (0.0) | (21.3) | (30.7) | (5.3) |

Table 8: US islands of innovation: inflow and outflow of mobile stars

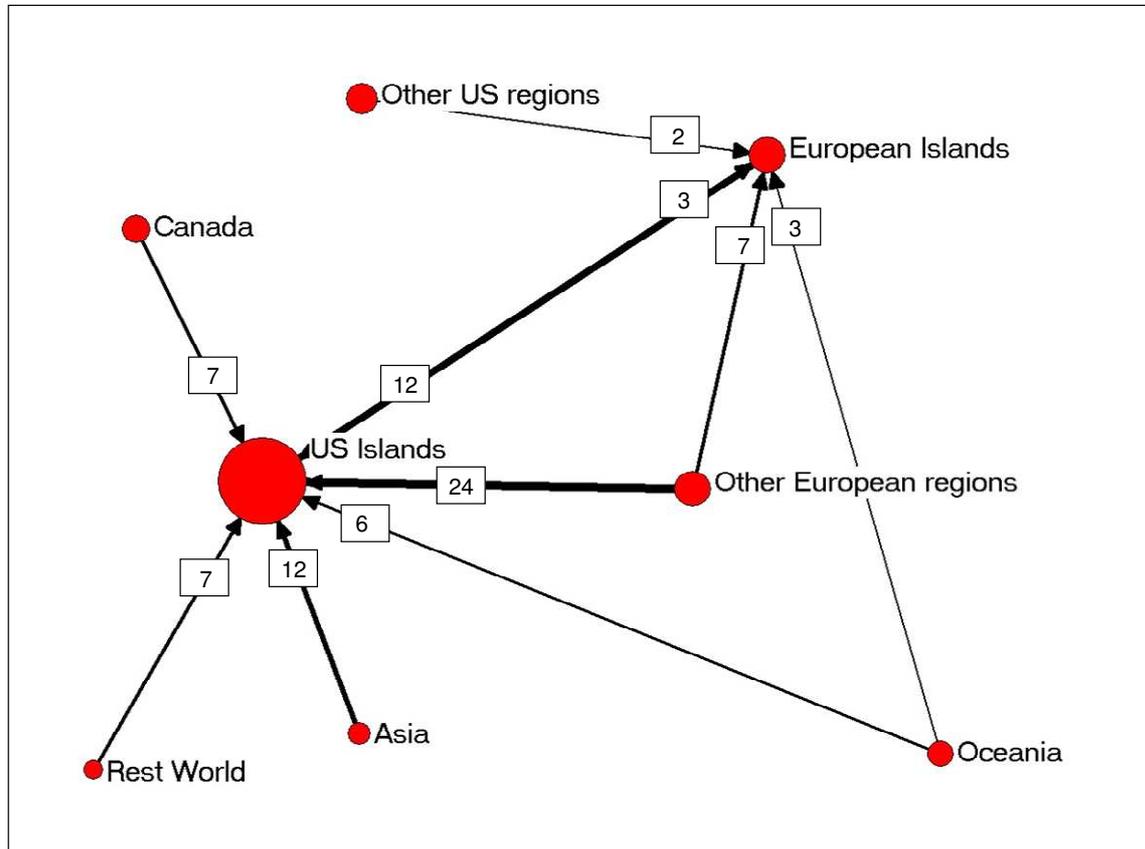
| | Inflow of internationally mobile stars | | | | Outflow of internationally mobile stars | | | | |
|------------------------------|---|----------------|------------|---------|--|---------|------------|---------------|--|
| | Total | Non- movers | Total | | Expatriate | Return. | Expatriate | Total loss | |
| | | | Expatriate | Return. | | | | | |
| Top US Islands of Innovation | | | | | | | | | |
| New York | 35 | 19 | 13 | 3 | 16 | 3 | 13 | 16 | |
| Los Angeles/San Diego | 32 | 21 | 9 | 2 | 11 | 1 | 8 | 9 | |
| San Francisco Bay Area | 29 | 13 | 12 | 4 | 16 | 1 | 17 | 18 | |
| Washington/Baltimore | 29 | 24 | 2 | 3 | 5 | 1 | 8 | 9 | |
| Boston | 21 | 12 | 8 | 1 | 9 | 1 | 7 | 8 | |
| Dallas/Houston/San Antonio | 19 | 12 | 5 | 2 | 7 | 0 | 1 | 1 | |
| Chicago/Milwaukee | 14 | 6 | 6 | 2 | 8 | 0 | 4 | 4 | |
| Raleigh Durham (RTP) | 12 | 7 | 3 | 2 | 5 | 0 | 0 | 0 | |
| Total Top US Islands | 191 | 114 | 58 | 19 | 77 | 7 | 58 | 65 | |
| Other US Islands | 39 | 21 | 12 | 6 | 18 | 2 | 7 | 9 | |
| Total all US Islands | 230 | 135 | 70 | 25 | 95 | 9 | 65 | 74 | |
| (in % of total US) | 59.0 | 58.2 | 63.6 | 62.5 | 52.1 | 69.2 | 74.7 | 74.0 | |
| Total United States | 390 | 232 | 110 | 48 | 158 | 13 | 87 | 100 | |

Table 9: European islands of innovation: inflow and outflow of stars

| | Inflow of internationally mobile star scientists | | | | Outflow of internationally mobile scientists | | | |
|-----------------------------------|---|----------------|------------|-----------|---|-----------|------------|---------------|
| | Total | Non- movers | Total | | Expatriate | Return. | Expatriate | Total loss |
| | | | Expatriate | Return. | | | | |
| Top European Islands | | | | | | | | |
| London | 26 | 13 | 6 | 7 | 13 | 17 | 7 | 24 |
| East Anglia | 12 | 4 | 2 | 6 | 8 | 4 | 4 | 8 |
| Munich | 8 | 2 | 1 | 5 | 6 | 3 | 1 | 4 |
| Copenhagen | 7 | 2 | 1 | 4 | 5 | 2 | 3 | 5 |
| Glasgow/Edinburgh | 7 | 3 | 1 | 3 | 4 | 0 | 1 | 1 |
| Paris (Ile de France) | 6 | 2 | 2 | 2 | 4 | 4 | 1 | 5 |
| Amsterdam/Rotterdam | 5 | 2 | 3 | 0 | 3 | 0 | 2 | 2 |
| Milan/Turin | 4 | 2 | 0 | 2 | 2 | 1 | 0 | 1 |
| Total Top European Islands | 75 | 30 | 16 | 29 | 45 | 31 | 19 | 50 |
| Other Islands of Innovation | 28 | 11 | 3 | 14 | 17 | 3 | 7 | 10 |
| Total all European Islands | 103 | 41 | 19 | 43 | 62 | 34 | 26 | 60 |
| (% of total Europe) | 52.3 | 59.4 | 47.5 | 48.8 | 48.8 | 34.3 | 48.1 | 39.2 |
| Total Europe | 197 | 69 | 40 | 88 | 128 | 99 | 54 | 153 |

Figures

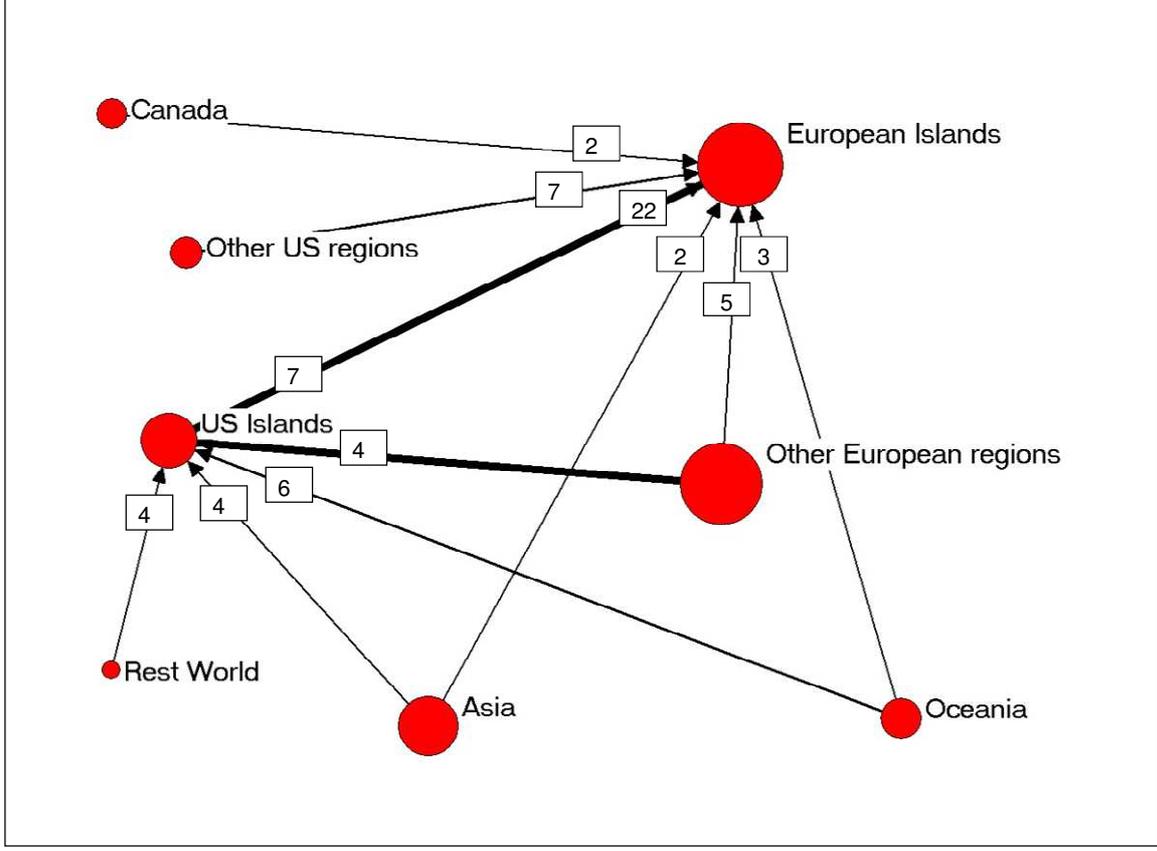
Figure 1: Movements of expatriates to US and European islands of innovation



View Only

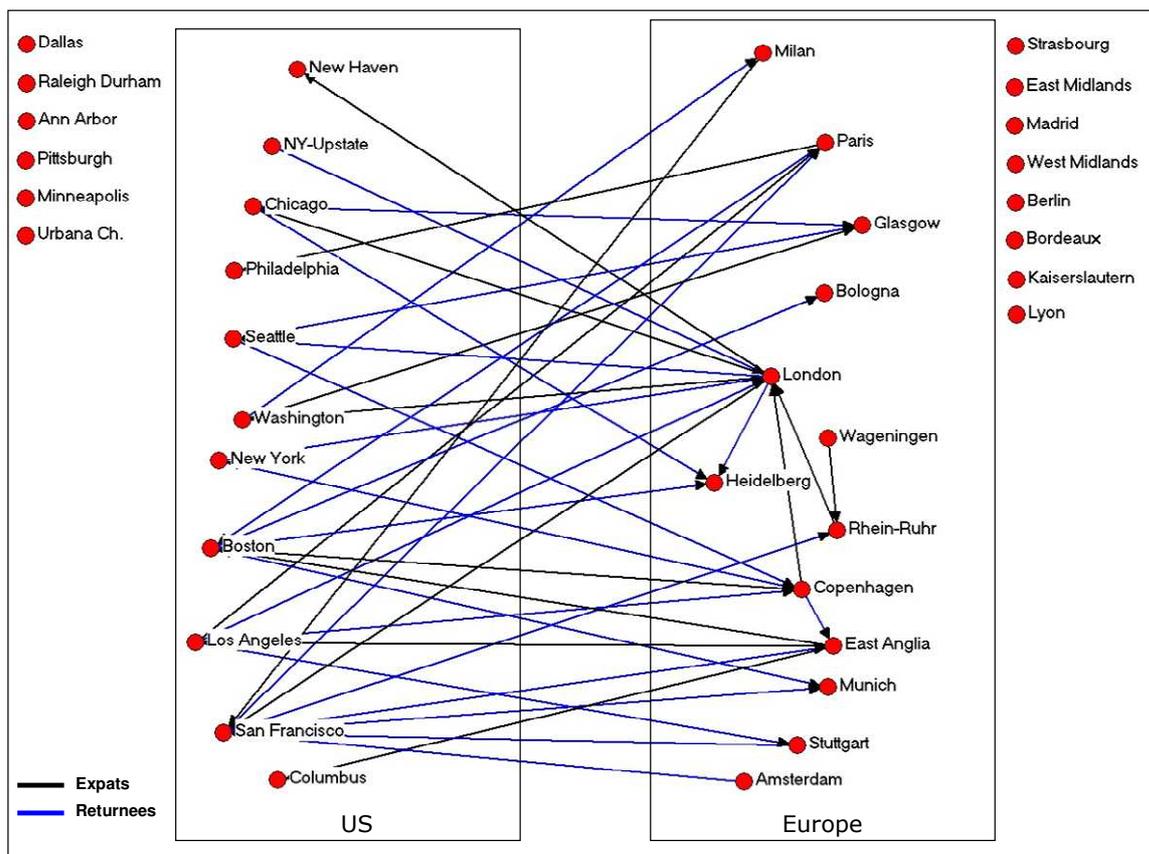
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 2: Movements of returnees to US and European islands of innovation



Review Only

Figure 3: International networking between islands of innovation



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Note

¹ Research disciplines: the 21 subject categories have been classified according to the Frascati Manual (OECD 2006) into broader fields of science and technology.

For Peer Review Only