# Publication and patent analysis of European researchers in the field of Production Technology and Manufacturing Systems

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## Abstract

This paper develops a structured comparison among a sample of European researchers in the field of *Production Technology and Manufacturing Systems*, on the basis of scientific publications and patents. Researchers are evaluated and compared by a variegated set of indicators concerning (1) the output of individual researchers and (2) that of groups of researchers from the same country.

While not claiming to be exhaustive, the results of this preliminary study provide a rough indication of the publishing and patenting activity of researchers in the field of interest, identifying (dis)similarities between different countries.

Of particular interest is a proposal for aggregating analysis results by means of maps based on publication and patent indicators. A large amount of empirical data are presented and discussed.

## Introduction

Evaluating the performance of a research system is a complex and tricky activity wherein many aspects are involved. At the risk of oversimplifying, there generally are two main pathways of interaction between the research system and its environment (Shelton & Leydesdorff, 2011):

- incoming resources, which are essential to feed the research system. They usually are human (e.g. staff) and/or economic-financial ones (e.g. public/private research funding);
- research outputs, which can be divided in two main types: (1) scientific publications (e.g. journals papers, conference proceedings, book chapters, monographs, etc…), addressed to the scientific community, and (2) technology transfer applications (e.g. patents, university spin-offs, consulting services etc…), addressed to the industry and the whole socio-economic system.

Although the first type of research output (i.e. publications) is commonly recognised, the second (i.e. technology transfer applications, which constitute the so called *third mission* for university research systems) has been much discussed only in the last 10-15 years (Nagpal & Roy, 2003; Geuna & Nesta, 2006). Nevertheless, technology transfer is particularly important for the applied scientific disciplines, since they are closely connected to industry and technology in general.

There is a double link between incoming resources and research outputs. While it seems reasonable that more resources are likely to produce more outputs (direct link), on the other hand, a significant part of the (future) resources may depend on the (past) outputs (reverse link). In this sense, there is no clear distinction between cause and effect. However, it can be said that generating good output is a necessary (but not sufficient) condition for a research system's life.

Indicators based on publications and patents – which are both objective and easily measurable quantities – are the most commonly used proxies for evaluating the previous two types of research outputs. In the literature, there are many cases in which these two typologies of indicators are used in combination. For instance, (Czarnitzki et al., 2007; Guan & He, 2007; Calderini et al., 2009; Breschi & Catalini, 2010) and many others. From most of these works, interesting results emerge about the potential correlation between intensity of research activity and patents.

The goal of this paper is to make a preliminary comparison among European researchers in the field of *Production Technology and Manufacturing Systems*, on the basis of the two analysis perspectives of publications and patents. While, in this specific field, some publication analyses have been recently presented in the literature (Franceschini & Maisano, 2011a and 2011b), there is lack of studies from the perspective of patents. This work should be useful for providing a rough indication on the different inclination of researchers to "classical" research and technology transfer, investigating about possible interactions (Agrawal & Henderson, 2002).

A homogeneous sample of researchers from several European countries was identified by referring to members of the CIRP (*Collège International pour la Recherche en Productique*, also known as *International Academy for Production Engineering*), one of the most important international associations of researchers in the discipline concerned (CIRP, 2011). Specifically, we selected the researchers from the first nine European countries in terms of number of CIRP members. The choice of limiting the analysis to European researchers is aimed at making the comparison as homogeneous as possible, especially regarding patent analysis (Criscuolo & Verspagen, 2008; Breschi & Catalini, 2010).

Analysis is carried out by several indicators that are collected using the Scopus database. Input data are publications and patents, with corresponding citations. These data are used to construct other indicators so as to better depict the performance of researchers (Franceschini et al., 2007). Of particular interest is the intensive use of the Hirsch (*h*) index and other *h*-based indicators, both at publication and patent level (Hirsch, 2005; Guan & Gao, 2009; Franceschini & Maisano, 2011b).

While not claiming to be exhaustive and complete, the results of this preliminary study can be useful for:

- providing a rough indication on the publishing and patenting activity of European researchers in the field of *Production Technology and Manufacturing Systems*, investigating possible relationships/interactions;
- identifying (dis)similarities between researchers from different countries, as regards their propensity to publish and patent (being aware that it can be strongly influenced by government policies or incentives).

## Methodology

The same set of indicators is used for both the analysis perspectives of publications and patents. In case of potential ambiguity, when presenting the analysis results, these two categories of indicators will be distinguished by means of the superscript "$^{(PUB)}$", for publication-related indicators, and "$^{(PAT)}$", for patent-related indicators. Indicators can be in turn divided in: (1) indicators related to individual researchers and (2) indicators related to groups of researchers from the same country. They are summarised in Figure 1 and described in detail in the following paragraphs.

All the indicators are calculated taking into account the publications/patents, and the corresponding citations, accumulated up to the moment of the analysis (February 2011).

### *Indicators for individual researchers*

***P***, ***C*** and ***CPP***. *P* is the total number of publications/patents and *C* is the total number of citations received by the scientific publications/patents of a researcher. *P* gives a quantitative information of the publishing/patenting activity. In case of publications, *C* is informative of the total impact/diffusion of one researcher's scientific publications, while, in case of patents, *C* roughly illustrates the overall knowledge flow generated by one researcher's patents. *CPP* is the average number of citations per publication (i.e. $C/P$) and provides an indication of the average impact/diffusion. *CPP* can be used to make comparisons between researchers, regardless of the fact that they have a different number of publications/patents.

***h*-index**. The *h*-index is a relatively recent but very popular indicator that synthetically aggregates two important aspects of the publication output: respectively impact/diffusion – represented by the number of citations of a paper – and productivity – represented by the number of different papers (Hirsch, 2005; Rousseau, 2006; Egghe, 2010; Franceschini & Maisano, 2010a). In general, the larger *h*, the larger the diffusion and prestige of one author in the scientific community. The *h*-index can be also used to evaluate the technological importance and impact of one researcher's patent portfolio, simply considering the number of different patents and the number of citations of each patent (Guan & Gao, 2009).

***Avg co-authors*** is the average number of co-authors relating to publications/patents of one researcher. This indicator is symptomatic of the tendency towards co-authorship.

$Y_{MIN}$ and $Y_{MAX}$ are respectively the year relating to the oldest publication/patent and the year relating to the latest one. They provide a rough indication of the temporal extension of the publishing or patenting activity of a researcher.

$C_{most\text{-}cited}$ is the number of citations received by the most cited publication/patent of a researcher, representing the "jewel in the crown" in terms of impact/diffusion.

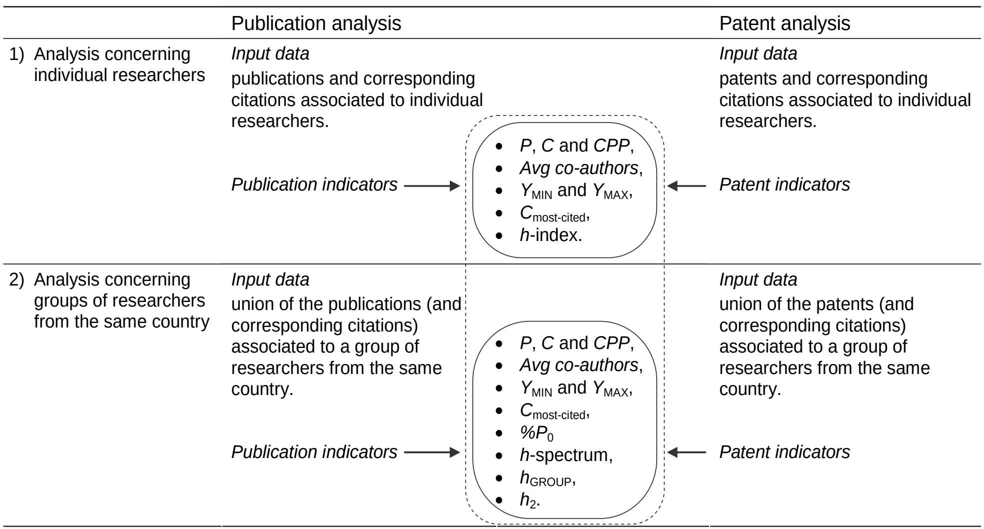


**Figure 1. Summary of the indicators in use. It can be noticed that the same indicators are used for both the publication and patent analyses.**

*Indicators for groups of researchers from the same country*

***P***, ***C*** and ***CPP***, ***Avg co-authors***, $Y_{MIN}$, $Y_{MAX}$ and $C_{most\text{-}cited}$ are exactly the same indicators seen in Sect. 2.1.1. In this case, they are constructed considering the union of the publications/patents associated to a group of researchers from the same country.

$\%P_0$ is the percentage of researchers with no publications/patents. While it is (almost) impossible to find a researcher with no publications, on the other hand, it will be shown that many researchers do not have any patents.

***h*-spectrum** is defined as the distribution representing the *h* values associated to a group of researchers. *h*-spectrum gives a "snapshot" of the population of a group (Franceschini & Maisano, 2010b; Lazaridis, 2010). We can distinguish between local *h*-spectra – i.e. those related to researchers of the same country – and a global *h*-spectrum, constructed considering the *h*-values of all the researchers at European level. Several indicators can be associated to the $h$-spectrum: the average ( $\bar{h}$ ) and the median ($h_{\text{MED}}$) as indicators of central tendency, the corresponding standard deviation ($s$) and interquartile range ($IQR$) as indicators of dispersion.

$\boldsymbol{h}_{\textbf{GROUP}}$ is the $h$-index of a group of researchers from the same country, that is to say the $h$-index of the union of the publications or patents associated to these researchers.

$\boldsymbol{h}_{\mathbf{2}}$ is the first successive $h$-index of a group of researchers. $h_2$ is defined in this way: a group has index $h_2$ if it has $h_2$ members with an $h$-index of at least $h_2$ (Schubert, 2007). Subscript "2" denotes that this $h$-index (of level 2) represents the group's performance, on the basis of the individual researchers' $h$-indices (of level 1, where subscript "1" is omitted). $h_2$ indicates the portion of members that "keep the show going" for one group of researchers, identifying the size of the most productive core of researchers.

## Data collection

A first problem, which is only apparently trivial, is identifying a sample of homologous researchers, belonging to different European nations, but involved in similar research issues. For example, regarding public research institutions, the categorization of scientific fields may vary from country to country (Mattson et al., 2008).

The expedient used to select a homogeneous sample of researchers from several European countries, is to refer to members of an important association in the discipline concerned. In this case, we referred to CIRP, which is one of the major international associations of academic and non-academic researchers (CIRP, 2011).

In this study, we selected about two-hundred total researchers, who are distributed among the following countries: Germany (62), United Kingdom (33), Italy (27), France (17), Netherlands (17), Switzerland (13), Poland (10), Denmark (9) and Sweden (9).

For each of these researchers, publication/patent statistics were collected using the Scopus search engine. We chose this database for three main reasons: (1) in the field of Engineering Science, Scopus' coverage is superior to that of Web of Science (Bar-Ilan, 2010); (2) Scopus is much more accurate than Google Scholar database (Labbé, 2010); (3) Scopus integrates patent statistics from the major worldwide patent and organisations, i.e. EPO (European Patent Office), USPTO (United States Patent and Trademark Office), JPO (Japan Patent Office) and WIPO (World Intellectual Property Organization) (Scopus-Elsevier, 2011).

Regarding publication statistics, Scopus makes it possible to quickly "isolate" researchers by their full first name(s) and affiliation. Nevertheless, seven researchers were excluded from the (publication) analysis, because of the risk of ambiguity.

Regarding patent statistics, data collection was much more difficult and time consuming. In fact, the Scopus patent database reports only the first name initials of a generic researcher, increasing the risk of homonymy. The number of researchers excluded from the patent analysis is doubled (14 researchers). Results associated to non-excluded researchers were examined carefully and cleaned.

The resulting samples of researchers used in the publication and patent analysis are summarized in Table 1, specifying how they are distributed among the different European countries.

After identifying the patents of each researcher, we determined the number of citations received. It may happen that sometimes, the same patent may have been deposited in more than one patent office. The (not very frequent) duplicate patents were identified quite easily, noting the title of the patent and the name of the inventors, and counted only once, whereas the corresponding citations were cumulated. We are aware that this citation "aggregation" could be questionable since the tendency toward citation may change from one patent office to the other (Criscuolo & Verspagen, 2008). However, we believe that these "aggregated" citations give a reasonable indication of the overall impact/diffusion of a patent (Cheng et al., 2010).

**Table 1. Country and staff number of the groups of researchers analysed. In particular, we report the staff number before and after the exclusion of some researchers, for publication and patent analysis respectively. Countries are sorted in descending order according to their staff number before exclusion.**

| Country | Group abbrev. | Staff number | | |
|---|---|---|---|---|
| | | Before exclusion | After exclusion | |
| | | | Publication analysis | Patent analysis |
| Germany | DEU | 62 | 61 | 60 |
| United Kingdom | UK | 33 | 31 | 26 |
| Italy | ITA | 27 | 25 | 27 |
| France | FRA | 17 | 16 | 15 |
| Netherlands | NED | 17 | 16 | 14 |
| Switzerland | CH | 13 | 13 | 13 |
| Poland | POL | 10 | 10 | 10 |
| Denmark | DEN | 9 | 9 | 9 |
| Sweden | SWE | 9 | 9 | 9 |
| | Total | 197 | 190 | 183 |

## Analysis results

Indicators (both at publication and patent level) concerning individual researchers are used to determine the indicators related to groups of researchers from the same country. Results are summarised in Table 2 and deeply discussed in the following paragraphs.

Figure 2 shows the (global) ***h*-spectra** related to the whole set of European researchers examined, respectively from the publication and patent perspective. As expected, distributions are right-skewed and the average *h*-index relating to publication analysis is significantly higher than that relating to patent analysis (see the last row of Table 2-a and -b) (Franceschini & Maisano, 2010b).

Global *h*-spectra may represent a European reference for individual researchers within the area of interest. For example, a researcher with $h^{(PUB)} = 3$ will fall on the 28th percentile. Analogous (local) *h*-spectra can be constructed for each of the nine groups of researchers from the same country.

Consistently with Lazaridis (2010), $\overline{h}$ is used as a synthetic indicator to perform quick evaluations and comparisons among the local *h*-spectra, even if – from a conceptual point of view – it would be more correct to use $h_{MED}$. The reason is that *h* is defined on an ordinal scale (Bornmann et al., 2008; Franceschini & Maisano, 2010a).

Particularly interesting is the comparison between the researchers' $h^{(PUB)}$ and $h^{(PAT)}$ values. In general, the latter ones are very low (e.g. almost 70% of the researchers have $h^{(PAT)} = 0$) for two main reasons: (1) patenting is a relatively rare event in the career of a researcher, as also confirmed by the very large portion of researchers with no patent ($\%P_0^{(PAT)}$, see Table 2); (2) only very few patents are cited heavily, also because it takes time for a patent to accumulate a large number of citations from later patents (Guan & Gao, 2009). In this sense, for individual researchers, $h^{(PAT)}$is significantly less effective than $h^{(PUB)}$, due to the lower discriminatory power.

$\boldsymbol{h_{GROUP}}$ gives an indication of the impact of a group of researchers on the scientific community. As shown in Table 2, and confirmed by (Guan & Gao, 2009), $h_{GROUP}^{(PAT)}$ does not suffer from the low discriminatory power of $h^{(PAT)}$, being based on a larger number of patents (and corresponding citations). Of course, large groups are favoured, since they generally have a larger number of publications and patents. For example, the group of German researchers (DEU) has the highest $h_{GROUP}$ value, both at publication and patent level. Thus, this indicator can not be used to make direct comparisons among groups with different size.

**Table 2. Analysis results concerning groups of researchers from the same country. For each group, several indicators are reported, both at (a) publication and (b) patent level. A detailed description of these indicators is provided in the text. Values are calculated using the Scopus database and taking into account the citations accumulated up to the moment of the analysis (February, 2011). Groups are sorted consistently with the order in Table 1. For some indicators, overall values concerning the whole set of researchers are reported in the last row of the two tables.**

(a) Indicators relating to publications (PUB)

| Group | $N$ | $P$ | $C$ | $P/N$ | $C/N$ | $CPP$ | Avg co-authors | $Y_{MIN}$ | $Y_{MAX}$ | $C_{most\text{-}cited}$ | $\%P_0$ | $\bar{h}$ | $h_{MED}$ | $s$ | $IQR$ | $h_{GROUP}$ | $h_{GROUP,\ norm}$ | $h_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEU | 61 | 4135 | 16266 | 67.8 | 266.7 | 3.9 | 3.2 | 1966 | 2010 | 795 | 0% | 6.9 | 6.0 | 4.2 | 5.0 | 48 | 6.1 | 11 |
| UK | 31 | 1412 | 9737 | 45.5 | 314.1 | 6.9 | 3.0 | 1961 | 2011 | 298 | 3% | 8.0 | 8.0 | 5.5 | 7.0 | 41 | 7.4 | 10 |
| ITA | 25 | 617 | 4758 | 24.7 | 190.3 | 7.7 | 3.5 | 1965 | 2010 | 371 | 0% | 6.7 | 7.0 | 2.8 | 3.0 | 29 | 5.8 | 8 |
| FRA | 16 | 496 | 2572 | 31.0 | 160.8 | 5.2 | 3.2 | 1974 | 2011 | 76 | 0% | 6.5 | 6.5 | 3.6 | 4.3 | 24 | 6.0 | 7 |
| NED | 16 | 346 | 3885 | 21.6 | 242.8 | 11.2 | 3.5 | 1973 | 2010 | 246 | 0% | 6.6 | 6.0 | 5.3 | 9.3 | 32 | 8.0 | 6 |
| CH | 13 | 253 | 1669 | 19.5 | 128.4 | 6.6 | 3.0 | 1964 | 2010 | 139 | 0% | 4.1 | 3.0 | 4.3 | 4.0 | 20 | 5.5 | 4 |
| POL | 10 | 372 | 2530 | 37.2 | 253.0 | 6.8 | 2.7 | 1967 | 2010 | 114 | 0% | 6.8 | 3.5 | 5.9 | 8.3 | 26 | 8.2 | 4 |
| DEN | 9 | 431 | 4294 | 47.9 | 477.1 | 10.0 | 3.4 | 1966 | 2010 | 147 | 0% | 10.8 | 10.0 | 3.8 | 4.0 | 30 | 10.0 | 8 |
| SWE | 9 | 126 | 648 | 14.0 | 72.0 | 5.1 | 2.5 | 1962 | 2010 | 132 | 0% | 3.8 | 3.0 | 1.5 | 1.0 | 12 | 4.0 | 4 |
| Overall | 190 | 8188 | 46359 | 43.1 | 244.0 | 5.3 | 3.2 | - | - | - | 1% | 6.8 | 6.0 | 4.5 | 7.0 | - | - | - |

(b) Indicators relating to patents (PAT)

| Group | $N$ | $P$ | $C$ | $P/N$ | $C/N$ | $CPP$ | Avg co-authors | $Y_{MIN}$ | $Y_{MAX}$ | $C_{most\text{-}cited}$ | $\%P_0$ | $\bar{h}$ | $h_{MED}$ | $s$ | $IQR$ | $h_{GROUP}$ | $h_{GROUP,\ norm}$ | $h_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DEU | 60 | 206 | 734 | 3.4 | 12.2 | 3.6 | 3.3 | 1964 | 2010 | 110 | 47% | 1.1 | 0.0 | 1.6 | 2.0 | 13 | 1.7 | 4 |
| UK | 26 | 31 | 107 | 1.2 | 4.1 | 3.5 | 3.3 | 1954 | 2010 | 31 | 65% | 0.6 | 0.0 | 1.0 | 1.0 | 5 | 1.0 | 2 |
| ITA | 27 | 8 | 8 | 0.3 | 0.3 | 1.0 | 4.5 | 2001 | 2009 | 7 | 89% | 0.1 | 0.0 | 0.3 | 0.0 | 1 | 0.2 | 1 |
| FRA | 15 | 51 | 113 | 3.4 | 7.5 | 2.2 | 2.3 | 1978 | 2010 | 29 | 60% | 0.5 | 0.0 | 1.1 | 0.5 | 5 | 1.3 | 2 |
| NED | 14 | 5 | 29 | 0.4 | 2.1 | 5.8 | 2.2 | 1971 | 2008 | 23 | 71% | 0.1 | 0.0 | 0.4 | 0.0 | 2 | 0.5 | 1 |
| CH | 13 | 70 | 403 | 5.4 | 31.0 | 5.8 | 2.6 | 1972 | 2009 | 80 | 46% | 1.7 | 1.0 | 2.2 | 2.0 | 9 | 2.5 | 3 |
| POL | 10 | 8 | 10 | 0.8 | 1.0 | 1.3 | 1.3 | 1970 | 1988 | 5 | 80% | 0.3 | 0.0 | 0.7 | 0.0 | 2 | 0.6 | 1 |
| DEN | 9 | 10 | 59 | 1.1 | 6.6 | 5.9 | 3.9 | 1982 | 2008 | 55 | 33% | 0.3 | 0.0 | 0.7 | 0.0 | 2 | 0.7 | 1 |
| SWE | 9 | 9 | 118 | 1.0 | 13.1 | 13.1 | 3.0 | 1968 | 2004 | 90 | 56% | 0.9 | 0.0 | 1.2 | 2.0 | 4 | 1.3 | 2 |
| Overall | 183 | 398 | 1581 | 2.2 | 8.6 | 3.9 | 3.0 | - | - | - | 60% | 0.7 | 0.0 | 1.3 | 1.0 | - | - | - |

To make $h_{GROUP}$ values comparable and obtain an indication on the average performance of a group of researcher, complementary to the one provided by $\bar{h}$, a normalization has to be introduced. A possible way is to multiply the $h_{GROUP}$ values by the inverse of the square root of the group size ($\sqrt{N}$). This normalization is quite consistent with other models in the literature, in which the relationship between $h_{GROUP}$ and $N$ is governed by the power law $h_{GROUP} \propto N^{\beta}$, with exponent $\beta$ around 0.4-0.5 (Franceschini & Maisano, 2011b; Ye, 2011).

The advantage of $h_{GROUP,\ norm}$ with respect to $\bar{h}$ is that it can not be inflated by the co-authorship among members of the same group. For example, in case of systematic co-authorship, the $h$-indices of the individual researchers would artificially increase, with a resulting increase in $\bar{h}$.

***P*** and ***C*** are two other indicators influenced by $N$; unsurprisingly, the highest values of these indicators are associated to the group of German researchers. A simple way to enable comparisons among groups on the basis of the members' "average efficiency" is to use the normalised indicators $P/N$ and $C/N$ (see Figure 3). Analysing these and other indicators that are not influenced by $N$ – such as $\bar{h}$ and $h_{GROUP,\ norm}$ – some interesting results emerge.

Regarding publications, Germans are overcome in terms of impact/diffusion (depicted by $C^{(PUB)}/N^{(PUB)}$ values) by the group of Danish and that of British researchers. This is due to the fact that, on average, publications of DEU are less cited than those of other groups. A confirmation is represented by the relatively small $CPP^{(PUB)}$ and $h_{GROUP,\,norm}^{(PUB)}$, with respect to other groups (see Table 2).

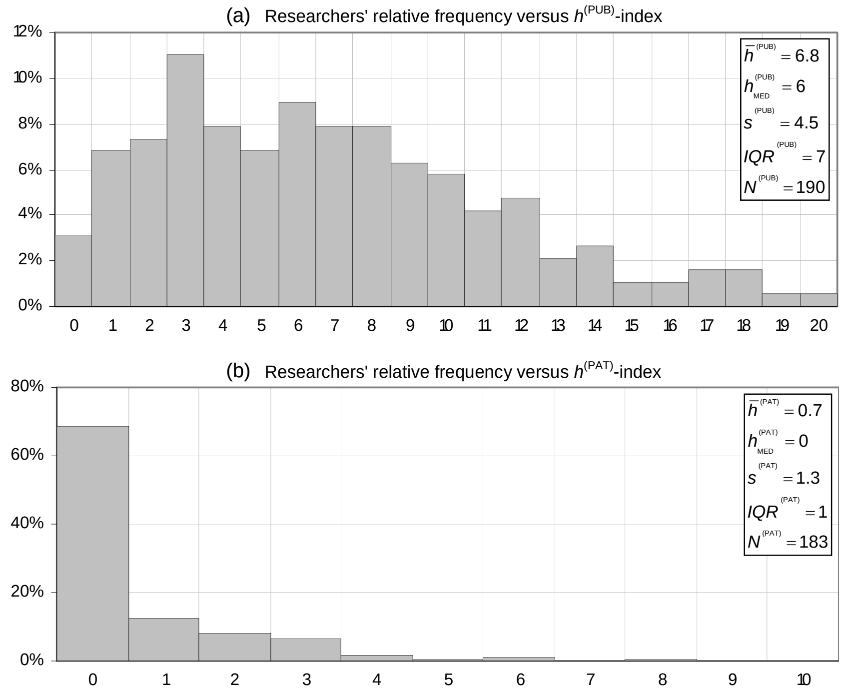


**Figure 2. (Global) *h*-spectra related to the whole set of researchers, respectively for publication (a) and patent analysis (b).**

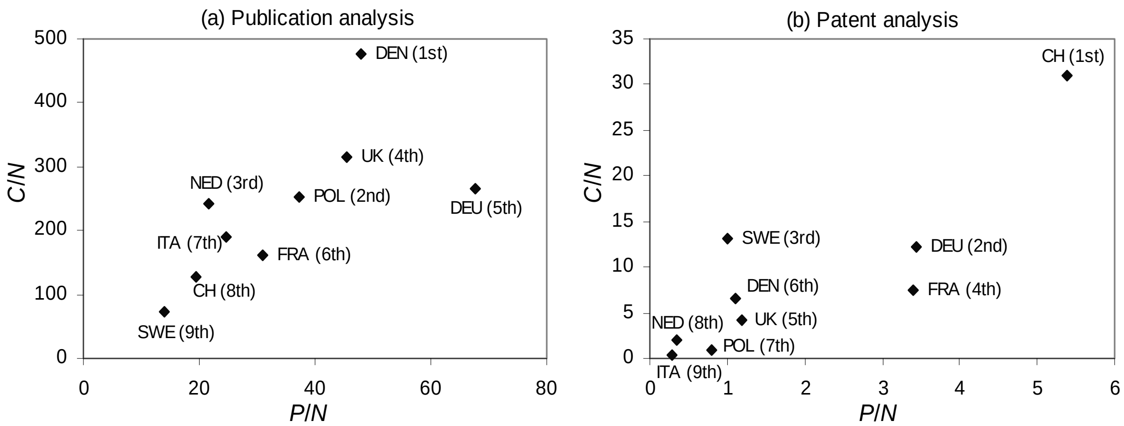


**Figure 3. *C*/*N* versus *P*/*N* for the groups of researchers from the same country, both at publication (a) and patent level (b). Numeric values are reported in Table 2. In brackets are reported the ranks obtained on the basis of the groups' $h_{GROUP}$, norm value, which aggregates the information relating to publications/patents of a group and corresponding citations (see Table 2).**

Regarding patents, Swiss researchers dominate, since their productivity and impact/diffusion is much higher than the other researchers', as evidenced by the very high $P^{(PAT)}/N^{(PAT)}$, $C^{(PAT)}/N^{(PAT)}$, $h_{GROUP,\,norm}^{(PAT)}$ and $CPP^{(PAT)}$ values (see Figure 3 and Table 2). Conversely, Italian researchers show a very low propensity to patent ($\%P_0^{(PAT)} = 89\%$).

A number of issues, that deserve further study, arise from these specific considerations:

- The different trend in publishing and patenting is the result of a conscious decision by researchers?

- Are there any external influences in the publishing/patenting behaviour, such as government regulations or (dis)incentives?
- Researchers with poor patent output are really unable to realize technology transfer?

These questions have been abundantly discussed in the literature (Van Looy et al., 2006; Mattson et al., 2008; Wong & Singh, 2010), although not specifically within the scientific field of interest. Probably a combination from the above factors contributes to generate the observed differences.

Finally, the groups' $h_2$ values are reported in Table 2. Two problems can arise with this indicator: (1) it is influenced by $N$ and (2) it is low discerning when $N$ values are quite small. Generally, the synthesis provided by $h_2$ becomes relevant when the number of the group members and the corresponding $h$-values have roughly the same order of magnitude, so – despite their different nature – they can be compared (Franceschini & Maisano, 2010a). For this reason, in case of patents, we note that $h_2$ is not as discriminatory as in the case of publications.

## Publishing and patenting: any relationship?

The most interesting aspect that emerges when comparing results of the publication and patent analysis, is the lack of correlation between these two kinds of research output. Precisely, there is no correlation ($R^2 \approx 0$) between the $P^{(PAT)}$ and $P^{(PUB)}$ values of individual researchers. We are aware that, in other scientific fields, it was found a general positive relation, supporting the thesis that these activities may actually reinforce one another (Van Looy et al., 2006; Breschi & Catalini, 2010; Wong & Singh, 2010).

Also, we analysed possible differences between academic and non-academic researchers. Although there is no apparent correlation among publication and patent productivity, there are some differences in terms of average amount of production. Precisely, the average total production of publications per capita (represented by the *mean* $P^{(PUB)}$ in Table 3) of academics is higher than that one for non-academics. This means that academics are more inclined to publish, even if – regarding the average impact/diffusion (represented by the *mean CPP*) – the difference is very little. As regards patents, we notice the opposite situation: productivity (represented by the *mean* $P^{(PAT)}$ in Table 3) of non-academics is significantly higher than that of academics. This is also confirmed by the high percentage of academics with no patents ($\%P_0^{(PAT)}$). Regarding the *mean* $CPP^{(PAT)}$, academics are predominant. However, this rather surprising result is given by the fact that, *mean* $CPP^{(PAT)}$ of academics is strongly influenced by the contribution of two researchers, with astonishingly high $C$ values.

**Table 3. Comparison among academic and non-academic researchers with respect to their propensity to publish or patent. For each of the two categories of researchers, the following indicators are reported: mean total publications/patents per-capita (*mean P*), mean total citations per-capita (*mean C*), *mean CPP* and percentage of researchers with no publications or patents (*%P*$_0$).**

| Affiliation | Publications | | | | Patents | | | |
|---|---|---|---|---|---|---|---|---|
| type | *mean P* | *mean C* | *mean CPP* | $\%P_0$ | *mean P* | *mean C* | *mean CPP* | $\%P_0$ |
| Academic | 49.1 | 259.0 | 5.3 | 0.6% | 2.0 | 8.6 | 4.3 | 62.7% |
| Non-academic | 32.7 | 167.0 | 5.1 | 0.0% | 3.4 | 8.8 | 2.6 | 46.7% |

## Aggregation of the two analysis perspectives

Researchers have been analysed from the two (separate) perspectives of publications and patents. Their aggregation remains an open issue, albeit it can be partially overcome by introducing some maps, which depict the research-output positioning of the researchers on the basis of two indicators associated to the perspectives of interest. For example, the map in

Figure 4 plots the $h_{\text{GROUP, norm}}$ values concerning publications and patents respectively for each of the nine groups of researchers. It can be noticed an apparent lack of correlation between the indicators of interest, confirming that – in the discipline concerned – publishing and patenting are quite independent activities.

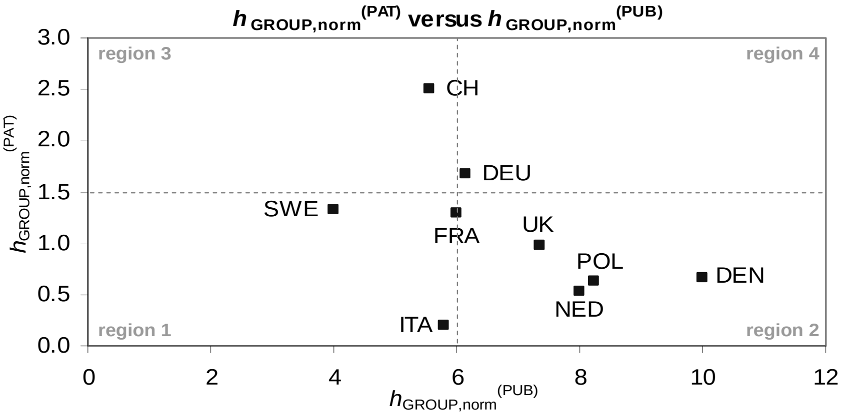


**Figure 4. $h_{\text{GROUP,norm}}$ illustrating the relationship between the $h_{\text{GROUP,norm}}^{(PAT)}$ and $h_{\text{GROUP,norm}}^{(PUB)}$ for groups of researchers from the same country. The map makes it possible to (qualitatively) identify different regions: (1) groups with relatively low performance in terms of patents and publications; (2) groups relatively efficient in terms of publications but not in terms of patents; (3) groups with medium-high performance in terms of patents but relatively poor performance in terms of publications and (4) groups with a remarkable performance both in terms of publications and patents.**

## Concluding remarks

The proposed analysis is based on a limited sample of researchers, thus it is wild to extend the results associated to national groups to the whole national communities of researchers in the field of *Production Technology and Manufacturing Systems*.
Another limitation is that – being based on *h*-index – most of the indicators in use could be subjected to the benefits but also criticisms made to *h*-index itself (e.g. they are sensitive to co-authorship, age of publications/patents, type of publications/patent, self citations, seniority of scholars, etc.. (Franceschini & Maisano, 2010a).
Nevertheless, the fact remains that this work has provided some remarkable initial results on the inclination of European researchers in the discipline of interest to publishing and patenting. Regarding the future, some cues for future research are (1) extending the study to a larger sample (both in terms of researchers and examined countries); (2) studying the time evolution of the attitude to patent/publish by researchers from different countries; (3) providing an interpretation to the differences among national groups of researchers in their publishing/patenting behaviour.

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