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A Case Study of Flanders using European Patent Data

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Abstract

The study tries to analyze regional technological capabilities, linking technological positions to economic strength of the region. To measure this link, we correlate the EPO patent data with trade data to assess the degree to which technological advantages are translated into comparative advantages for the Flemish region in Belgium. The analysis for Flanders provides some interesting insights. Following the skewed distribution of firms, the technological areas in which Flanders is able to build a strong position are very specific: printing technology, weaving technology, photography and recently also telecommunications. Weak positions are outspoken in car technology. Linking these strengths and weaknesses in technological areas to economic activity revealed an important mismatch between both. Most of the Flemish patents are in sectors without any comparative advantage, while most of the sectors where Flanders does hold a comparative advantage, like chemicals and pharmaceuticals, do not show strong technological advantages in terms of patents. Given the mismatch that was detected between technological positions and economic advantages, it is of crucial importance to better understand the (missing) links between the various actors in the regional innovation system. The analysis points out two important issues. The large and growing number of foreign applicants to Belgian/Flemish inventors and the large number of subsidiaries of foreign firms among Belgian/Flemish applicants illustrate the pervasiveness of the foreign dimension in the Belgian/Flemish technological landscape. Also very specific to the Belgian/Flemish situation, is the limited importance of universities or research centers in terms of patenting activities.

A Case Study of Flanders using European Patent Data[1]

Koenraad Debackere, Marc Luwel and Reinhilde Veugelers

1. Aim of the study

It is well recognized that technological capabilities are of tantamount importance to obtain competitive advantages for firms and hence for regions and nations. Governments can capitalize on this by stimulating innovative activities to secure long-run economic growth. Implementation of such policies requires identification of technological strengths and weaknesses and to which extent technological positions acquired by firms, have led to economic strength. From the early 1990s onwards, responsibilities over technology policy have been increasingly more decentralized from the federal to the regional level in many countries, including Belgium. This implies assessing technological positions and economic strengths at the regional level as necessary information for the development of a regional innovation policy. But being able to identify regional technological strength and weaknesses and their translation towards competitive advantages, is also useful for the industrial sector.

Our study is a first attempt to analyze regional technological capabilities and competitive strengths. Using the patent statistics of the European Patent Office (EPO), the technological strengths and weaknesses of the Flemish region, the largest region in Belgium, are identified. To measure the link (or the gap?) between those technological positions and the economic strengths of the region, we correlate the patent data with trade data to assess the degree to which technological advantages are translated into comparative advantages for the Flemish region. Understanding the link between technological position and economic advantage therefore is the major subject of this paper. In exploring this link, we encountered some interesting methodological problems that will be discussed in this paper as well.

[1] This research was supported by a grant from the Flemish Minister for Science and Technology.

2. On the use of EPO patent information

The patent system is designed to stimulate inventions and investments to develop and commercialize innovations by granting temporary monopoly rights to the innovator, while at the same time stimulating diffusion by specifying property rights and making the technical information embedded in the patent publicly accessible (Griliches, 1990, Mazzoleni & Nelson 1998). By modulating the time span and the scope of the patent protection granted to the applicant, governments can influence the fundamental dilemma between appropriation and diffusion, and hence attempt at maximizing the social benefits from technological advance. Taking into account the costs to apply for a patent as well as the "imperfect" benefits for the individual innovator, it is clear that not all innovations will be patented. For instance, even in the case of a "strong regime" of appropriability, the innovator will still have to invest heavily in upholding his patent rights (Teece, 1986).

Not astonishing, quite some empirical studies, using survey information such as the Yale survey (e.g. Levin et al., 1987) or, for Europe, the CIS-survey (Community Innovation Survey) have shown that patents are typically not rated as the most efficient protection mechanisms. The CIS results for Flanders, for instance, indicate that patents are rated on average to be not important, while secrecy, design complexity and short product development lead-times are of major importance in protecting innovations (Veugelers and Cassiman, 1998). Process innovations are often kept secret, while more and more companies attempt at protecting their product innovations through the development of an "integrated design capability" that offers them a "time" and "complexity" advantage over their competitors in the development of new product applications (Debackere and Rollez, 1998). In addition, the efficiency of patent-protection is company and sector specific, with especially the small companies and firms in IT technologies being less inclined towards applying for patent protection (Veugelers and Cassiman, 1998).

However, at the same time, companies are increasingly aware of the strategic value of "collections of patents" to increase their bargaining power in the many technological "make," "buy" and "cooperate" decisions they face. Indeed, the value of an individual patent in and of itself may be prone to the skepticism just described. However, the global competitive arena which many companies are facing, forces them to use patents as an entry deterrent and as a weapon in building bargaining power to negotiate agreements with competitors.

Emphasis therefore has shifted from individual patents as efficient protectors of specific know-how, towards the development of "patent portfolios" as a way to secure growth, expansion and entry into specific product-market combinations. Increasingly, companies realize that building and maintaining technological competencies requires a consistent and wide range of patents, which allows a strong bargaining position in technology transactions and supports swapping or cross-licensing major parts of (or even complete) patent portfolios. To develop, what Merges and Nelson (1990) label as cumulative systems of technology, requires the ability to use of number of already developed components and hence negotiate licenses in an environment where litigation is not a serious threat. As Grindley and Teece (1997) report:

> "The size of the patent portfolio of some firms is often too great for it to be feasible to identify individual infringements ... companies protect themselves against mutual infringement by cross-licensing portfolios of all current and future patents in a field-of-use, without making specific reference to individual patents ... The portfolio approach reduces transaction costs and allows licensees freedom to design and manufacture without infringement".

Or, as one of the major Flemish patent applicants told us, *"it is the length of your pile against the competitor's pile that matters most in strategic transactions on the mutual use and swap of patents."*

In sum, patenting behavior can be an important dimension in understanding firms' innovative strategies. Though, it is clear that patents are only an imperfect proxy for the full scope of technological activities of firms, with a potential for both under-representing as well as over-representing their innovative capabilities. Despite these limitations, patent data are widely used, if only because of their completeness, accessibility, reliability and international comparability. The EPO data have been widely used in many studies (Griliches 1984 & 1990; Schmoch et al., 1992). Next to patent count data, it is obvious that patent documents, because of the legal "reporting" requirements surrounding them, provide the researcher with a wealth of information that can be used for various types of analyses and research questions. For instance, typical patent documents contain the names and the addresses of the inventors and their applicants, as well as references to other scientific and technological documents. This information can be easily used to map progress and collaboration in technological fields as well as to assess the vitality of various organizations (firms as well as universities) in a particular field of technological development (Rappa, Debackere and Garud, 1992). Scholars like Francis Narin (1987, 1988 & 1997) have been extremely prolific in using patent data as a source of data yielding insights beyond the "mere" number counts and citation analyses.

Compared to the USPTO data, EPO data allow us to disentangle patent applications and patent grants. Indeed, in the U.S. systems, patents are only listed in the USPTO databases once they have been granted to the applicant. In the European system, this is not the case. Eighteen months after filing for the patent, the full document is disclosed, regardless whether it has been granted or not. This difference in procedure is embedded in a different emphasis in patent philosophy. In the U.S. system, patent protection aims at safeguarding the rights of the inventor. The European system targets the timely diffusion of new technological information so as to stimulate the rate of technological progress.

Of course, not all patents filed are eventually granted. There are two major reasons for this difference. The first one is obvious. Whenever the patent request does not live up to the expectations of newness and originality as stated in the many patent conventions that exist, the patent will not be granted.

A second explanation is more strategic in nature. We just mentioned the rising importance of patent portfolios in the global competitive arena. Just as patent portfolios may impede entry into specific product-markets and curtail international expansion strategies of competitors, filing for patents without having the intention to pursue the complete patent application trajectory may be part of a pre-emptive strategy. Indeed, when filing for a European patent, the applicant knows in advance that the application will be published eighteen months later, and hence from that point in time onwards, belong to the public domain. By doing so, the applicant may intentionally pre-empt others from staking claims to a similar invention. Thus, the European system with its publication rules based on filed patents instead of on granted patents, may support companies' strategic intent to pre-empt.

Since patents differ greatly in quality (see for instance Trajtenberg, 1990), scholars have since long sought to assess the value of individual patents. Three approaches have been subject to extensive research and have acquired a status of being valid measures as it comes to assessing patent quality. They are: (1) analyzing the citation patterns to specific patents, (2) studying the extent to which patent renewal fees are paid, and (3) examining the geographic scope of the patent protection requested. In this respect, the lack of citation information in the regular EPO data is unfortunate.

In the analysis reported here, only patent count data are used. Both patent applications and patent grants are considered in the present study. Patent applications are considered to be closer to the input side of technology creation (serving as a proxy measure of the creation of new technologies). Patent grants are considered to be closer to the output end of the technology creation process (serving as a proxy for the exploitation of results of technological creativity). Of a total of about 750,000 patent applications available in the volume 1997/001 of Espace Bulletin, covering the period December 1978 till December 1996, 9537 patent applications have a Belgian applicant and/or inventor. Patent data have been assigned to the different Belgian regions on the basis of the addresses of the applicants and/or inventors. Belgium consists of 3 different regions: Flanders, Wallonia and Brussels. Flanders located in the north of Belgium is the largest region, representing 60 % of Belgian GDP (in 1992). Slightly over 67% of all Belgian patent applications have a Flemish applicant and/or inventor. On average, about 47% of all EPO patents applied for are eventually granted. This average holds for the Belgian case as well as for the complete EPO database.

The patent database was further extended with additional layers of data. Patent data are connected to economic data, to further assess the technological and the economic position of Belgium and Flanders. These data layers included VAT data on production statistics and export statistics, as well as data on the structure of the companies holding the patents (independent or part of multi-national corporate structures). This extended database forms the starting point for an integrated data effort on the Flemish R&D environment.

The next section starts with an overview of the major patent statistics for the Flemish region. Section 4 provides an analysis of the technological capabilities of Flemish companies and research institutes on the basis of the EPO patent data. This pattern of technological strength is then linked to economic performance data in section 5. A conclusion summarizes the main findings.

3. Patents in Belgium and Flanders: an overview

As shown in Figure 1, patent applications have been rising in Belgium as well as in Flanders. (The drop after 1994 is explained by the 18 months delay in the EPO publishing procedures, as explained previously). A similar trend is present in the time series of the patents granted. Given the time lags between the publication of the patent application and the final grant of the patent (which on average is between 3-and-4 years), the data on granted patents are only complete till the period 1990-91. To improve on comparability when analyzing time series, we distinguish three different sub-periods: 1980-85, 1985-90 and 1990-94. Blocking the patent data into these time periods further increases the stability of the data since idiosyncratic changes in patent counts in a particular year are neutralized.

-- Insert Figure 1 about here --

About 30 % of all Belgian patent applications with Belgian inventor do not have a Belgian applicant. Foreign applicants (with Belgian inventors) are mostly U.S.-based, but also German, Dutch, French and British applicants are pervasive, following the importance of these countries as home countries to Belgian subsidiaries. As shown in Table 1, their numbers increase over time: most notably the presence of U.S. applicants with Belgian inventors has known a sharp rise over the last five years. This trend might be indicative of the higher importance paid to patent portfolio as a strategic instrument by U.S. companies. The same trend holds for Flanders, where the Brussels region (being home to many corporate head offices) also figures as an important "foreign" applicant. The Walloon region is less important as a home base for applicants with Flemish inventors.

-- Insert Table 1 about here --

This foreign dependency stretches even further than the number of foreign applicants. In Table 2, we show that slightly over half of the Belgian firms applying for patents are Belgian subsidiaries of foreign parents.

-- Insert Table 2 about here --

An extremely small number of patents with non-Belgian inventors have a Belgian applicant, reflecting the low pervasiveness of Belgian parent corporations with subsidiaries abroad.

In Table 3, we highlight the trend in patent applications and patent grants according to an institutional typology, disentangling applicants belonging to the public administration, corporate applicants, private persons as applicants, public research institutes and academic centers. We notice the small share of universities and public research institutes for Belgium as well as for Flanders both in terms of applications and grants. Universities are never co-applicants for corporate patents. Moreover, the trend in academic patent activity has been quite flat over the three time periods considered. This is a contrast to the US, which witnessed an increased entrepreneurial activity of universities, reflected in higher university patenting activity (Henderson et al. (1995)). The highest "hit" ratio (i.e. the ratio of grants over applications) is to be found in the corporate sector.

-- Insert Table 3 about here --

Within the corporate sector, the concentration of patents within a limited number of companies is overwhelming. Twenty companies hold almost half (48%) of all Belgian applications. For Flanders, this concentration is even higher, with 63% of the patents held by the top-20 companies. Agfa-Gevaert, for instance, is the number one and holds 1010 out of the 3990 Flemish applications, Janssen Pharmaceutica is second with a total of 201. This concentration stresses the importance of analyzing Belgian/Flemish patent data at the company level. For the Belgian companies actively involved in patenting, the number of different technological areas in which they operate is quite limited. Almost 65% of all Agfa-Gevaert patents are located within her top 4 IPC codes. For Janssen Pharmaceutica, this IPC-code concentration even amounts to 90%. Bekaert, with a ratio of 39% of its 137 patents belonging to its top-4 IPC codes, is the most diversified over technological areas.

Given the trend towards managing strategic patent portfolios and the subsequent "field of use" approaches, this finding might raise some concerns about the awareness of the Belgian and Flemish industry on the way patents are increasingly being used in the competitive arena. For instance, even if Agfa-Gevaert possesses by far and large the most extensive patent portfolio in Belgium and Flanders, this portfolio is still small in scope relative to its two major competitors, Kodak and Fuji. For the other top-20 companies like Janssen Pharmaceutica, Bekaert, Picanol, Alcatel (Belgium), and New Holland (Belgium), the relative position viz. their major competitors is stronger, though. Although the number of patents in their portfolio is more limited, their focus enables them to still play a significant role in their technological competitive arena. Of course, as the vast majority of Belgian and Flemish companies has less than 40 patents in their portfolio, the concern about their awareness on the strategic use of patent portfolios remains relevant.

4. Technological capabilities in Belgium and Flanders.

In order to study the technological fields, in which Belgium and Flanders have acquired strong positions relative to other countries, we use a "Relative Advantage" measure as first developed by Balassa (1961), but which is now adapted to measure the Relative Technological Advantage of countries in specific technological areas:

RTAij (relative technological advantage of country j in technological area i)

$$= \Sigma_i \Sigma_j (Pij/Pj) / \Sigma_i (Pi/P)$$

with

Pij: number of patents of country j in area i
Pj: number of patents of country j in all areas
Pi: number of patents of all countries in area i
P: number of patents of all countries in all areas

RTAij compares the share of Belgian or Flemish patents in a certain technology area, with the share of all other countries in the same area. If Belgium or Flanders holds a share that is larger than all other countries, it is said that Belgium or Flanders holds a "revealed technological advantage" in this area [2]. We use the IPC-codes to define technological areas and included both Western Europe and all EPO countries as the reference group of countries. Since we concentrate on technological activities, we have analyzed patent applications.

In this paper, we concentrate on the major strong and weak positions. In discussing these positions, we distinguish between areas with a large patent share or a small patent share. Having a strong position in areas with little patent weight will have less impact than a strong position in areas with many patents. Areas with a high share of patent applications but no strong positions are question marks. In the Patel and Pavitt terminology (1997), these technologies are indicated as "background" technologies, while the "core" technologies are found in areas where a strong position is combined with a high share. Advantages in areas

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[2] Since RTA does not measure absolute but relative advantages, each country j has at least one technological area I in which it holds a relative technological advantage.

with only a limited number of patents are associated with niche strategies, built on strong positions in small technology fields.

-- Insert Table 4 about here --

From Table 4, we learn that Belgian and Flemish advantages do not always coincide. This is the case with chemical technologies and biotechnology. Although biotechnology is often claimed to be a Flemish stronghold, a detailed look at the data shows that the Belgian position is at least as outspoken as the Flemish one. This is mainly due to the presence of a major player, SmithKline Beecham Biologicals, in Wallonia.

Strong technological positions occur in traditional IPC-classes such as food and agriculture. The absence of strong positions in technology domains, which are future oriented such as fiber optics (IPC-class G02) and logisitics is also striking (IPC-class B65). In addition, we find an extremely weak position in technology domains like automobiles, notwithstanding the strong economic position of Belgium and Flanders in these fields (see below).

On the other hand, we see that Flanders has been gaining a significant advantage in the IT- and telecom-related field, which are two important core technologies. This position has been acquired only recently, over the last decade. Also, the field of instrumentation and printing has been well developed (mainly due to the presence of Agfa-Gevaert), as well as a number of machine- and textile-related IPC-classes (due to the presence of two major Flemish companies, Picanol and Bekaert).

To conclude, the strong technological positions of Belgium and Flanders mostly reflect the relative technological strengths of the top-20 companies in these fields, rather than being a "real" regional advantage that is supported by a larger platform of companies and research organizations. Only for the IT-related technologies (and to a much lesser extent for biotechnology) might one state that a strong position has developed which is in turn supported by a broader platform of institutions. This finding, of course, makes the technological position of Belgium and Flanders look rather vulnerable, as this position is highly concentrated among a few players and hence not supported by a critical mass of technology-intensive organizations, at least as revealed by patent data.

5. Patents and economic performance

In order to map technological strength onto relative competitive strength in markets, we need to link the technological areas with economic sectors. Concordance tables that allow for this mapping are not error-free and require a high level of aggregation of areas to be consistent. On the basis of the MERIT concordance tables (Verspagen (1994)), the reclassification of Table 4 using industry sectors rather than technological positions (IPC) allows to map shares in patents with technological specialisation per sector of economic activity for Flanders. Patents granted rather than applications are used here in order to approximate more closely the economic exploitation of technological development. These results are summarized in Table 5.

Patent share and strength per economic sector

The most important economic sectors linked to Flemish patents are “instruments” and “machines,” with each about 20% of all patents. For instruments, this is mainly due to Agfa-Gevaert, while in machines Picanol and Bekaert are the major players. In both of these sectors, Flanders has managed to build up a strong technological position, especially in instruments. Defending these core technologies is not obvious. Both in instruments and machines, the RTA index decreases over the three sub-periods, and also shares in patents have been decreasing.

-- Insert Table 5 about here --

Textiles/clothing, telecom and printing/publishing are relatively new strong position, but they are currently still a niche position in terms of share in total patents. Their share in patents granted has, however, been increasing over the different sub-periods. Also their larger share in patent applications, as compared to patents granted, reflects the growth character of these technologies. They hence have the potential to become "core" technologies. The other niche positions, non-ferrous metals and stone/glass, are more difficult to expand and even to maintain. For instance, in the non-ferrous metals sector, the RTA has been steadily declining, and in the last sub-period 1990-94, failed to generate a RTA larger than 1.

Metals are an important sector in terms of shares in patents, but generates no strong comparative technological position, although the RTA index is quite close to 1. Two other important sectors in terms of shares in patents are chemicals and pharmaceuticals. But also in these sectors Flanders lacks a strong technological position relative to other European companies. This demonstrates the strong technological competition in this area, which signals that "being good is not yet good enough" to keep up with the international scene. But the lack of a strong technological advantage can also be related to the pervasiveness in Flanders of subsidiaries of foreign firms in chemicals and pharmaceuticals. Most of these firms have centralized R&D and hence have their patent activities outside Flanders. Increasingly, however, Flanders is able to attract international R&D centers, especially in specific pharmaceutical fields, where the RTA has been increasing over the different sub-periods.

Important sectors like cars, steel, food & drink, electr(on)ics and computers are located in the marginal area. Only the last sector, computers, is increasing its importance and strength over time. Especially the first three sectors (cars, steel, food & drink) will turn out to be not marginal in terms of economic importance.

Mapping patents and economic positions

As already indicated, the reclassification of patents over economic sectors allows to map technological and economic weight and strength. This mapping of technological strength onto economic strength for Flanders shows a lot of divergences. The results of this exercise are reported in Table 6. A measure for competitive advantage can be constructed using the traditional Balassa-index RCAij, which is the corollary of the RTA index, using exports instead of patents:

RCAij (relative comparative advantage of country j in sector i)

=

$\Sigma_i \Sigma_j (Xij/Xj) / \Sigma_i (Xi/X)$

Xij: exports of country j in sector i

Xj: exports of country j in all sectors

Xi: exports of all countries in sector i

Xij: exports of all countries in all sectors

Source: for Flanders: NIS and for Western Europe: EUROSTAT[3]

The combination of strong or weak positions in technology versus strong or weak positions in exports generates four possible outcomes. First, the comparative advantage of the sector can be based on a technological advantage. Alternatively, the comparative advantage can be build on other tangible or intangible advantages, such as brand name or low costs of production as well as location-specific advantages. Sectors with technological advantage must not necessarily display a comparative advantage. For instance, there may be a time lag between having a technological advantage, expressed in terms of patents, and its exploitation in terms of market positions. Or the technological advantage may not suffice to compete with players in world markets, that have other advantages in complementary assets. Product diversification may take longer to materialize than the opportunities associated with technological diversification, because of specialized assets and capabilities required to enter unfamiliar markets. Finally, there are those sectors where the region has neither a comparative advantage nor a technological advantage. We labeled the four groups that are derived from this classification as follows:

- Convergence between technology and competitive advantage: domains of activity where comparative advantages are supported by strong technological positions,
- Divergence between technology and competitive advantage
  - domains of activity in which technological advantages have not (yet) been translated into comparative advantages,
  - activity domains where comparative advantages are not (longer) based on technological advantages,
- No technology or competitive advantage signals an activity domain that is build neither on comparative nor on technological strengths.

A first important observation for Flanders is that the three major patenting sectors (instruments, metals and machines) with a total of 53% of all patents, only represent 9% of the total industrial production over the time-period 1982-94. The "large" production sectors are food/drinks (16%), chemicals (15%), construction (12%) and cars (10%). These sectors together represent only 14% of all patents granted. In the first two sectors, food & drinks and chemicals, Flanders displays a strong comparative economic advantage.

-- Insert Table 6 about here --

The mismatch between technological and economic strength for Flanders is illustrated by the observation that only 35% of all patents are in sectors with strong comparative advantage. Only in the sectors "Paper & Publishing" and "Stone & Glass", a strong technological position is translated in a strong comparative advantage. But these sectors represent less than 5% of the total Flemish patent population and less than 7% of the total Flemish production.

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[3] Exports to the EU are taken; as reference group only Western Europe is used. Two different data sources had to be used, since regional export data are collected by the NIS, but are not reported in the EUROSTAT series.

The three background technologies: metals, chemicals and pharmaceuticals, which fail to reveal a strong technological advantage, but were important in terms of patent shares, are all areas in which Flanders holds a strong comparative advantage. Metals, with a RTA=0.96 for the overall period, is close to a technological advantage. In chemicals and pharmaceuticals, both high-tech sectors, where technology is an important key dimension in firm's success, Flemish firms seem to be very successful in export markets, despite the absence of a strong patent-position. This is reminiscent of the many subsidiaries of foreign multinationals in Flanders who build on transfers in technology know-how elsewhere patented within the organization.

The most striking observation is the position of the sector "machines" and "instruments." Both of the sectors are core sectors in Table 5, with the highest share in patents combined with a technological advantage. But in both of these sectors, Flanders is far from having a comparative advantage with RCA for machines of 0.32 and 0.38 for instruments.

A first explanation could be the long time lag between the building of a technological position and the exploitation of it in international markets, where the latter requires access to more specialized assets. Downstream assets and capabilities remain more specific than capabilities to exploit technological complementarity, certainly for more generic technologies. Applying a dominant logic developed in large incumbent firms may constitute a roadblock to successfully enter new market segments (e.g. Henderson (1993)) Second, this might suggest that Flemish companies are not commercializing the patents themselves or are just patenting strategically to pre-empt competition. The accumulation of technological capabilities may be exploited by other strategies than own downstream activities, such as joint ventures or collaborative agreements, or by licensing. Also the high level of aggregation of the analysis has to be taken into account. Maybe Flemish firms build up strong technological positions in high-tech sub-fields. When aggregating the production in these sub-fields with larger segments of the market, which are less patent-intense, these advantages get wiped out.

But also the problems with the statistical procedures can be an important explanation. First of all, the conversion from IPC to economic sectors (Verspagen, 1994) is not free of error.[4] Another problem is that the production and exports data classify sales of firms fully to their main activity and ignore any diversification movement. Although most of the companies in the sample do not diversify outside the aggregate sectors used in the analysis, for the large Flemish companies important for the patent statistics (like Agfa-Gevaert en Bekaert) this diversification is important. All this suggests that for Flanders with a skewed patent distribution, the firm is the more appropriate level of analysis. In Table 7, we show, for the two big players Agfa-Gevaert en Bekaert, their diversification in terms of production and patents.

-- Insert Table 7 about here --

Both companies are not representative for the average Flemish firm in the patent-database, since both of them have a diversified patent portfolio. Agfa-Gevaert has most patents in instruments and in the graphical sector, but its main production activity is in specialty chemicals, i.e. photochemical products (Nace 259), while it also has some production in telecom (Nace 344). For the moment, Agfa-Gevaert is still allocating its production in chemicals, which seem to suggest the mismatch between sector of technological activities and sector of economic activities cannot be ignored for this company.

Bekaert, the company with the most diversified patent-portfolio, is also diversified on the production dimension, be it that there is still a large proportion in steel cord. The production diversification is however not completely correlated with the technological diversification. The large number of patents in textiles & clothing is not reflected in production statistics. This is partly because a number of those R&D activities that are already translated in production activities, take place within affiliate companies, while the patents are registered at the parent company.

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[4] For instance, steelcord can be allocated to steel (Nace 22) or to metal products (31). This is an important example since Bekaert, the major patent holder in this area in Flanders, is according to

All this suggests that before drawing any conclusions on the link between technological performance and economic performance, more work is necessary when using the proposed methodology. On the one hand analyses are needed on a more detailed firm level, on the other hand, on more stable, less skewed distributed datasets, such as at the EC level. Nevertheless, the result for Flanders that there exists a mismatch between technological and economic positions, has also been observed on other occasions, on other datasets. Patel and Pavitt (1993) for instance when examining US patents of large firms found that their technological bases, measured by patent classes, were much wider than their product mix. Gambardella and Torrisi (1998) found on a sample of large electronic companies that firms that focused their downstream activities, but widened their technological capabilities had on average a better performance. All these results suggest an interesting question of why firms would expand their technological portfolio if they do not exploit this by moving into product markets wherein these technologies can be applied? As already suggested supra, accumulation of technological capabilities may be exploited by other strategies than own downstream activities. But also a wider technology base, not exploited elsewhere, may be valuable to the company in its existing product markets, if it allows improving core products by creating more complex designs incorporating many technologies (for instance at the level of component technologies). Further, more detailed case study analysis would be most welcome to shed further light on this issue.

6. Conclusions

The study tries to analyze regional technological capabilities, linking technological positions to economic strength of the region. Before drawing any conclusions from the results reported for Flanders, some important caveats need to be mentioned. First, the use of patent statistics to measure technological capabilities presents a limited and very specific proxy. Reasons both for having too much or too few patents can be identified. Furthermore, patent counts give no information on the value of patents. Finally, the strong concentration of

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production statistics active in steel (Nace 223) while according to the patent-concordance it is

Belgian and Flemish patents in a small number of large firms, makes the analysis very sensitive to firm-specific effects. The EPO patent data allow for both applications and grants to be measured, each of which identifies different aspect of the technological process. The former is closer to the technological dynamism of the agents, while the latter comes closer the economic exploitation of the technology. But the delay in the patent administration between applications and grants, restricts the use of the recent periods for information on patents granted.

Taking into account all these caveats, the analysis for Flanders provides some interesting insights. Following the skewed distribution of firms, the technological areas in which Flanders is able to build a strong position are very specific: printing technology, weaving technology, photography and recently also telecommunications. Weak positions are outspoken in car technology. Linking these strengths and weaknesses in technological areas to economic activity revealed an important mismatch between both. Most of the Flemish patents are in sectors without any comparative advantage, while most of the sectors where Flanders does hold a comparative advantage, like chemicals and pharmaceuticals, do not show strong technological advantages in terms of patents.

Besides statistical artifacts arising from a skewed and biased data set, this can be a result of the long time delay in exploiting technological strengths or roadblocks to access specific assets to successfully enter new product markets. Alternatively, the accumulation of broad technological capabilities may be exploited by other means than own downstream activities, such as licensing, or may be exploited in existing product markets, where the trend towards the multidisciplinary character and convergence of technologies allows for an intensification of existing product designs.

But also the pervasiveness of subsidiaries of foreign firms in Flanders that use technologies developed elsewhere in the parent company to combine these technological

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allocated to metal products (31).

strengths with strong Flemish location advantages to sustain a comparative advantage, cannot be ignored in explaining the mismatch between technological and economic strength.

This paper has shown the complexity in mapping and measuring the relationship between technological activity and economic positions. Despite methodological caveats, some results from the analysis just reported, provide interesting suggestions for future research. First of all, it is necessary to move to a more detailed firm level of analysis to get a better insight into the relationship between the patent position of Flemish companies and their competitive position in an increasingly global industrial context. This analysis will allow to find an answer on how firms can exploit a broadening scope of their technology portfolio to gain economic strength. Second, given the mismatch that was detected between technological positions and economic advantages, it is of crucial importance to better understand the (missing) links between the various actors in the regional innovation system. The analysis points out two important issues. The large and growing number of foreign applicants to Belgian/Flemish inventors and the large number of subsidiaries of foreign firms among Belgian/Flemish applicants illustrate the pervasiveness of the foreign dimension in the Belgian/Flemish technological landscape. How this foreign dimension in know-how creation translates into value added for the region remains an important but empirically unexplored topic. Also very specific to the Belgian/Flemish situation, is the limited importance of universities or research centers in terms of patenting activities. More work is clearly needed and currently undertaken at these institutions to fully exploit their technological capacities in (international) technology transactions.

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FIGURE 1: EPO-patents filed and granted in Belgium/Flanders

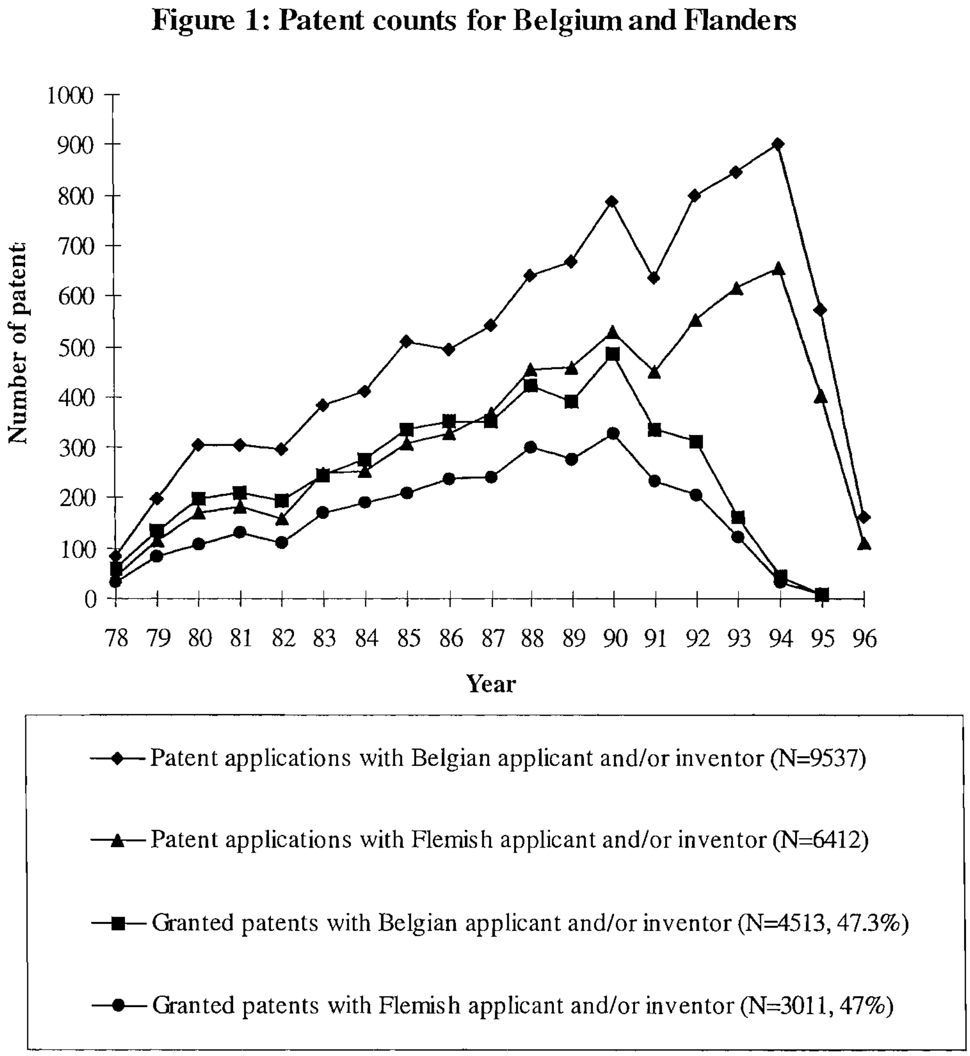

TABLE 1a:

Patent applications with Belgian inventor and non-Belgian applicant:

By country of applicant

Country	1985	1989	1993	1978-1994
United States	14%	13.5%	20.3%	11.6%
Netherlands	4.5%	5.7%	5.1%	4.2%
Germany	6.7%	6.5%	5.1%	5.7%
France	5%	4.1%	4.1%	3.9%
U.K.	5.2%	5%	2%	3.1%

TABLE 1b:

Patent applications with Flemish inventor and non-Flemish applicant:

By country of non-Flemish applicant

Country	1985	1989	1993	1978-1994
United States	13.4%	10.9%	19%	13.3%
Brussels	9.3%	10.4%	4.8%	10.5%
Netherlands	5.2%	5.8%	5.1%	5.2%
Germany	7.8%	6.3%	4.2%	5.8%
France	3%	2.4%	1.2%	1.9%
U.K	4.1%	5.6%	2.4%	3.4%

TABLE 2: Organizational type of Belgian Companies active in Patenting

	Independent company	**Belgian parent**	**Foreign parent**	**Combined Belgian/foreign**
Applications	800 (22%)	854 (23%)	1975 (54%)	6 (<1%)
Grants	435 (24%)	431 (24%)	1376 (52%)	2 (<1%)

TABLE 3: Patents applied and granted as a function of organization type

		1978-1996			1980-1984		
		Applied	**Grant**	**% [1]**	**Applied**	**Grant**	**%**
Belgium	Administration	50	32	64	14	12	85,71
	Company	5589	2804	50,17	983	699	71,11
	Person/inventor	1069	391	36,58	323	122	37,77
	Public research institute	90	32	35,56	8	5	62,5
	University	127	47	37,01	23	13	56,52
		6925	3306	47,74	1351	851	62,99
Flanders	Administration	1	1	100	1	1	100
	Company	3401	1707	50,19	513	396	77,19
	Person/inventor	543	205	37,75	134	51	38,06
	Public research institute	66	19	28,79	0	0	
	University	74	22	29,73	14	5	35,71
		4085	1954	47,83	662	453	68,43
		1985-1989			**1990-1994**		
		Applied	**Grant**	**%**	**Applied**	**Grant**	**%**
Belgium	Administration	27	19	70,37	7	1	14,29
	Company	1720	1187	69,01	2259	777	34,4
	Person/inventor	348	145	41,67	298	97	32,55
	Public research institute	18	13	72,22	45	14	31,11
	University	48	19	39,58	45	14	31,11
		2161	1383	64	2654	903	34,02
Flanders	Administration	0	0		0	0	
	Company	1022	743	72,7	1498	501	33,44
	Person/inventor	177	70	39,55	174	65	37,36
	Public research institute	8	6	75	42	13	30,95
	University	23	8	34,78	28	8	28,57
		1230	827	67,24	1742	587	33,7

(1) % = Ratio of patents granted over patent applications

Table 4:
Mapping share in patents and RTA per IPC code
Average over 78-94 (Belgium)

BELGIUM:

	Strong Position RTA>1	**Weak Position RTA<1**
High Share in Patents	**CORE**	**BACKGROUND**
	A01 (agriculture), A23 (foods), B29 (plastic working), B41 (printing), C01 (inorganic chemistry), C08 (organic compounds), C11 (oils & fats), C12 (biochemistry), C21 (iron metallurgy), C23 (coating), C25 (electrolytic process), D03 (weaving), E02 (hydraulic engineering), E04 (building), E21 (earth drilling), F24 (heating), G03 (photography), H04 (electric communication technique)	A47 (furniture), A61 (hygiene), B01 (physical apparatus), B60 (vehicles), B65 (conveying, packing), C03 (glass), C07 (organic chemistry), F16 (engineering elements), G01 (measuring), H01 (basic electric instruments), H02 (generation & distribution of electric power)
Low Share in Patents	**NICHE**	**MARGINAL**
	A22 (butchering), A42 (headwear) A46 (brushware), A63 (sports) B09 (solid waste disposal), B22 (casting), B32 (layered products) B68 (saddlery), C02 (treatment of waste), C04 (cements), C06 (explosives), C13 (sugar), C22 (non-ferrous alloys), C30 (crystal growth), D07 (ropes), F03 (machines for liquids), F28 (heat exchange), F41 (weapons), G12 (instrument details)	All others

Table 4:
Mapping share in patents and RTA per IPC code
Average over 78-94 (Flanders)

FLANDERS:

	Strong Position RTA>1	**Weak Position RTA<1**
High Share in Patents	**CORE**	**BACKGROUND**
	A01 (agriculture), B29 (plastic working), B41 (printing), C11 (oils & fats), C12 (biochemistry), C21 (iron metallurgy), C23 (coating), C25 (electrolytic process), D03 (weaving), E02 (hydraulic engineering), E04 (building), E21 (earth drilling), F23 (combustion apparatus), F24 (heating), G03 (photography), H04 (electric communication technique)	A47 (furniture), A61 (hygiene), B01 (physical apparatus), B60 (vehicles), B65 (conveying, packing), C03 (glass), C07 (organic chemistry), F16 (engineering elements), G01 (measuring), H01 (basic electric instruments), H02 (generation & distribution of electric power)
Low Share in Patents	**NICHE**	**MARGINAL**
	A22 (butchering), A42 (headwear) A46 (brushware), A63 (sports) B09 (solid waste disposal), B26 (cutting tools), B32 (layered products), B68 (saddlery), C02 (treatment of waste), C04 (cements), D02 (yarns), D07 (ropes), F03 (machines for liquids), G06 (computing)	All others

Table 5:
Mapping share in patents and RTA per economic sector:
Average over 84-94

	Strong Position RTA>1	**Weak Position RTA<1**
High Share in Patents	**CORE**	**BACKGROUND**
	Instruments Machines	Chemicals Pharmaceuticals Metals
Low share in Patents	**NICHE**	**MARGINAL**
	Textiles/clothing Printing/publishing Telecom Non-ferrous metals Stone/glass	Computers Steel Food/drinks Electrotechnical

Table 6:
Technological advantage versus comparative advantage
(CT convergence implies Comparative (C) and Technological (T) Advantages converge, while CT divergence points to both Advantages diverging)

	Tech Advantage RTA>1	**No Tech Advantage RTA<1**
	+ CT CONVERGENCE	**CT DIVERGENCE (C>T)**
Comp Advantage RCA>1	Paper/Publishing Stone/glass	Food & drink Wood & Furniture Metals Chemicals Pharmaceuticals
	CT DIVERGENCE (C<T)	**NO ADVANTAGES**
No Comp Advantage RCA<1	Machines Instruments	Electrotechnical (excluding telecom, radio & TV)

TABLE 7: Diversification of Agfa-Gevaert and Bekaert

Production activities	Patent activities (counts)
AGFA-Gevaert	
Chemical, 95% of total production (Nace 25)	170
Machinery (Nace 32)	71
Telecom (Nace 344)	70
Instruments (Nace 37)	513
Graphical (Nace 47)	277
Others (Nace 49)	115
Bekaert	
Steel, 94% of total production (Nace 22)	17
Non-ferrous (Nace 224)	17
Chemical (Nace 25)	10
Metal (Nace 31)	35
Machine (Nace 32)	32
Textile (Nace 43+44+45)	28