ANALYTICS OF TECHNOLOGY ENDOWMENT MAKING BUSINESS ECOSYSTEMS, CLOSING-THE-LOOP CHAIN NETWORKS AND SYSTEMIC PRODUCTS DOMAINS

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Abstract

This paper reviews current techniques of patent analytics. It outlines how patenting indicators in the context of big data of products and new systemic technology are not yet fully explored: New promising fields are technology landscape semantics, ecosystem technology portfolio analysis and technology geographies. These techniques are then briefly justified for the example of technology forecasting purposes within a current Horizon 2020 project, sustainablySMART.

Keywords: Technology forecast, patent analysis, innovation management, sustainablySMART.

1. INTRODUCTION

Companies file patents in order to protect their technology and to inform stakeholders about their technology assets. The analysis of patent output is then a method benchmarking technology competence between competing firms. As technology output indicator, patent counts let firms analyse emerging markets for new technology and the development of related products and services.

Established domains of patent analytics include the bibliometric analysis of patent titles and patent classes, profiling a company's technology competence [1, 2]; social network analysis or mapping techniques for exploring a technology field [3, 4 ,5]; and the evaluation of technology (patents) stocks quality [6, 7 , 8]. There is also a number of technology showcases for the utility of patents analysis deployed to indicate the shape of technological fields [4, 9, 10, 11].

Less explored are patent text analyses by nested keywords search, where keywords are derived from systematic literature review [12, 13].

Researchers especially in economics of technology have also tracked properties of patent fields over time.

First, patenting fields can be tracked using a fixed set of technology classifications provided by the patent offices. Concordances estimate the match of patent classes with certain industries. Patent examiners classify new patent applications by science discipline into pre-defined patent classes. E.g., IPC class C for "Chemistry and Metallurgy", including well defined sub classed such as C02F "Treatment of Water, Waste Water, Sewage or Sludge". The patent classification tries to cluster technology by process, purpose or technologically distinct industry niche sectors, whatever is most characteristics for those developing the technology in question. For IPC class C, the description of scope is as follows: "*Section C covers a) pure chemistry, which covers inorganic compounds, organic compounds, macromolecular compounds, and their methods of preparation; b) applied chemistry,* *which covers compositions containing the above compounds, such as: glass, ceramics, fertilisers, plastics compositions, paints, products of the petroleum industry. It also covers certain compositions on account of their having particular properties rendering them suitable for certain purposes, as in the case of explosives, dyestuffs, adhesives, lubricants, and detergents; c) certain marginal industries, such as the manufacture of coke and of solid or gaseous fuels, the production and refining of oils, fats and waxes, the fermentation industry (e.g., brewing and wine-making), the sugar industry; d) certain operations or treatments, which are either purely mechanical, e.g., the mechanical treatment of leather and skins, or partly mechanical, e.g., the treatment of water or the prevention of corrosion in general; and e) metallurgy, ferrous or non-ferrous alloys.*"

Patents implicitly give information about who has entered a market with R&D activity and who appears having abandoned it. Although the patent offices may change classifications over time, previous filed patents are usually additionally then assigned or reassigned to new, added classes as appropriate.

Second, patenting fields can be tracked using a fixed sample set of firms. Note that patents name their applicants and inventors.

New patents then filed over time either indicate unchanged, new emerging or shifting R&D priorities. This may be used to track a set of a company's most regarded competitors or relevant technology complementors. Figure 1 contrasts the two approaches of tracking patenting fields over time.

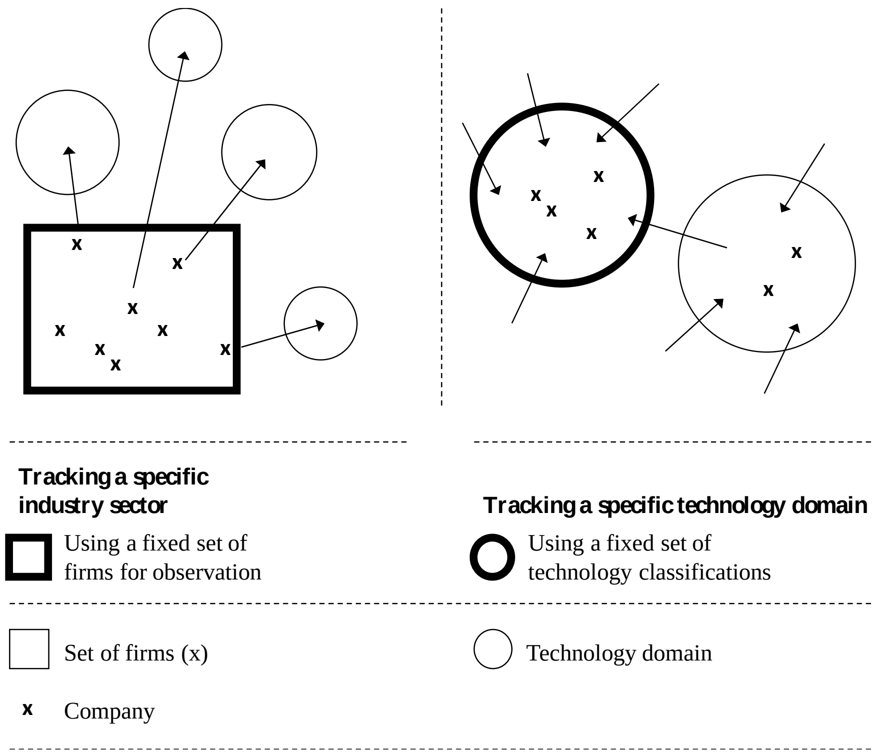

Figure 1 – Tracking Patenting Fields' Inter-temporal Dynamics

2. PATENT ANALYTICS

2.1 PATENT ANALYTICS FOR BIG DATA

The depth of patenting count techniques and mapping and visualisation of technology domains vary across industries. Patent profiles scoping of competitors is particularly advanced in R&D departments of high-technology sectors such as pharmaceutical industry. Current challenges in technology strategy related analytics for instance are: facing big data [14]; learning/time series analytics; and representation of expertise not explicitly written down in the patent's text of abstract, title or claims

[15, 16]. The advancement of high performant ICT furthermore gives rise to new machine-aided analysis of documents such as with metrics and heuristics [8] and for image and designs recognition [17].

ICT and clean technologies are examples of increasingly large but integrated systems in scale and scope, representing big data amounts to design, manage and monitor them. Take for instance:

- From local, physical data storage toward cloud storage. Big data and its accessibility becomes a product.
- From single IT products toward ecosystems of integrated hardware, complementary products, software apps, subscriptions, and services-on-demand.
- Disintegrated product-based industries becoming integrated bundled-products-with-services-offerings industries. E.g., from gasoline cars toward electric cars or fuel cell cars, then incorporating their value chain and value adding services. The concept of zero emission vehicles considers the full carbon emissions output from energy production, over manufacturing, embodied natural materials, to disposal/recycling/recovery.
- From transport as a service toward transport as an infrastructure provision. This includes optimising traffic routing, optimising by design, and learning behaviour from real time data analytics.
- From modular products (in terms of well-defined components and interfaces) toward modules as standalone products. The issue here then is relevance – how to analyse the patent landscape of the relevant system and how to define the boundaries of relevance beyond the company's own module.

A specific challenge from big data arises in the function-argument-structure of systems. Which patent claims are particularly relevant depends on the strategic positioning of the firm within a business ecosystem of products and partners, or within an extended value chain network. Is it an interface/design, a process technology, basic research or a product feature, and so on? Whilst the early advances in patent analysis were in statistics and database querying of economics scholars/ICT, the emerging research frontiers now lie in demanding an unfolding of multi-component settings of products, services, process technology, patent-protected engineering know-how and related services. It is this complexity that, so our argument, may require a shift in tasks from counting and statistics of technology competition toward a more heuristic, pattern-detecting of relevant big data subsamples.

We define the systematic pattern-retrieval from text mining in firm strategy context as "patent scoping". Figure 2 displays the paradigm shift from counting technology toward reducing datasets size for advanced analytics purposes.

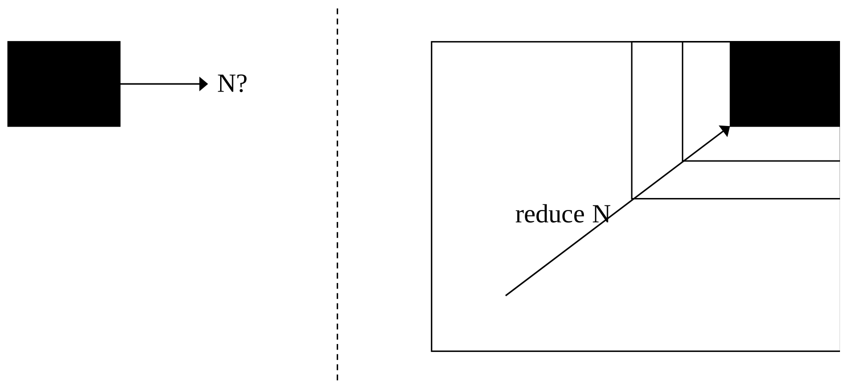

Figure 2 – Reducing Data Amount by Analytics

2.2. SEMANTIC ATTEMPTS TO PATENT ANALYTICS

The terminus “semantics” is chosen to express that language follows inherent structures. This includes conceptual categories and the making of relationships among items. More specifically, function-argument-structures. The argument of an item’s properties is derived from the expected functionality. A sentence names the place of a thing or object, paths (to/from/away from and so on), the event actioned, the states of the thing/object as well as causes and effects [18, ch. 2]. Language can be interpreted as functional structure, that is, a set of objects in mutual context (see semantics’ quantification in [19]). Patent abstracts are plain human texts, following technical conventions of industry, and specific key words that signalise materials, technology vintages/generations and application purpose. The word “process” for instance indicates process innovations whereas elsewise a patent is likely product or service innovation related. Other areas of semantics such as tonality do not apply to patent analysis: Patents are always written in formal tone. The semantics of a patent texts could rather reveal properties of the analysed technology field and landscape in question.

In the context of big data, as being large sets of interconnected firms, sector and products information, a “business model” describes how and why the different system parts coherently come together. In such sense, it defines the boundaries of the patent search. Chesbrough and Rosenbloom argue the business model itself becomes the unit of analysis, if planning for a successful implementation and commercialisation of technological invention [20]. Likewise, commercial success is determined to some extend by the strategic fit of corporate strategy and firm internal resources; the fit of technology; and alignment with the right business model [21].

The role of business models in this paper’s context remains ambiguous: Firms do landscape their technological domains for competitive threats and opportunities. Thereby, they set new directions and so reshape historic technological landscape. In case of business model innovation and disruptive technology rollout, changes in business models are triggered and triggered beyond the single firm. Depending on the status position of the firm, previous technology landscapes might be fundamentally restructured.

The previous mentioned, a patent is a contextualised set of texts. Table 1 outlines a variety of examples how to conduct patent scoping from textual data.

Table 1 – Approaches of Patent Analytics as Scoping Technology Landscapes

Patent file field / descriptor	**Firm descriptors from other databases**	**Search strategy**	**Scoping purpose**
Abstract, Title	-	Matches key words / semantics	Reduce N of dataset
Abstract	-	Contains words which facilitate the analysis in typologies (e.g., “process” indicating process technology)	Allocate technology to value chain(s) (product, service, process technology?)
Abstract, Claims	-	Compare business model related keywords with text	Identify purposes and direction of technology landscape
Citations	-	Track references with other patent families	Define the boundaries of a specific technology domain
IPC classes [technology classification]	-	Number of classes and for chosen technology	Evaluate technology scope and foci in product, process or additionally in business model context
		Patents in same class(es)	Evaluate a firm’s or consortium’s technology competence
IPC classes [technology classification], Claims	-	Estimate probabilities of firm of field to further engaging in a certain direction of technology development	Identify trends
	Industry	Derive function-argument	Evaluate purposes of technology

	classification, or Business model ecology	structures	
Applicant(s)	-	Several applicants? Companies named?	Map firm collaboration
		Comes from Town, Country	Map geography of technology
Inventor(s) [address]	-	Comes from Town, Country	Map geography of technology
Priority date [and comparing different, related patents]	-	Technology filings over time	Visualise technology trajectory; Identifying technological trends on industry level or for product categories

3. TECHNOLOGY FORECASTING IN THE SUSTAINABLY-SMART PROJECT

This paper provides the basis of a patent analysis to be conducted in the Horizon 2020 research and innovation project sustainablySMART. The project pursues developing closing the loop approaches for mobile information and communication devices, taking an integrated product lifecycle perspective. The project consortium consists of 17 partners coming out from seven European countries. Their joint research work is to push re-use, remanufacturing and recycling to the next level of advanced industry techniques. Partners are manufacturing companies; applied research institutions; and universities.

The research agenda involved generating new product design approaches for improving end-of-life performance, products' re-use and remanufacturing aspects. More specifically, implementing "design for a circular economy" concerning smartphones, tablet computers, and their components. Whilst product-centred in approach, the project does also consider necessary process technology innovation. Examples are re-/de-manufacturing processes capable of improving resource efficiency: through optimized sorting capabilities and efficiency; through novel disassembly technology for products' re-use purpose; better material separation; high-quality performance testing (batteries); and the re-working) of re-usable components (semiconductors and modules). This is also to create a market-push for re-usability of parts, providing enhanced availability of repair and cascading re-use opportunities. The project develops an approach of economic advantage from closing the loop as compared to state-of-art end of life practices (e.g., shredding). It will address business models in nine case studies.

One work task of this project concerns the technology forecast in the context of such business models and loop closed value chains. A remanufactured or re-used product competes, however, with latest product in use value and with a number of alternative life cycle prolonging options. This includes the rational of multiple overlapping second and third use cycles versus generating waste / the disposed product / waste streams [22]. The R&D departments would therefore extend the traditional technology forecast (what new features, materials and so on; which new competitors) with a landscaping of the relevant technology providers ecology for the entire anticipated new product life cycle – loop closed. That implies: What process technologies at all stages: product technology development; first use prolongation (e.g., refurbishment and components updating); recycling and recovery; waste treatment. Within the project, the technology scoping looks at the product in conjunction of the business model specified. Such patent analytics can be considered as specific type of landscaping within a specific industry's patent stocks.

Given that competition in extended lifecycles unfolds with time-lag, technology forecasting should explore options much more than counting the landscape as is. Semantics as displayed in this paper provided missed methods for accounting the technology available or yet to emerge. Moreover, if new business models serve the effective commercialisation of technology, then new technology threatens outdated business model and the companies relying on the latter. Development trajectories of a new technology can shape business development opportunities from new closed-loop business models and vice versa [23, 24].

4. DISCUSSION

This paper reviewed patent analytics as a matter of scoping emerging technology, and of profiling the historic technology trajectory of established industry segments. Nonetheless, such analysis takes place on a strategic level before the legal and feasibility study of a new product development. The analysis is focused on the information function of patents. The development of a new product thereafter has to evaluate the risks of infringing upon competitors' patents, infringing related patent pools, the right scope and effectiveness of the patent claims and so on. This evaluation focuses on the protection function of patents. The practitioner might question whether the strategic analysis or scoping of patent output has a separate merit in itself. We argue that there is a market and need of intermediaries such as R&D and innovation consulting firms and technology management academics to inform particularly small and medium enterprises about trends in their relevant patenting domains. Leading or large multinational corporations may well have patent management departments which are already undertaking the kind of patent scoping that our paper outlined.

A paradigm shift from primarily counting and statistics in technology competition analysis toward a more holistic patent scoping especially requires mixed methods. Relevance of key termini and technology classes may be best established from expert interviews, conducted for mapping key words and business model descriptions behind a strategy rational. A three-faced inquiry creates the basis for a complex whilst "better" search strategy:

- Which key words technically describe the essential things for our company, in relation to the network of relevant things in the product ecosystem/value chain/network of business model partners?
- Which patent claims does the business model suggest are essential?
- Strategy rational: What is the company's strategy for the use of patents and complementors' technology?
- Strategy rational: Does the technology serve a product and service, or rather is the technology itself offered?

The qualitative findings from experts and business model formalisation are then to be combined with synonyms keywords, proxies of patent quality, exclusion of false matching terms and known technology field boundary definitions. Such a search strategy would then be applied to advanced quantitative methods. Again, given the complexity, big data demands for tools simplifying even the reduced data sets' representation. Examples are graphical enriched social network analysis or 3D technology landscapes.

5. CONCLUSIONS

Patents texts can be used as a body of technology information over time and of technology endowed in product ecosystems or the commercialisation of new business models. Our paper outlined how this analysis differs from conventional patent counts analysis and the analysis of single firm's patent portfolios. "Patent scoping" is rather about retrieving the relevant sets of technologies, systems' core component design and appropriated application claim from large public data sets. The most intuitive databases for this purpose are triadic patent and national patent databases, such as e.g. PATSTAT. Previous research has tracked technologies over time using such patent data but with a limited range of techniques. This paper conceptualised new frontiers of semantic analysis and enriched visualisation where technology endowment is within a complex system of relevant external assets.

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