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Temporal analysis of patents in the engineering field

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Abstract. Patent analysis is considered a strategic tool for understanding the technological dynamics of a country, especially in highly complex sectors such as engineering. In the Brazilian context, assessing the representativeness and temporal evolution of patent filings in the engineering area allows us to identify innovation trends, emerging technological sectors, and potential development opportunities. This study aims to analyze the temporal distribution of engineering-related patents filed in Brazil, based on data available on the Espacenet platform, seeking to understand the evolution of technological interest in this specific sector over the years. The methodology adopted involved extracting data on patents filed in Brazil from 1900 to 2024 from the Espacenet repository. For the purposes of this research, patents classified in sections B (Processing operations; transportation), E (Fixed constructions), and F (Mechanical engineering; lighting; heating; armament; explosion) were considered to belong to the engineering area. The data were organized according to the year of filing and the corresponding IPC section, allowing the construction of time series and comparative analyses. The results reveal a progressive growth in the number of patent applications in engineering over the last decades, with peaks at certain periods. The areas with the greatest representation were those associated with industrial processes, material handling and transportation systems. Furthermore, it was possible to observe an increase in the technological diversity of patents in recent years, suggesting an expansion of the activities of inventors and companies in different fields of engineering. However, it is possible to conclude that the temporal analysis of patents allows mapping the technological development of a given segment. The representation of engineering in the patent system reflects its importance as a vector of development and its relevance in the scientific and technological advancement of the country.

Keywords: Patent, Analysis, Engineering, Pytente.

1 Introduction

The constant growth of technological and scientific production in recent decades is evidenced by the significant increase in patent filings in various areas of knowledge. Patents, in addition to being instruments for protecting industrial property, are relevant indicators of the innovative activity and technological development of a given segment Nascimento, Speziali[1].

It is clear that there are several ways to keep up with technological developments, such as reading news, specialized publications, participating in conferences and technological events, following academic research, among others. However, the main source of data on technological development is patent documents. According to the National Institute of Industrial Property (INPI), approximately 70% of technological knowledge is disclosed exclusively through this type of document. Patent data contain valuable information for technical analyses, in addition to being considered the main way of sharing technological knowledge Calzolaio et al.[2].

Given the above, patent analysis is considered a strategic tool for understanding the technological dynamics

of a country, especially in highly complex sectors, such as engineering.

In the Brazilian context, the temporal analysis of patents in the engineering field allows us to identify innovation trends, emerging technological sectors and potential development opportunities. This analysis is particularly important, since this field is directly linked to the development of technical solutions applied to industry, infrastructure, energy, mobility, automation, among other strategic sectors.

1.1 Objectives

This study aims to analyze the temporal distribution of engineering-related patents filed in Brazil, based on data available on the Espacenet platform, seeking to understand the evolution of technological interest in this specific sector over the years. As well as highlighting the analysis of patent documents as a relevant tool for technological analysis.

1.2 Methodological processes

This work is characterized as exploratory and descriptive research, with a quantitative approach, based on bibliometric analysis of patent data.

The data were collected from the public database of the European Patent Office (EPO – Espacenet) and using Brazil as the selection criterion as the deposit country and the subclasses of the International Patent Classification (IPC) related to engineering. The time frame considered the period from 1990 to 2024.

2 Development

The first stage of this research consisted of acquiring bibliographic data on patents filed in Brazil between 1900 and 2024 related to engineering areas. The classification of patents as belonging to this domain was carried out based on the International Patent Classification (IPC), assigned to each patent document. This criterion is widely adopted, since all granted patents are mandatorily categorized according to their technological nature, in accordance with the guidelines of the IPC system, used in Brazil and internationally Brasil[3].

For the purposes of this study, patents linked to the field of engineering were considered to be those classified in the following sections of the IPC, according to the World Intellectual Property Organization (WIPO) WIPO[4]:

- Section B – Processing Operations; Transportation;
- Section E – Fixed Constructions;
- Section F – Mechanical Engineering; Lighting; Heating; Armament; Explosion.

These sections cover in a representative manner the technological domains traditionally associated with the different types of engineering.

The repository selected for data collection was Espacenet, maintained by the European Patent Office (EPO), due to its relevance, scope and, especially, the availability of the web service called Open Patent Services (OPS). OPS is a programmatic interface based on RESTful architecture, which allows structured access to data from the EPO patent database. Communication is carried out through XML (eXtensible Markup Language) and JSON (JavaScript Object Notation) standards, which are used for communication and formatting of responses to submitted requests, according to previously defined parameters. This resource therefore enables the development of automated strategies for the extraction of large volumes of patent data.

The queries were structured using the Contextual Query Language (CQL), according to the official specifications of the OPS service OPS[5]. The syntax adopted to retrieve the documents of interest was as follows:

- pd="19000101 20241231" AND pn="BR" AND (ipc="B" OR ipc="E" OR ipc="F")

In which:

- **pd** refers to the range of filing dates (from January 1, 1900 to December 31, 2024);

- **pn** indicates the country of filing, with "BR" corresponding to Brazil;
- **ipc** represents the sections of the International Patent Classification selected for this study.

Using the strategy presented, the collection stage was implemented and automated using the Pytente tool. Pytente is a technological solution developed specifically to support the collection, storage and processing of patent bibliographic data. The tool was designed to optimize the collection of large volumes of records from open access repositories, such as Espacenet Silva [6].

After collection, Pytente organizes the data into tables in a local SQLite database. The adoption of SQLite is appropriate because it does not require the implementation of a dedicated server and does not require complex configurations. These characteristics make SQLite a practical and easy-to-use solution, in addition to supporting up to 280 terabytes of data SQLite[7].

Furthermore, organizing the data collected in a relational database enables the use of SQL (Structured Query Language) queries to retrieve data for analysis. Although using SQL requires technical knowledge, this language offers greater flexibility for retrieving information, allowing the use of any field from the defined tables as search and selection criteria. Fig. 1 presents the conceptual model of the database established by Pytente.

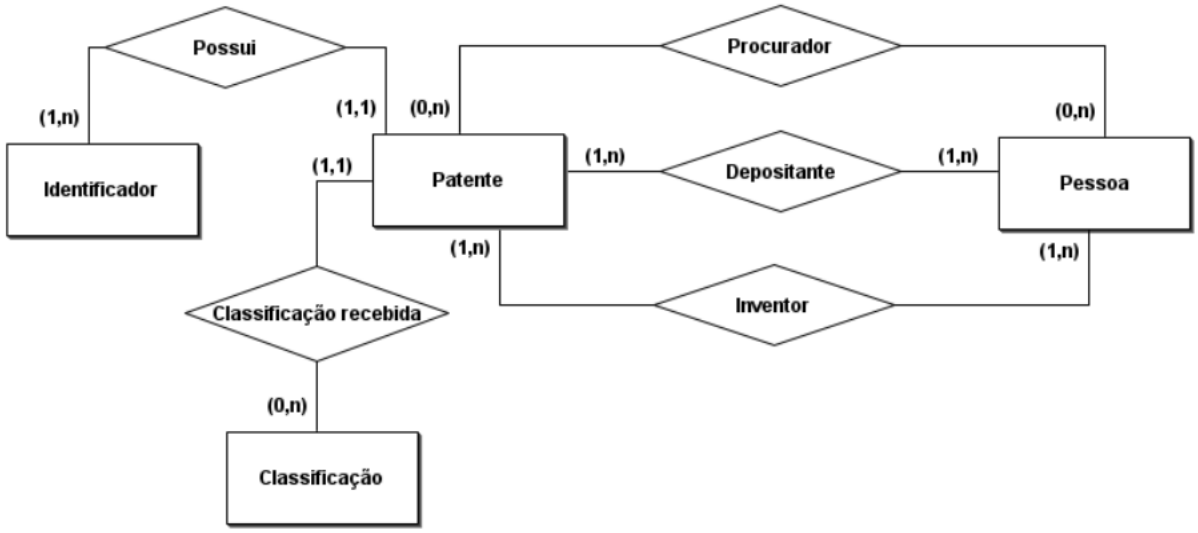


Figure 1. Conceptual model of the database established by Pytente

Using the set of strategies presented, it was possible to recover 298,372 patent documents. The collection was carried out in January 2025.

3 Analysis and discussion of results

In order to provide an overview of technological developments in the engineering sector, an analysis was carried out of annual patent filings for the period between 1972 and 2024, the filing date of the oldest patent and the filing date of the most recent patent, respectively. This analysis is based on the total set of patents collected and seeks to highlight temporal trends and patterns. The results of this analysis are presented in Fig. 2.

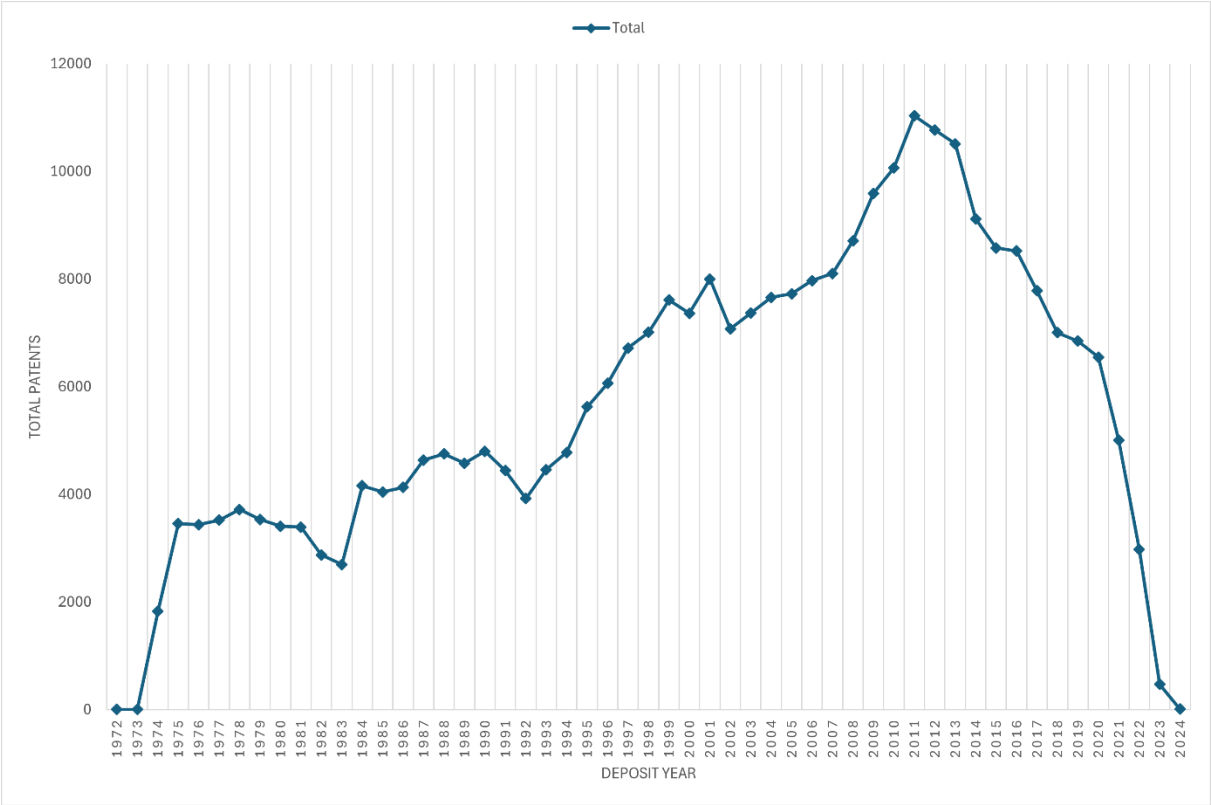


Figure 2. Temporal evolution of the number of patent deposits

The graph presented shows a significant growth in the number of patent applications over the years, reflecting an intensification of innovative activity generated by engineering. During the period analyzed, the annual average of applications was approximately 5,629 patents. When restricting the analysis to the last ten years of the period considered, this average drops to approximately 5,374 annual applications, with 2011, 2012, 2013 and 2010 standing out as the most productive years, with 11,032, 10,771, 10,511 and 10,067 applications, respectively.

Since the 1990s, there has been a more consistent and accelerated growth in patent filings. This suggests a period of strengthening of the business environment and culture of innovation in Brazil, suggesting a period of technological advancement. This growth may be associated with a greater awareness of the relevance of intellectual property and the interest of international companies in protecting their inventions in Brazil.

However, a sharp reduction in the number of filings is noticeable from 2020 onwards. This decline does not match the indicators presented by the INPI in May 2024, which indicate an average of 27,267.50 annual filings between 2020 and 2024 in Brazil [8]. This discrepancy suggests the possibility that a portion of the filings made in this period were not available in the Espacenet database at the time of data collection. This gap can be explained by bureaucratic processes that delay the availability of records in Espacenet or by the fact that they are in a confidentiality period.

Expanding the analysis, Fig 3 shows the temporal evolution of the number of patent deposits, discriminating the sections of the classifications attributed to the patents.

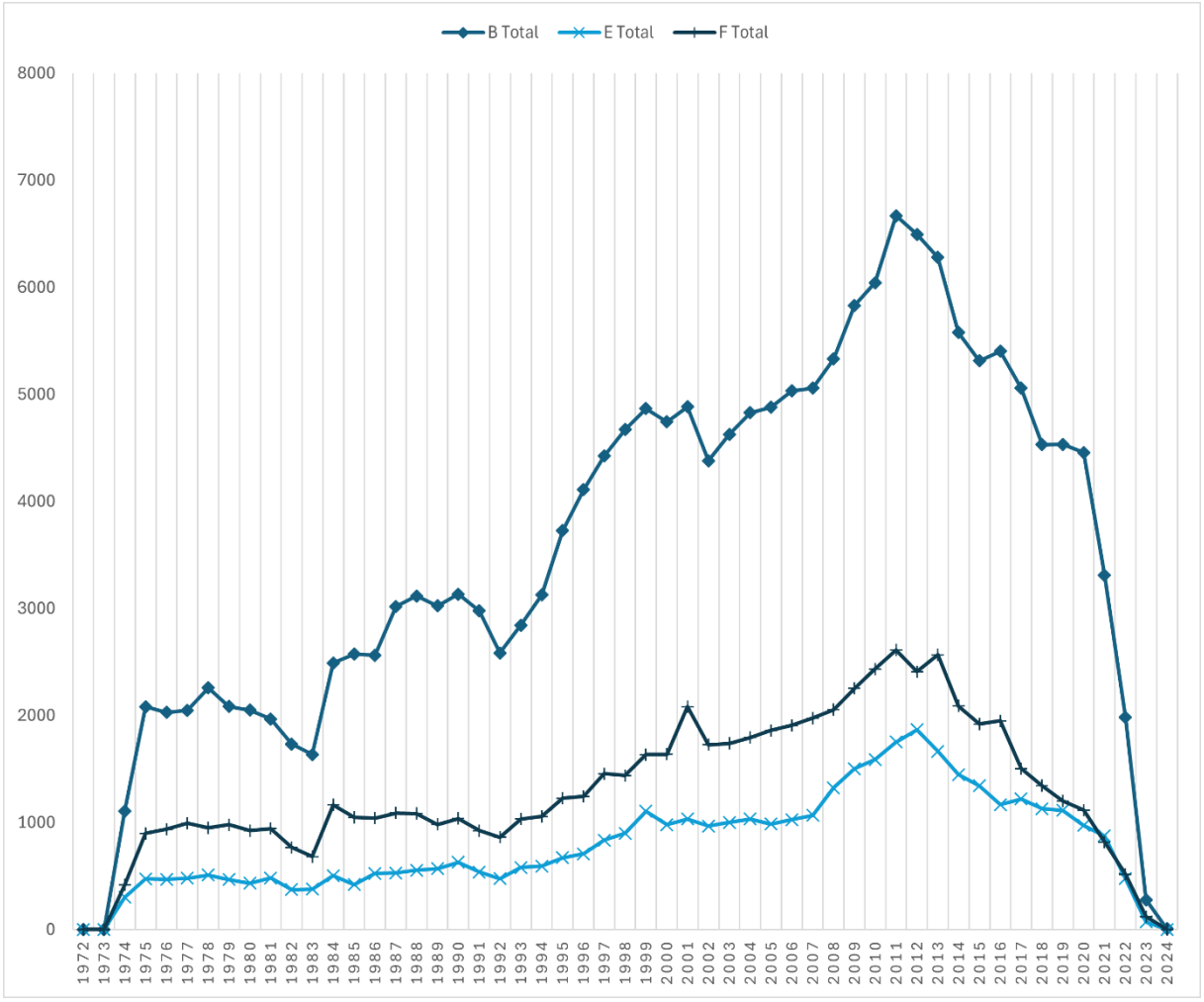


Figure 3. Evolution of the number of patent applications grouped by classification

According to the data analyzed, it is observed that patents classified in Section B (Processing Operations; Transportation) have the largest volume of deposits in the period considered, with an annual average of 3,543.07 registrations. This result highlights the predominance of technologies associated with industrial processes, material handling and transportation systems.

Next, the patents classified in Section F (Mechanical Engineering; Lighting; Heating; Armament; Explosion) stand out, which present an annual average of 1,291.74 deposits, reflecting the continued relevance of developments in the field of mechanical engineering and technologies applied to energy efficiency, safety and automation of systems.

Finally, patents classified in Section E (Fixed Constructions) correspond to the lowest average among the three sections analyzed, with 794.87 annual deposits, indicating a relatively more modest inventive activity in this segment, although still significant in the context of engineering, especially in areas linked to infrastructure, buildings and civil works.

4 Conclusions

The results obtained through the temporal analysis of patent filings in Brazil, in the field of engineering, highlight the importance of this instrument as an indicator of technological activity and innovative dynamics in the country. A consistent growth in the volume of filings was observed from the 1990s onwards, reflecting a strengthening of the national innovation ecosystem and an increase in awareness of the importance of intellectual property protection.

The predominance of filings in the sections of Section F associated with processing, transportation and mechanical engineering operations highlights the centrality of these segments for the country's technological development. On the other hand, the lower relative volume of patents in the area of fixed constructions suggests opportunities for strengthening inventive activity in this specific sector.

The drop observed in deposits from 2020 onwards, possibly related to delays in updating records in the Espacenet database or to periods of confidentiality, demonstrates the need for caution in interpreting the most recent data and reinforces the importance of using complementary sources, such as the National Institute of Industrial Property (INPI) itself, for more comprehensive and up-to-date analyses.

Overall, this study contributes to the understanding of the technological evolution of engineering in Brazil, offering support to researchers, public policy makers and innovation managers. Furthermore, it highlights the relevance of patent analysis as a strategic tool for monitoring technological trends, identifying development opportunities and strengthening the country's industrial competitiveness.

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