DIGITAL MATURITY IN THE INDUSTRY OF ELECTRONIC BOARDS ASSEMBLY

INTRODUCTION AND METHODOLOGY

Manufacturing companies need flexible solutions to address extremely dynamic markets and to manage the growing demand for customization by customers. In some contexts, advanced robotic systems represent an opportunity; however, in other environments, this level of automation fails to penetrate. The **lack of automation** is mainly widespread when **components vary significantly in terms of size, shapes, and** dimensions, as is the case with the **assembly of electronic boards**. In this industry, especially for small and medium-sized enterprises (SMEs), human labor is still essential, and the industrial Pick and Place process of diversified components is carried out by human operators.

Within this context, **DIH Lombardia** is participating in **DIH4TAKING**, a project that focuses on object detection and pose estimation for **Pick and Place** activities of **electronic components**, such as microprocessors. Automating these processes could ensure a significant overall growth in the productivity of manufacturing companies. DIH4TAKING aims to develop an integrated and modular perception pipeline supported by the principles of Industry 4.0 to better harness the benefits provided by Artificial Intelligence technologies in this field.

For this reason, DIH Lombardia has decided to conduct an analysis of the **digital maturity** and Industry 4.0 level of the manufacturing companies operating in the abovementioned sector, in order to assess their current state and understand future scenarios. To carry out this analysis, ***"Test 4.0"*** was used, a tool which measures the degree of digitization of the enterprises by investigating multiple key business processes, from design to distribution, covering executive, organizational, technological, and control aspects. **Macroprocesses** and **dimensions of analysis** are presented in Figure 1 and Figure 2, respectively.

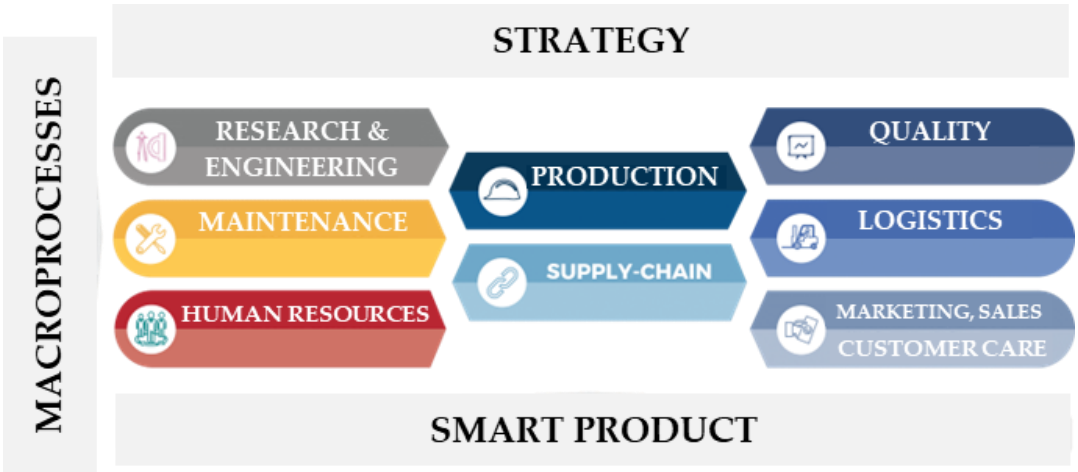

Figure 1. Macroprocesses

Figure 2. Dimensions of analysis

Each macro-process is evaluated on a scale of five increasing levels of digital maturity:

- **Level 1** represents processes which have a limited degree of control, managed ad hoc and exclusively in a reactive manner. They are characterized by low digital maturity and less advanced technologies.
- **Level 2** represents partially controlled processes, developed with technologies and systems that are still not highly advanced or integrated. Process management relies mainly on the experience of the entrepreneur, CEO, or area manager, and the readiness for digital change is still quite limited.
- **Level 3** consists of processes that exhibit an intermediate level of digital maturity/readiness for I4.0 transformation due to regular control activities as well as technologies and systems which are partially integrated and automated. Moreover, these processes are, to some extent, managed in an integrated manner across different business functions.
- **Level 4** involves generally controlled processes developed with largely integrated and automated systems, managed generally in an integrated manner across various business areas. The level of digital maturity is considered quite good.
- **Level 5** represents the highest level. Processes are systematically monitored and controlled, supported by advanced technologies and systems that are integrated across multiple business functions. As a consequence, an excellent level of digital maturity emerges.

The sample consists of **45 companies** operating in the **B2B** market, mainly in the **electronic, electrical, and optical industries**. The majority of the selected organizations realizes **products through Make (or Engineering) to Order strategies**. The most frequent Ateco codes are: **26.11** (manufacturing of electronic components), **26.12** (manufacturing of assembled electronic boards), and **27.90** (manufacturing of other electrical equipment).

KEY RESULTS

The findings reveal that approximately **half of the sample** (51%) gets a digital maturity index between **3,00 and 3,99**. In detail, the score of 35% of the companies operating in the electronic circuits industry - and/or similar devices sectors – is lower than 3,50 but equal to or higher than 3,00.

Lower values, ranging **from 2,00 to 2,99**, account for **40% of the total companies**, which exhibit limited/moderate digital maturity due to partial integration across various business functions and technological solutions as well as processes which are often managed exclusively based on experience. In this case, the distribution of the companies in the mentioned cluster is almost identical, with 19% scoring a digital maturity index below 3,00 but equal to or above 2,50, and 21% falling between 2,00 and 2,49.

Finally, **9% of companies** presents a high orientation toward digital transformation and position themselves at a level of digital maturity where int**egration and interoperability are widespread** (from 4,00 to 5,00). Within the sector, **no company** is represented by a digital maturity index **below 2,00**.

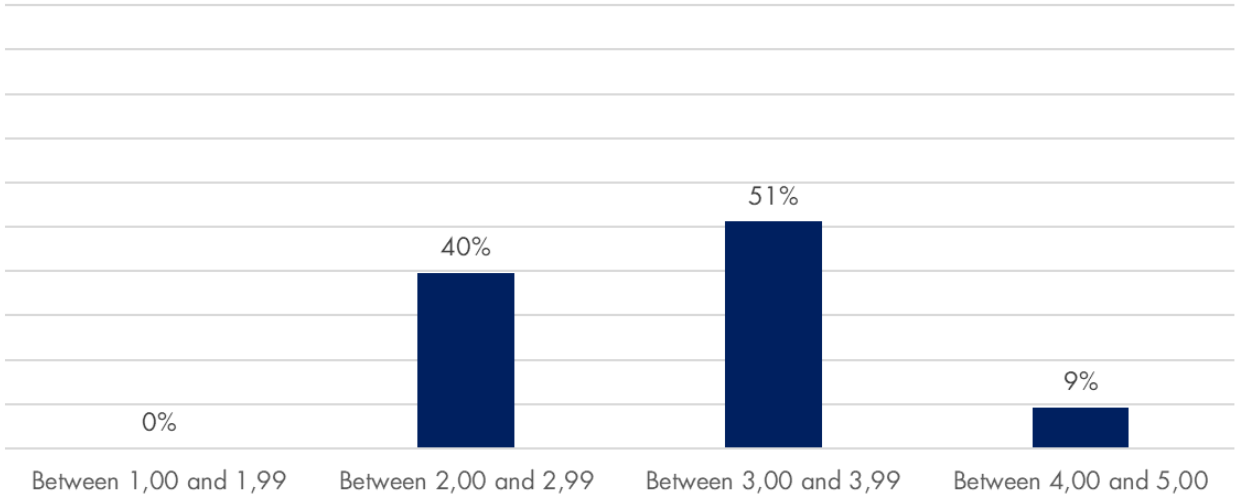

Figure 3. Distribution of the sample within the classes of digital maturity

This distribution highlights how the analyzed manufacturing companies have begun to pay attention to the digitization process, starting to grasp some of the benefits it offers. However, it also appears clear that further opportunities and possibilities are still being neglected. The key constraints that inhibit companies to successfully implement digital transformation are **availability of internal resources** (47% of the sample), **costs** (40%), **corporate culture and ability to assess opportunities** (24%), as well as **companies' reluctance to digitally integrate through information exchange along the supply chain** (22%).

The digital maturity index is calculated by combining the degree of digitalization of the four dimensions of analysis. The average results of the analyzed sample are depicted in the graph of Figure 4.

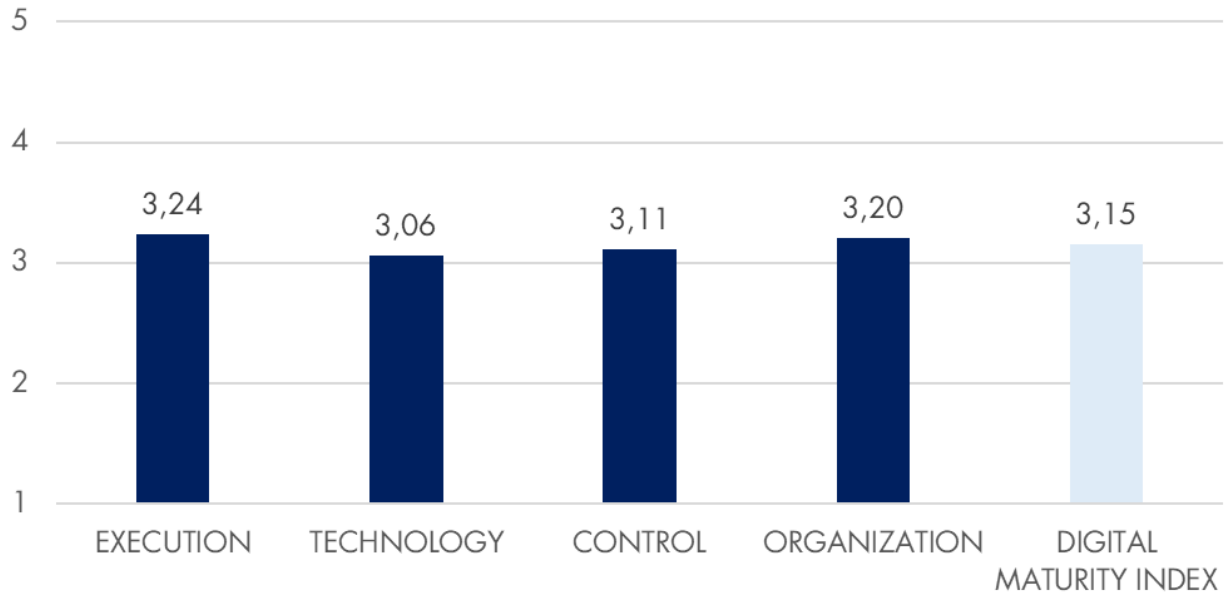

Figure 4. Average Indexes of the digital maturity of the dimensions of analysis

The average maturity level is equal to **3,15**, exceeding the findings presented by DIH Lombardia in a study involving 396 **Lombardy companies** from different sectors (2,99) (see website) as well as the results of the representative sample of the **national system** of DIHs of Confindustria (2,85). Moreover, the high alignment along the four different dimensions of analysis indicates an excellent balance in process management. At the same time, it emerges the importance of keep investing in I4.0, increasing the level of digitization rather than stabilizing at the current level.

Execution (3,24), **Organization** (3,20), **Control** (3,11), and **Technology** (3,06) highlight a moderate definition and adoption of methodologies and procedures, as well as good collaboration among different functions within companies. Monitoring and analysis are systematic just in some cases, and ICT systems, hardware, and software supporting processes are not always advanced and/or fully integrated.

According to the analyzed macroprocesses, the **Quality** function positions itself at the highest level of digital maturity (3,62); very similar values are found in **Design and Engineering** (3,49) and **Production** (3,40). These results underscore the inclination of the analyzed companies to focus on differentiating aspects of the product, such as excellence in design and quality, and strong competitiveness in production costs.

On the other hand, the **remaining functions** place below the threshold of 3,00, as highlighted in Figure 5. These macroprocesses exhibit almost identical scores, showing a significant gap compared to R&D, Production, and Quality. The study reveals that, in many cases, there are

significant difficulties in pursuing digital innovation across all the areas and all the business processes.

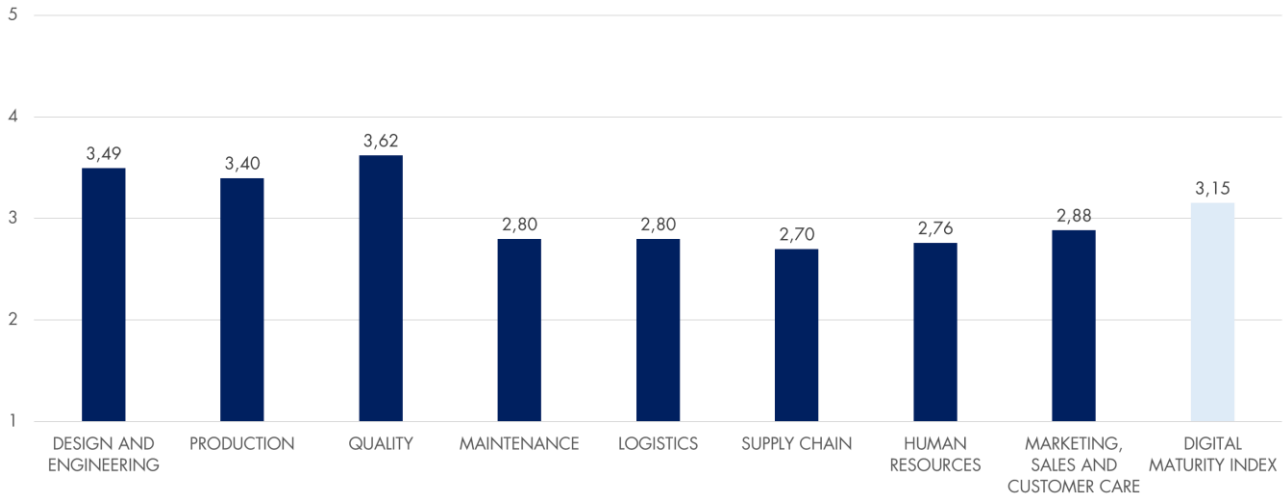

Figure 5. Average Indexes of the digital maturity of the macroprocesses

Then, DIH Lombardia decides to go deeper into the results of each macroprocess, aiming to distinguish their key strengths and weaknesses.

DESIGN AND ENGINEERING

In the R&D function (3,49), there is a high level of digital maturity regarding **product development**. Conversely, this level drops when considering **process engineering**. On one hand, dealing with product, it emerges a significant orientation toward **data** usage, with significant levels of **integration** among various systems. **Bill of Material** (BOM) as well as different versions of the product are generally managed in a dedicated digital environment. **CAD** tools are widespread, and concept validation is often carried out digitally through appropriate **simulation tools** (Figure 6).

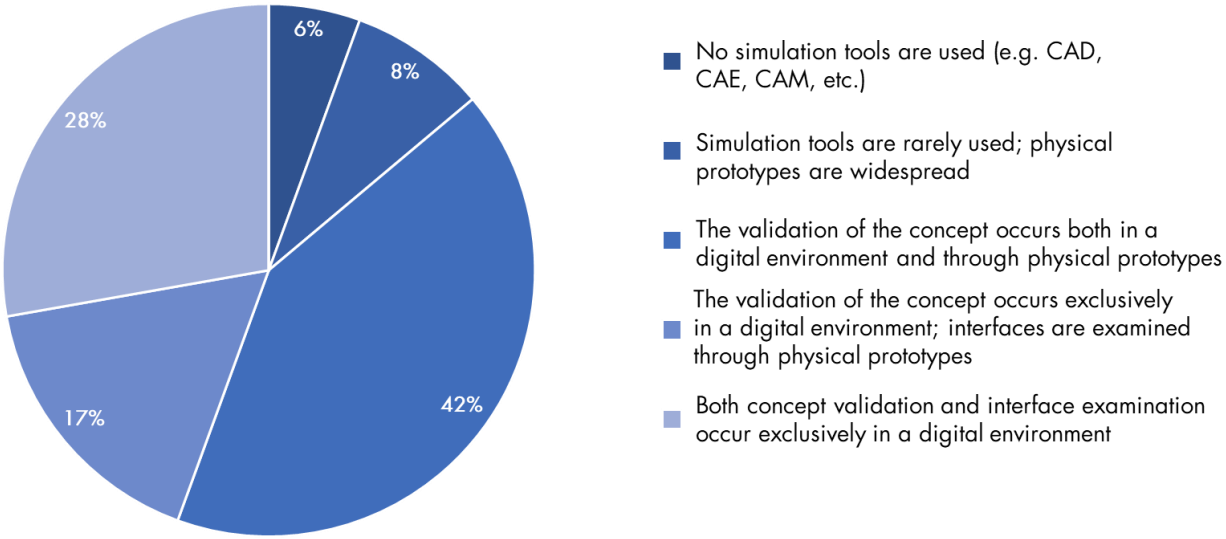

Figure 6. Digital simulation tools for concept validation of the product

On the other hand, regarding process engineering, simulation tools such as **Virtual Commissioning** and **Digital Twin** are rarely used for the design and validation of production lines and work cycles (36%). Additionally, only 18% of companies have at least partial integration and automation between systems.

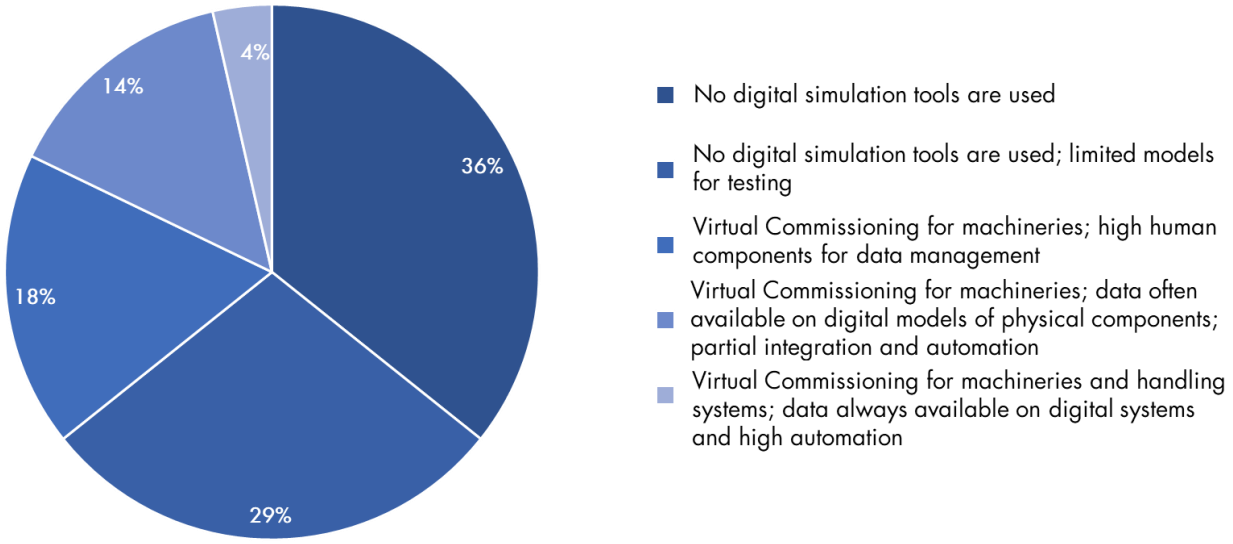

Figure 7. Digital simulation tools for process engineering

PRODUCTION

The digital index obtained from the Production function (3,40) originates from structured and digitally mature elements, including widespread use of **ERP** (Enterprise Resource Planning) **systems** and a proper **balance** between **personnel** with specialized tasks and operators with cross-functional skills. However, there are still activities managed in a predominantly traditional manner, including **performance analysis and production cost evaluations**, which often rely exclusively on human experience. Despite the Production function represents one of the macroprocesses characterized by greater technological result, there are still multiple opportunities for improvement. These include extending the ERP to processes currently conducted through **Office** and implementing **Manufacturing Execution Systems** (MES).

QUALITY

Concerning Quality, the analyzed companies achieve the best result (3,62). It emerges the presence of **control activities at multiple stages**, **formalized procedures** for managing quality issues, and a high level of **integration with other business functions** for identifying corrective actions. However, there is one aspect that requires high attention: the lack of **advanced, dedicated, and integrated information systems** for accessing and analyzing quality data. To summarize, the executive and organizational structure, combined with a positive attitude toward monitoring and analysis activities, enables many companies to upgrade their digital maturity level through investments in technologies, which are not yet widely adopted.

MAINTENANCE

Maintenance exhibits a lower orientation toward digital transformation compared to the processes described above (2,80). While the sample study reveals a **good organizational structure**, weaknesses are highlighted in **data management**, **poor digital culture**, and strong prevalence of **experiential approaches**. This generally results in a limited adoption of **predictive and remote maintenance** (29%).

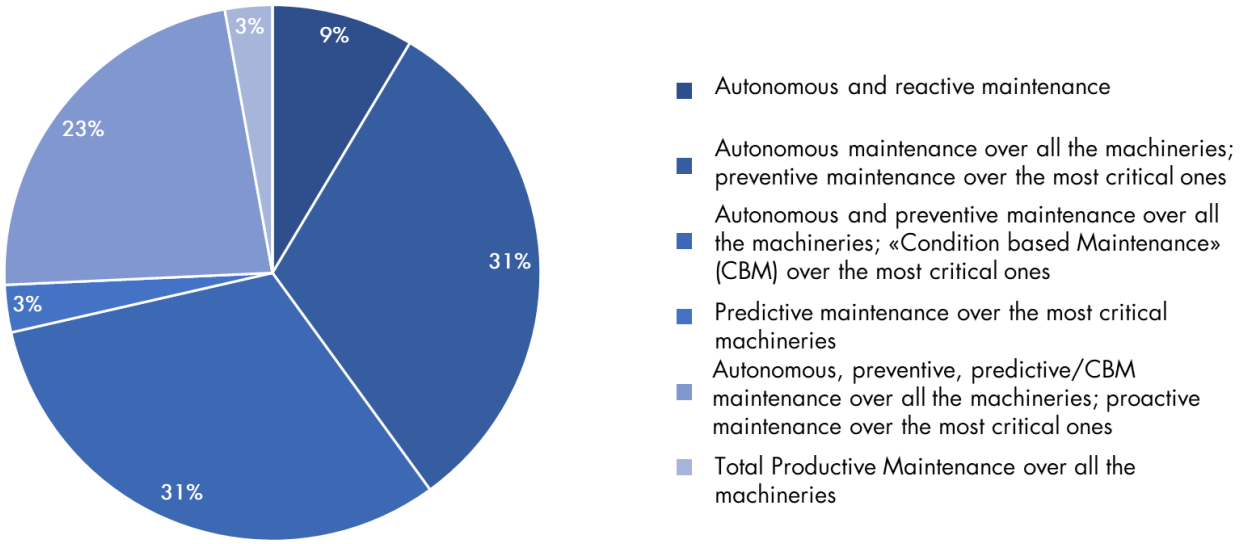

Figure 8. Maintenance techniques

The integration into the network and the connection with tools for fault diagnostics and prognostics are not common. Moreover, the analysis reveals that *Computerized Maintenance Management System* (CMMS) solutions are only sporadically utilized.

LOGISTICS

The Logistics function (2,80) shows its main strengths about **lean approaches**, which are usually widespread within warehouses, where **standardized methods** are commonly adopted. This is complemented by good practices in the **picking process**, with pick lists designed with the goal of increasing the operator efficiency. Conversely, two particularly relevant digital weaknesses within the function are mentioned: in most companies there is not a **Warehouse Management System** (WMS) **integrated with the ERP**, and formalized processes for measuring **technical and/or economic performance indicators** are not widespread.

SUPPLY CHAIN

Companies of the sample face challenges in planning and implementing initiatives as well as integrating and exchanging information with their production and/or distribution chain (2,70). This results in **limited tracking capabilities of physical flows** with different *tiers* as well as a not optimized **demand planning** process. Similarly, order-delivery-invoicing-payment cycles with customers and suppliers are executed through traditional channels, such as email and calls, rather than **dedicated electronic connections**. The best findings in the function,

although not yet optimal, relate to the ability to conduct structured analyses regarding **supplier performance** (Vendor Rating).

HUMAN RESOURCES

The HR function (2,76) exhibits structural limitations mainly arising from a lack of **formalized roles and leadership teams** for digital transformation. This is accompanied by a common absence of **digital skills mapping** activities as well as by limited **up-skilling and re-skilling programs**. Despite a moderate use of technological tools for administrative support, cultural limits may increasingly translate into technical gaps, risking to impede innovation and digital transformation projects.

MARKETING, SALES, AND CUSTOMER CARE

Within this macro-process (2,88), three functions can be distinguished: Marketing, Sales, and Customer Care. Marketing has the highest level of digital maturity, characterized by a great attention on **brand presentation** and common **online availability of information** and product catalogues.

Sales presents a lower level of digitalization, largely due to the absence of **digital sales platforms** (e-commerce). Then, it is explored the use of **rapid prototyping technologies** to develop Proof of Concept and communicate and test new products with customers.

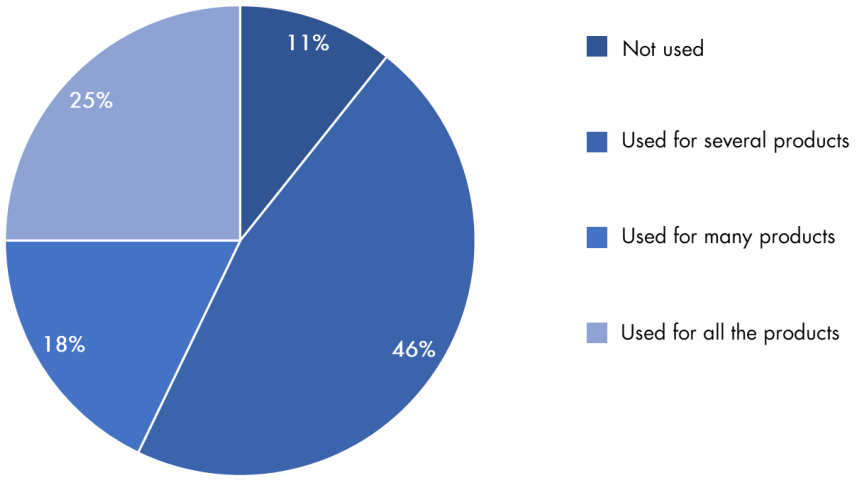

Figure 9. Usage of rapid prototypation technologies (%)

In this case, the results are quite positive: only 11% of the sample does not adopt such technologies, while the remaining 89% is implementing them. Specifically, 25% use them on all their products, and 18% on many of them.

In the end, concerning Customer Care, the use of **traditional channels** (lack of chatbots, live chat, etc.), the limited adoption of **Customer Relationship Management** solutions (CRM), and the **traditional document management** still prevail in too many companies.

CONCLUSION

In conclusion, to summarize the presented results, the analysis shows that companies operating in the electronic circuits industry and/or similar devices sector achieve good digital results in functions such as Quality, Research and Development, and Production, while they are more weaknesses in other processes, especially in Supply Chain management. Moreover, both technological and organizational-cultural investments are crucial for companies to grow and successfully capture the competitive advantages that digital transformation can generate. An increase in the level of automation, supported by a suitable and appropriate structure, can lead to a significant improvement in the performance of the companies of the sector.