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The Transition towards Industry 5.0: An empirical study through the lenses of RBT

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INTRODUCTION

Over the course of human history, technical advancements have encouraged the evolution of production methods.

The First Industrial Revolution began with the development of mechanisation. The introduction and subsequent usage of electricity, within the assembly line, marked the dawn of the second Industrial Revolution. Industry 3.0 started when manufacturing organisations arose with the deployment of automatic machinery, replacing the workers. While the idea of the Fourth Industrial Revolution was rooted in achieving better performances throughout ever-growing relationships among stakeholders.

The most current Industry 5.0, however, departs from this trend.

Industry 4.0 has faced difficulties because of the economic effects of the Covid-19 outbreak, the conflict in Ukraine, and the growing public awareness of climate change.

The supervened challenges have exposed fundamental problems within the model's regenerative components, worker well-being issues, and environmental factor.

By filling in the gaps left by Industry 4.0 and dismantling neo-liberal capitalism, the introduction of a new industrial paradigm has been encouraged by the emergence of society 5.0.

Therefore, the introduction of Industry 5.0, as an evolution and logical advancement of its predecessor, has shifted the role of profit primacy in favour of shareholder primacy and envisioned a value-driven transformation model with the goal of balancing economic sustainability with environmental and social sustainability.

Therefore, the characteristics of the most recent Industrial Revolution pose questions about how traditionally profit-driven organisations could adapt.

Thus, the objective of the thesis stems from the realisation of a necessary transformation of companies, dictated by the new demands of a society that is more attentive to the issues of environmental sustainability, human wellbeing, and the role that man must play within companies, and the need to develop capacities that enable companies to be ready for possible changes in the geopolitical scenario.

Consequently, the study seeks to identify the resources that a company must possess to adopt Industry 5.0.

The thesis consists of three parts: literature review, theoretical framework, and empirical analysis.

The first chapter reports on the development of the Industrial Revolutions from the first up to today's Industry 5.0. The literature review then describes the transition between the different Industrial Revolutions, delving into the needs of society and the response of companies to global shocks.

The elements defined in the literature review thus provide a starting point for the development of the thesis, which continues with the description of the Resource Based Theory with the aim of identifying the resources that companies need to adopt Industry 5.0.

The second chapter discusses and explains the history and development of RBT while also examining its potential applications. Then, to answer the RQ, a sequence of deductions based on the preceding two chapters will be made.

The third chapter will first define the methodology of the empirical investigation. Following the introduction of the interview subjects, the questions will be defined. The findings of the interviews will then be provided and employed to test the hypothesis.

The research question will then be addressed.

Finally, potential insights that the thesis' results could reveal will be highlighted, weighing the perspectives of both scholars and practitioners.

CHAPTER 1. Literature Review - On the way to Industry 5.0

The evolution of production processes throughout human history is prompted by technological developments, which promote the upscaling of working conditions and lifestyle (Desouttertools.com, n.d.). However, the most recent Industrial Revolution deviates from this pattern.

To examine the thesis's topic, it is required to outline the historical path of industrial practise transformation to comprehend the changes that have marked the frameworks of previous revolutions.

First, the industries' transformation from 1.0 to 3.0 will be quickly shown, and then Industry 4.0 and 5.0 will be thoroughly defined.

First Industrial Revolution

The development of mechanisation in the 18th century triggered the First Industrial Revolution. As a result, hand production techniques were replaced by steam-powered machinery (Kent & Kopacek, 2019).

Therefore, according to Demir et al. (2019), *"Industrial revolutions are mostly targeted on separating man's work with machine's work"* (p. 1).

The Industry 1.0 era was marked not only by the adoption of steam, but also by the introduction of technology, which resulted in the development of the first ever weaving loom in 1784. (Sing & Sharma, 2020).

In the following years, alternative practises for steam power such as the steamship and the steam-driven locomotive were implemented, lowering transportation costs for commodities and people, resulting in disruptive societal shifts.

To cope with the increasing complexity brought about by revolutionary technology, companies had to adopt different strategies, namely division of labour and lean production (Sing & Sharma, 2020).

At a glance, the Industrial Revolution led to the betterment of working conditions and the rise of real wages (Kent & Kopacek, 2019).

Second Industrial Revolution

The Second Industrial Revolution began in the nineteenth century with the discovery and subsequent use of electricity, as a facilitator for the implementation of the assembly line.

Henry Ford (1863-1947) imagined of mass manufacturing in a Chicago slaughterhouse where pigs were strung from conveyor belts and workers only performed a single part of the process (Desouttertools.com, n.d.). As a result, Henry Ford implemented the same concept to the automotive, inspiring other industries such as air, metal, and chemical (Sing & Sharma, 2020).

Assembly lines and interchangeable components have been critical in enabling economies of scale and heightening competition by constructing a multinational market dominated by the increasing importance of capital.

Since the mid-nineteenth century, the Industry 2.0 paradigm has been central in Europe and the United States, resulting in an increase in the number of factories.

Furthermore, the never-ending development of production sites led to overcapacity. As a result, the corporations pursued merger tactics in order to rebuild market trust.

During Industry 2.0, manufacturers established first-hand research and development divisions (Freeman & Soete, 1997, as cited in Sing & Sharma, 2020), resulting in advancements in the heavy steel production (adoption of electricity) and giving birth to the chemistry industry (Sing & Sharma, 2020).

In general, assembly lines, on the one hand, achieved the previously mentioned economies of scale, cutting finished product costs, on the other hand, rendered production processes excessively rigid, disallowing personalisation.

Third Industrial Revolution

Industry 3.0 began in 1970 throughout the adoption of automatic equipment by manufacturing companies, used for processes that were challenging for human workforce. Implementation of such new technologies revolutionized the procedures of production, creating more routine types of work (Kent & Kopacek, 2019).

Therefore, the assembly line conceived by Henry Ford has been simplified and made more efficient, by the automation.

In the 1980s, Industry has witnessed the development of many innovations such as: computer-based integrated manufacturing (CIM), computer-aided design (CAD), computer-aided manufacturing (CAM), and flexible processing mechanisms (FMS), which gave birth to the term Advanced Manufacturing Technology (AMT) (Sing & Sharma, 2020).

The goal of such brand-new technologies was to deal with a more time-saving and flexible production process, to respond to clients' ever-changing needs, and so increase the possibility of customization (Goldhar & Jelinek, 1983, as cited in Sing & Sharma, 2020).

Furthermore, the move from analogue to digital systems, as well as changes in the electronics industry in the late twentieth century, shaped, Industry 3.0, often known as the digital revolution. During those years, several electrical devices such as transistors, integrated circuits, programmable logic controllers (PLCs), and the first software were developed.

Consequently, with the adoption of new technologies, manufacturers started to investigate the possibility of relocations, pulled by the necessity of cutting costs. However, globalisation has caused several challenges related to relocations, as underdeveloped countries have little automation potential. Finally, the difficulties were seized trough the elaboration and the adoption of the Supply Chain Management [1](Sing & Sharma, 2020).

[1] Supply chain management encompasses all processes that transform raw materials into finished products. It entails actively simplifying a company's supply-side processes in order to optimise customer value and obtain a competitive advantage in the marketplace.

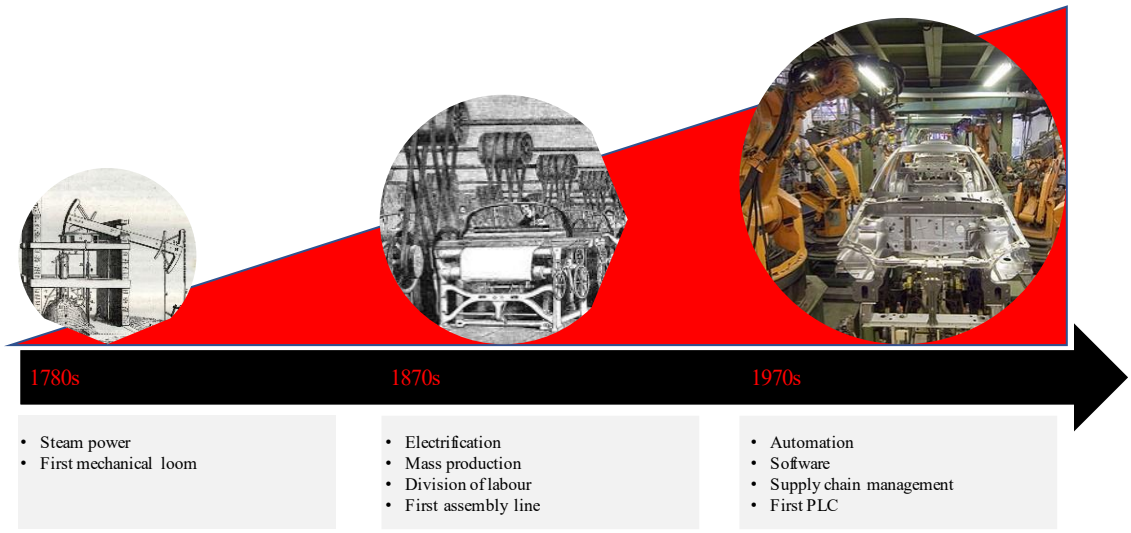

Fig. 1 Summary of the first three Industrial Revolutions (Own elaboration).

Fourth Industrial Revolution

Within the present paragraph, the origins of the Fourth Industrial Revolution will be identified with some of the definitions coming from important world figures. Then, the technologies that governed the revolution will be defined. Thirdly, the effects of the Industrial Revolution and thus the adoption of technological innovations will be outlined. Finally, qualitative, and quantitative results from different studies will be mentioned.

The Origins of Industry 4.0

In 1940, the fundamentals of Industry 4.0 were initially outlined within the Albert Carr's work (1940, as cited in Özdemir & Hekim, 2018) entitled *"America's last chance"*. However, the term Industry 4.0 has been coined during the German federal government's high-tech strategy in response to the digitization of manufacturing (Kagermann, 2013; 2014, as cited in Özdemir & Hekim, 2018).

The concept of the Fourth Industrial Revolution resides on the achievement of increased performances, not only within manufacturing facilities, but also with the ever-increasing connections among stakeholders.

For this very reason, Industry 4.0 has been an imperative within the most important chancelleries of the world. In fact, the words of some of the most significant personalities and scholars who have examined the phenomenon since its origin will be presented in the following rows of text.

According to the former German Chancellor Angela Merkel (2014, as cited in Davies, 2015) Industry 4.0 is *"the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry"* (p. 2).

Furthermore, Klaus Shwab, Chairman of the World Economic Forum (n.d., as cited in Özdemir & Hekim, 2018) disclosed his angle concerning Industry 4.0 as follow:

> *The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.* (p. 68).

In addition, European Union throughout Davies (2015) formulated its definition, according to which: *"Industry 4.0 is a term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products"* (p.2).

Therefore, the objective of this new industrial stage is the increase of efficiency and productivity, by incorporating new technologies in the production process (Demir et al., 2019).

However, it is important to specify that according to Professor Kopacek (2018, as cited in Kent & Kopacek, 2019) the concept of Industry 4.0 is not, only, restricted to the automation of a single manufacturing site. Somewhat, Kent & Kopacek (2019) focused their study on the interoperability among functions: production material sourcing, supply chain and wholesale, to achieve a high level of operational efficiency, responsive manufacturing, and improved product design.

To reinforce the need for a common description, Aquilani et al. (2020) highlighted the delay on outlining a holistic definition of Industry 4.0 capable to include all the relevant elements that triggered the transition to new business models. The classification stressed the role of IOT technologies within the production processes and the request for a digitized, connected, smart and decentralized value chain with the target of realising a greater level of flexibility and robustness within the firms.

In Regard to which could be the correct definition, it is worth to mention that according to Xu et al. (2021), "*all agree upon the Reference Architecture Model Industrie 4.0 (RAMI 4.0)"* (p.531).

The model has the aim to guarantee the comprehension of the contributors of industry 4.0, by the unpacking of complex practises into easier unities (Schweichhart, 2016).

RAMI 4.0 was built by the German Electrical and Electronic Manufacturer's Association and was made up of three-dimensional coordinate system, which represent the architecture of Industry 4.0.

From the information model of automation has been designed the *Hierarchy Levels axis* corresponding to different functionalities within factories/facilities. Furthermore, the *Layers axis* describe properties of the

machines. Finally, the *Life Cycle Value Stream axis* reports the life cycle of products and facilities plus the business models and the advantages of using industry 4.0 (Weyrich, 2014, as cited in Xu et al, 2021).

Technological Drivers of Industry 4.0

Despite the identification of a common ground capable of defining what Industry 4.0 is, there is currently no organised classification of which technologies are required for the shift.

In this sense, BCG (n.d.) created a framework organising the technologies, considered as drivers of the Fourth Industrial Revolution, within 9 pillars:

1. Additive Manufacturing: production process throughout the use of 3D printing. The advantages are connected to the flexibility in the manufacturing, avoiding the prototyping of small components.
2. Augmented Reality: companies can reduce the latency in the decision making and working procedures.
3. Autonomous Robots: the advantages are brought by the intercommunication between machines and the creation of a safer work environment.
4. Big Data and Analytics: enable the collection and the acknowledgment of a multitude of data from all the stakeholders of the firm. Furthermore, the discovery of data enables the firms to take data driven decisions, through the design of KPIs.
5. The Cloud: technology implemented by firms to connect different sites, hence increasing the communication within all the hierarchy levels. In addition, cloud technologies are used in combination with big data and analytics to increase data-driven services by making them achievable to all the functions.
6. Cybersecurity: Increased connection and the adoption of common communications protocols are encouraged by Industry 4.0. As a result, there is an increasing need to defend vital industrial systems and manufacturing lines against cyber-attacks. Thus, secure, reliable communications, as well as sophisticated access management for computers and user identity verification, are critical.
7. Horizontal and Vertical System Integration: Industry 4.0 is built with the aim of connecting companies, departments, functions, and capabilities. As follows, it is compulsory the implementation of an ever-increasing communication and integration of data in order to achieve automated value chains.
8. The Industrial Internet of Things: is based on the construct of IOT related to the capacity of smart objects to be identifiable, to communicate, and to interact (Miorandi et al, 2012). Therefore, IOT refers to the enrichment of manufacturing devices with computers that facilitate the communication and interaction between machines. Furthermore, it promotes the decentralization, boosting data driven decision making, and empowering real time reactions.
9. Simulation: widely employed in plant operations to handle real-time data and to replicate the actual environment. When it is used correctly, enables operators to test and adjust settings in multiple variants, reducing machine setup times and enhancing quality.

Furthermore, it is critical to emphasise a study that organises the technologies in a more selected manner, as well as the related goals behind such an innovation.

Yet, it is interesting to understand the different implementation patterns in manufacturing firms.

According to Frank et al (2019), technologies are divided within two groups: *Front-end technologies* and *Base technologies*. The first group is composed by four dimensions: Smart Supply Chain, Smart Working, Smart Manufacturing, and Smart Product. The second group by the Internet of Things, Cloud, Big Data, and Analytics.

Base Technologies are critical because they are existent in all the Smart factors within the Front-end technologies' dimensions. To this effect, Base Technologies are the driving forces of industry 4.0, making possible the interconnectivity within the manufacturing systems (Frank et al, 2019).

Considering the front-end technologies, it is necessary to specify that each dimension described above is also composed of the technologies that are needed for its adoption. Thus, according to this study, there is a kind of hierarchy within what are the processes and technologies to be adopted to achieve Industry 4.0.

The Frank et al. (2019) work compared with the BCG study can be useful to understand the broadness and lack of a holistic vision of the enablers of Industry 4.0. However, even if the aim of the present thesis is not to solve this problem, it is considered important to build a solid background, hence avoiding misunderstanding, in respect to the following paragraphs regarding industry 5.0 and its respective technologies.

Effects of Industry 4.0 on the firms

It is now possible to describe the outcomes of Industry 4.0 in manufacturing processes, outcomes, and business models.

To that end, Qin et al. (2016) organised the four factors that shaped manufacturing visions in Industry 4.0:

1. *The factory* evolved towards Smart Factory. Considered as the integration of all the resources of the firm, which enable the internal communication within departments and functions, consequently increasing the level of responsiveness to internal and external stimuli. Furthermore, the modularity and the end-to-end connections characteristics of the new innovations enabled the decentralization and the interdependence within production processes. As a result, according to Davies (2015), adopting new paradigms can enhance productivity by 20%.
2. *The Business* moved towards the necessity of an ever-increasing communication within companies, factories, suppliers, logistics, resources, and customers. In addition, the communication within the business network pushed to the reduction of the environmental impact. According to the European Union (Davies, 2015), embracing Industry 4.0, companies could also compete on the base of innovation and on the capacity of respecting the specific design-requests of customers. Furthermore, the creation of Smart Products could be an opportunity, hence companies could adopt business models based on the sale of services rather than on the production of new items.

3. *The Products*, as anticipated, became Smart Products. These items are equipped with sensors and processors that provide information to the production system and give functional recommendations to customers. Furthermore, communication provides product developers with knowledge that might also help with design, prediction, and maintenance. According to Davies (2015), the already mentioned Smart Factory assists with an increased flexibility which results in the mass customisation of the products, hence enabling the production of small lots in accordance with the customer specifications, without compromising the efficiency. In addition, also the speed of production and the quality of products is affected by the application of Industry 4.0. Davies (2015) described how data-driven supply chains can speed up the manufacturing process by 120%, while increased quality contributes to cost reduction and increased competitiveness.
4. *Customers* obtained several advantages. Through Industry 4.0 firms can extend methods of payments as well as after sales services, both depending on the behaviours and the preferences of the customers. The location of manufacturing sites could be re-shore nearer to the customers since the automation could defuse relocations. Therefore, by making the clients closer, it will also be easier to involve them in the design process.

Eventually, the changes in manufacturing processes, outcomes, and business models could be quantified and summarised throughout the research of the Picasso Project of the German Federal Ministry of Education and Research (Bauernhansl, 2016, as cited in polat & Erkollar, 2020).

According to the study, when firms adopted Industry 4.0, numerous aspects of their cost structure altered significantly, as follows: inventory costs - 30/40%, production costs - 10/30%, logistics costs - 10/30%, complexity costs - 60/70%, quality costs - 10/20%, and maintenance costs - 20/30%.

Cons of Industry 4.0: towards a new framework…

Due to the shocks that have hit the world (Covid-19, Ukrainian conflict, Environmental crisis), Industry 4.0 is no longer able to fulfil the goals that are demanded by society. Changing life habits and new needs mean that industry requires a redesign, focusing on new goals.

It is natural that a solely technical paradigm centred on efficiency through connectivity and artificial intelligence can no longer be regarded adequate. What is observed is that the economic dimension cannot be the exclusive consideration. Indeed, the Sustainable Development Goals (SDGs), as encapsulated in the 2030 Agenda, have signalled the necessity for a course correction in Europe. This is a 2015 United Nations (UN) - sponsored action plan aiming towards people, prosperity, and the environment (United Nations, n.d.). It features 17 goals, as illustrated below.

Fig. 2 Sustainable Development Goals (THE 17 GOALS | Sustainable Development, n.d.)

On the contrary, Industry 4.0 translates into a 'winner-takes-all' model that generates monopolies and giant tech inequality (Dixson-Declève et al., 2022). Taking into consideration the 17 points described in Agenda 2030, it is possible to identify how the new industrial strategy should be designed. The deficiencies of Industry 4.0, according to Dixson-Declève et al. (2022), can be summarised across three dimensions:

1. Regenerative features of industrial transformation, so as to both embrace the circular economy and positive restorative feedback loops not as an afterthought, but as a key pillar of the design of entire value chains.
2. An inherently social dimension, demanding attention to the wellbeing of workers, the need for social inclusion and the adoption of technologies that do not substitute, but rather complement human capabilities whenever possible.
3. A mandatory environmental dimension, which leads to the promotion of transformation that eliminates the use of fossil fuels, promotes energy efficiency, draws on nature-based solutions, regenerates carbon sinks, restores biodiversity and crafts new ways of thriving in respectful interdependence with natural systems.

Consequently, European Union sees the need for a long-term industrial strategy that focuses on the digital and low-carbon economies while allowing businesses to remain competitive.
This new perspective is known as Industry 5.0.

Society 5.0

Japan had a critical role in defining a new social vision. Indeed, even the previously described Industry 4.0 has been conceptualised differently, identified as *Super Smart Society* (Aquilani et al., 2020). Undeniably, it was deemed too naive to attribute changes in Japanese society to new technologies.
According to Salvatore (2018, as cited in Aquilani et al., 2020) the Japanese Government believed that Society 5.0 will be achieved through Industry 4.0.
It is critical to emphasise that Industry 4.0 is not the only component that can be recommended for societal paradigm shifts. The new vision of society reflects some of the ideals introduced by the United Nations with the SDGs plan, as previously noted.
As a matter of fact, Keidanren (2016, as cited in Potočan et al., 2021) emphasised the modelling of Society 5.0 based on the aforementioned UN development goals:

> *Society 5.0 presented a new vision of society that incorporates several new technologies and social activities and achieves both economic development-primarly based on Sustainable Development Goals established by the United Nations, and solutions to key social problems in the present society.* (p.795).

The term Society 5.0 has been firstly announced in 2016 by the Japanese Government, during the Fifth Science and Technology Basic Plan (Aquilani et al., 2020).
Society 5.0 is a human centred society (Aquilani et al., 2020, Fukuda, 2019, Potočan et al., 2021). Its objective is to satisfy personal needs (Aquilani et al., 2020, Fukuda, 2019) promoting economic and social equality (Fukuda, 2019, Potočan et al., 2021), facilitating the merge of cyber and physical space (Aquilani et al., 2020, Potočan et al., 2021), hence, generating the betterment of data collection, which enriches the problems solving and value creation (Aquilani et al., 2020).
According to Salvatore (2020, as cited in Aquilani et al., 2020), there are two essential components of the transition towards Society 5.0, namely the managerial thought and the Japanese culture. Indeed, the culture and the managerial practices enlighten the required collaboration between people and institutions, creating less formal relationship. The role of the individual is crucial, the Human-Centricity within the new society is a vademecum to understand the transformation.
While, from a management standpoint, the correlation between value co-creation and open innovation can be investigated.

For this very reason, the open Innovation, and the value co-creation are frameworks that match perfectly with an anthropocentric society, since it is required the participation of the individuals, the firms, and the institutions.

Aquilani et al. (2020) published a study in which wonder the role of open innovation and value co-creation within the transition towards Society 5.0.

First things first, it is crucial to define the two managerial concepts drawing from the literature.

The role of Open Innovation and Value Co-creation

During the Second Industrial Revolution, innovation was the task of research and development departments. However, the notion of OI is not new; in 2006, professor Chesbrough improved his 2003 definition (West and Bogers, 2013), characterising the phenomenon as follows (Innovative Medicines Initiative (IMI), 2017):

> *Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, As the firms look to advance their technology Open innovation combines internal and external Ideas into architectures and systems whose Requirements are defined by a business model.* (p.2).

Hence, according to the definition, can be grasped the sense of anthropocentrism within this managerial view, which can be adopted to explain the functioning of a new vision of society.

Returning to the study conducted by Aquilani et al. (2020), it is possible to describe the role that this managerial vision had within the transition from Industry 4.0 to Society 5.0.

The starting point is the assumption that a company on its own has difficulty innovating. Nevertheless, Industry 4.0 has played a pivotal role in improving communication through its technological innovations, stimulating the adoption of OI. Fukuda (2010, as cited in Aquilani, 2020) stated the presence of a link between OI and the transition to a new vision of society, stressing the necessity of creating an environment that allows information flow and serves as an incubator for innovation.

Therefore, the literature confirms the role of Industry 4.0 as a facilitator for the adoption of Society 5.0.

Again, Fukuda (2010, as cited in Aquilani, 2020) emphasised the importance of public-private collaboration in creating a stable economic and social atmosphere.

Finally, in order to accept OI processes, the task must be originated and carried out by a diverse set of players, as outlined by Chesbrough: *"Co-creation is the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically"* (Galvagno & Dalli, 2014, p.644).

According to the definition, it is simple to understand the existence of a link between open innovation and value co-creation, since both managerial perspectives include the concept of some collaboration among the most various actors.

Because the site where value is created is where interactions are triggered, organisations that follow this strategy will perform better not only economically, but also socially and environmentally, by leveraging the abilities of their stakeholders (Leavy, 2014, as mentioned in Aquilani et al., 2020).
Thus, it is the empowerment of the interested party in such a fashion that a mutually positive outcome is achieved, a so-called win-win situation (Ramaswamy, 2014, as cited in Aquilani et al., 2020).
Therefore, *"Value Co-creation can be considered the approach to be used to build Society 5.0"* (Aquilani et al., 2020., p.8).
Thus, value co-creation is not the only managerial strategy thought to achieve Society 5.0; activities carried out by businesses and/or other organisations involving individuals can also drive this change. There are some parallels between the two approaches, in that value co-creation stimulates innovation in all fields, which in turn helps to improve OI processes.
Finally, Kaihara (2016, as cited in Aquilani et al., 2020) opted for the term *systems of systems* to define the virtuous mechanism that explains the link between value co-creation and the achievement of Society 5.0. According to this study, inclusiveness is the facilitator along with Industry 4.0 technologies that allow the improvement of society.

The Japanese government has launched a series of projects whose foundations are based on the concept of mutual value, generated by collaboration between the public and private sectors, between the company and the citizen, and in general between the members that make up a society (Fukuda, 2019).

- *Kashiwa-no-ha Smart City*: The task was to create a city that is environmentally friendly, promotes long and healthy lives, and fosters industrial innovation.
- *Town of Tamaki*: The goal was to deal with the sparsely and aging populated areas of the city. The town developed, thanks to the University of Tokyo, a responsive and free public travel system, by which the senior citizens do not need to contact an operator. The technological system is able to arrange the routes with the purpose of reducing the economic and environmental costs, plus bettering the sociality of the elderly, since they are now able to participate in community events.
- Eventually, *The Agricultural Production Corporation*: was established in the town of Yamamoto, in 2011 after the terrible earthquake that devastated the island, to revitalize the industry of the city, through the combination of the knowledge and skills of farmers and the precision of technology.

The Role of Firms

Aquilani et al. (2020) designed a model that condenses OI and Value Co-creation as well as industry 4.0 technologies. The framework graphically represents the role of enterprises in the transition to Society 5.0.

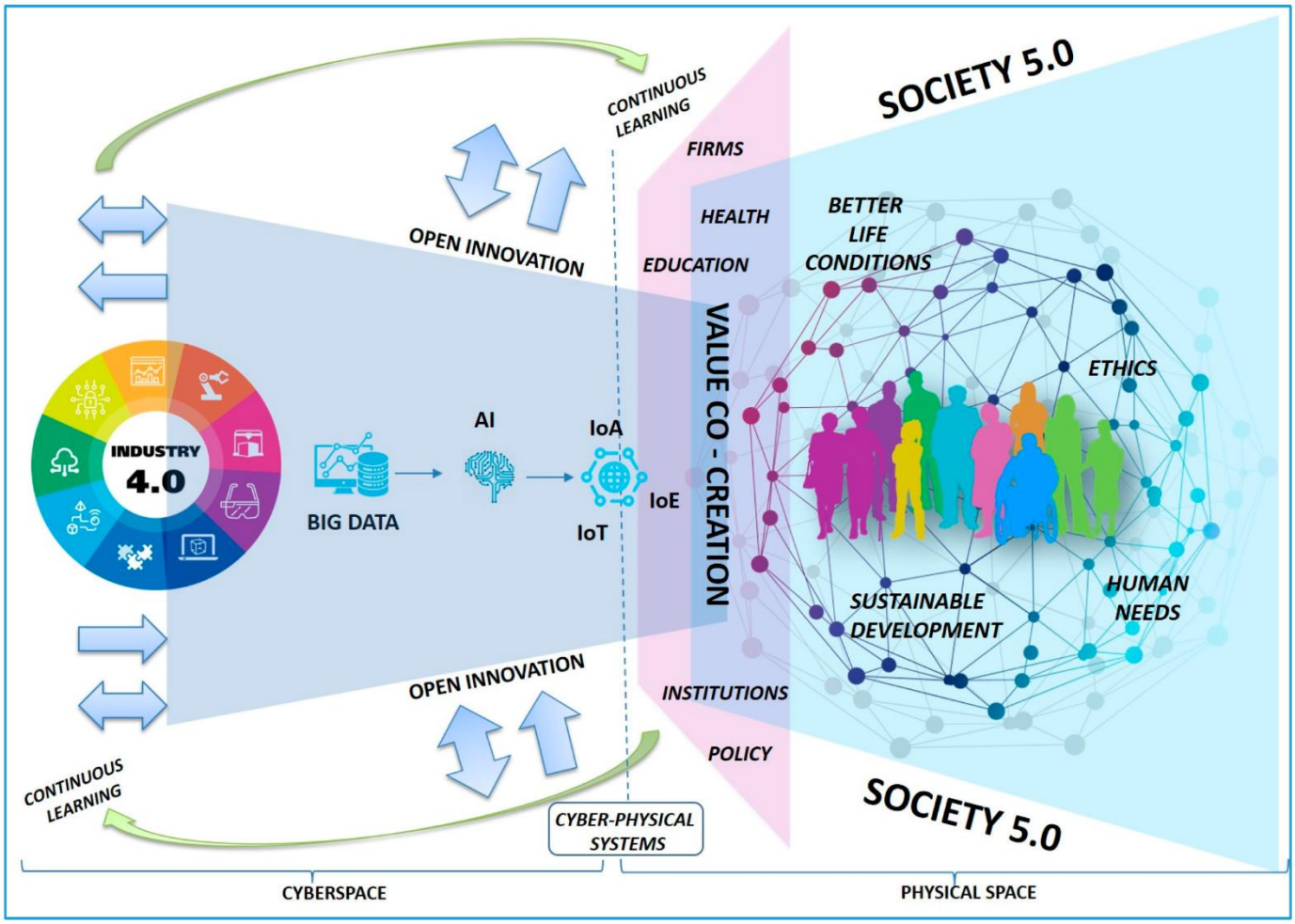

Fig. 3 The transition from Industry 4.0 to Society 5.0. (Aquilani et al., 2020, p.11).

The figure consists of two main parts: cyberspace and physical space. The left part is the environment in which the technologies of Industry 4.0 are positioned, while the right part graphically represents the place where society, as a sum of individuals, is located.

Instead, the central part represents the area of communication between the two sections, the place where individuals and companies collaborate.

Definitely, as defined by Chesbrough (2003), the boundaries dividing companies and society have become porous, allowing collaboration between stakeholders and companies, thus making it possible for IO to operate.

Quoting Aquilani et al. (2020):

> *This division into two areas means understanding how enabling technologies, beginning with big data, through the intervention of AI and IOT, allow for the conversion of information into concrete interventions on society in general, thus passing from a purely virtual environment (cyberspace) to a real and everyday life environment (physical space).* (p. 11).

It is therefore Industry 4.0 technologies that act as a bridge between the cyber space and the physical space, transforming information into actions that improve social welfare.

As a result, companies support the direct transition to the 5.0 society through collaboration with a diverse set of stakeholders, including institutions, individuals, and communities, as well as universities and research centres, which, as demonstrated by the Japanese example, frequently leads to optimal results. The Society 5.0 will reposition humanity in the centre of priorities, and man will become more aware of the importance of improving his social conditions and ensuring long-term development. This awareness will be left to new technology, which will be required to handle future difficulties in a more efficient, safer, and ecologically responsible manner.

Industry 5.0

The past Industrial Revolutions have always boosted and shaped the change within society throughout the use of new technologies and the subsequent, as mentioned in previous chapters, betterment of the quality of life.

However, society 5.0 is requiring a new paradigm for the industry that goes beyond the neo-liberal[2] capitalism. In this scenario, it is industry that is attempting to adapt to society. Following the footsteps of the United Nations' Sustainable Development Goals, new concepts of social development, such as Sustainability and Human-Centricity, have become essential to corporate objectives. As a result, industry is an essential component of society (Leng et al., 2022).

Society's mobilisation in favour of civil rights and environmental conservation has increased. The solidarity shown for Ukrainian citizens, the Black Lives Matter movement, and the sounding board established around Greta Thunberg’s speech all verified this shift in society. Industry heeded the warning and realised the importance of refocusing not just on supply, but also on demand. It recognised that competition will be focused not only on cost-cutting, but also on challenges such as growing wealth and protecting the environment. (Dixson-Declève et al., 2022).

[2] Neo-liberalism is an ideology and model of economic policy that emphasises the value of competition under free market conditions. Although there is a heated debate about what the characteristics and dominant current of thought of neo-liberalism are, it is most commonly associated with the economic practice of 'laissez-faire'. In particular, neo-liberalism is often characterised in terms of the 'creed' concerning economic growth as the means by which humankind succeeds in progressing, the belief in the free market as the most efficient way to allocate resources, and the emphasis on the minimal state (i.e. a state that intervenes minimally in social and economic affairs) and the commitment to freedom of trade and capital.

Critics, therefore, portrays Industry 4.0 as an obsolete paradigm that can no longer respond to society's needs. It is neo-liberal capitalism, founded on the concept of profit and shareholder primacy, that is considered to be the proponent of problems such as social inequality, or the depletion of natural resources, as well as environmental damage (Ghobakhloo et al., 2022).

According to Nahavandi (2019) the paradigm describing Industry 4.0 is unable to consider the human costs resulting from the optimisation of production processes. The author, therefore, sees in Industry 4.0 the lack of a social dimension, indeed, he forecasts that if nothing changes in this regard, the benefits of Industry 4.0 would be fully negated by political and labour union pressures.

To that aim, it is required to implement a new model that capitalises on the lessons and improvements made to overcome the pandemic crisis, along with a hyper-connected industrial ecosystem based on big data that enriches and absorbs the ideals of sustainable development (Ghobakhloo et al., 2022).

Industry 5.0 is the name given to the new paradigm.

Industry 5.0 recognises, unlike previous revolutions, the role it must play within society. The pivotal objective for which it was conceived is the promotion of sustainable development, such that production processes respect the environment and the well-being of workers (Akundi et al., 2022).

Therefore, the concepts of Society 5.0 and Industry 5.0 are linked, not exclusively in the sense of a shift concerning processes or production methods, technologies, or internal organisation companies, but rather the initiation of a new economic and social vision (Breque et al., 2021).

In support of the above, the European Commission (Dixson-Declève et al., 2022), through its studies, predicts the reduction of industrial pollutant emissions by 25.1%. These figures are, however, conditional on the transformation of the economy, a change resulting from the adoption of the founding principles of Industry 5.0, including resilience, sustainability, regenerative and circular economic principles, as well as governance and policy changes, and the adoption of Horizon Europe and National Resilience and Recovery Programmes. In this respect, the Industry 5.0 vision represents an economic model that is not only based on production and consumption, but embraces the demands of Society 5.0. The Fifth Industrial Revolution, therefore, focuses on a concept that puts human progress and well-being at the centre, based on the reduction and reshaping of consumption habits towards sustainable development. As previously stated, Industry 5.0 is meant to serve as a bridge in a transition aimed at overcoming the neoliberal capitalism model, which involves the shrinkage of the *profit primacy* in favour of *shareholder primacy* (Dixson-Declève et al., 2022).

Finally, what has been mentioned in these opening lines can be summarised as follows. The creation of Industry 5.0 was grounded on the sudden realisation that Industry 4.0 had failed in terms of social and environmental sustainability, as highlighted by the Agenda 2030. Industry 5.0 therefore seeks to overcome the limitations of its predecessor by focusing more on the principles of social justice and environmental sustainability and less on technologies adopted for the sole purpose of making production more effective and efficient from a purely economic point of view (Xu et al., 2021).

Technology, as will be discussed in detail later in the dissertation, plays an important role, but this relevance it is not justified by the effects generated regarding the economic efficiency of production sites or the interconnection of multiple departments or business locations. Therefore, Industry 5.0 is not a technology-driven revolution, rather it represents a value-driven transformation (Xu et al., 2021), with technology having the task of facilitating this revolution, nevertheless with broader objectives. Then again, Industry 5.0 is not solely based on technology, but on goals and principles including Human-Centricity, Sustainability, and Resilience. Technology will have the task of facilitates these principles/objectives. (Akundi et al., 2022).

The factors that have been taken under analysis up to this point are the change in society (society 5.0) and the role of technology. Precisely for this reason, the Fifth Industrial Revolution takes the form of a socio-technological phenomenon, which brings with it the principles of Human-Centricity as opposed to the productive-centricity that characterises Industry 4.0 (Ghobakhloo et al., 2022).

The new industrial vision, and the aims it brings with it, are thus defined by the position of man inside the enterprise, with the goal of promoting human life and well-being. Then, this is the key to understand Industry 5.0, despite the fact that the literature is still in its early phases and study findings are limited and less methodical. (Leng et al., 2022).

A reference model for Industry 5.0

The participants of a workshop with Europe's technology leaders in 2020 have agreed upon the theory according to which Industry 5.0 could not be considered as an alternative of Industry 4.0, but rather as an evolution/logical continuation. As a result, the notion of Industry 5.0 emphasises values rather than technology, such as the importance of humanity, the environment, and societal benefits. This paradigm shift is founded on the idea that technology may be designed to serve values, rather than vice versa, and that technical progress can be generated to satisfy societal needs. This is especially true as the Fourth Industrial Revolution alters the way value is created, exchanged, and distributed. Furthermore, under Industry 5.0, technologies must be viewed as components of systems designed to improve social and environmental values, rather than as mere technologies that determine firm's growth (Müller, 2020).

However, because the framework is grossly understudied, Ghobakhloo et al. (2022) have produced a *Reference Model* that depicts the technology constituents, concepts, components, and fundamental value objectives of Industry 5.0 in a holistic manner. The first step is to consider Industry 5.0 as a socio-technical phenomenon.

Industry 5.0 is a technology phenomenon since it is focused on technological advancements and the digitization of industrial value networks. Furthermore, Industry 5.0 is a social phenomenon since it is based on a culture of interaction among stakeholders to govern and direct technological growth in order to support fundamental sociocultural values such as human dignity, equality, privacy, and autonomy.

The Reference Model, as seen in the diagram below, is based on the aforementioned principles.

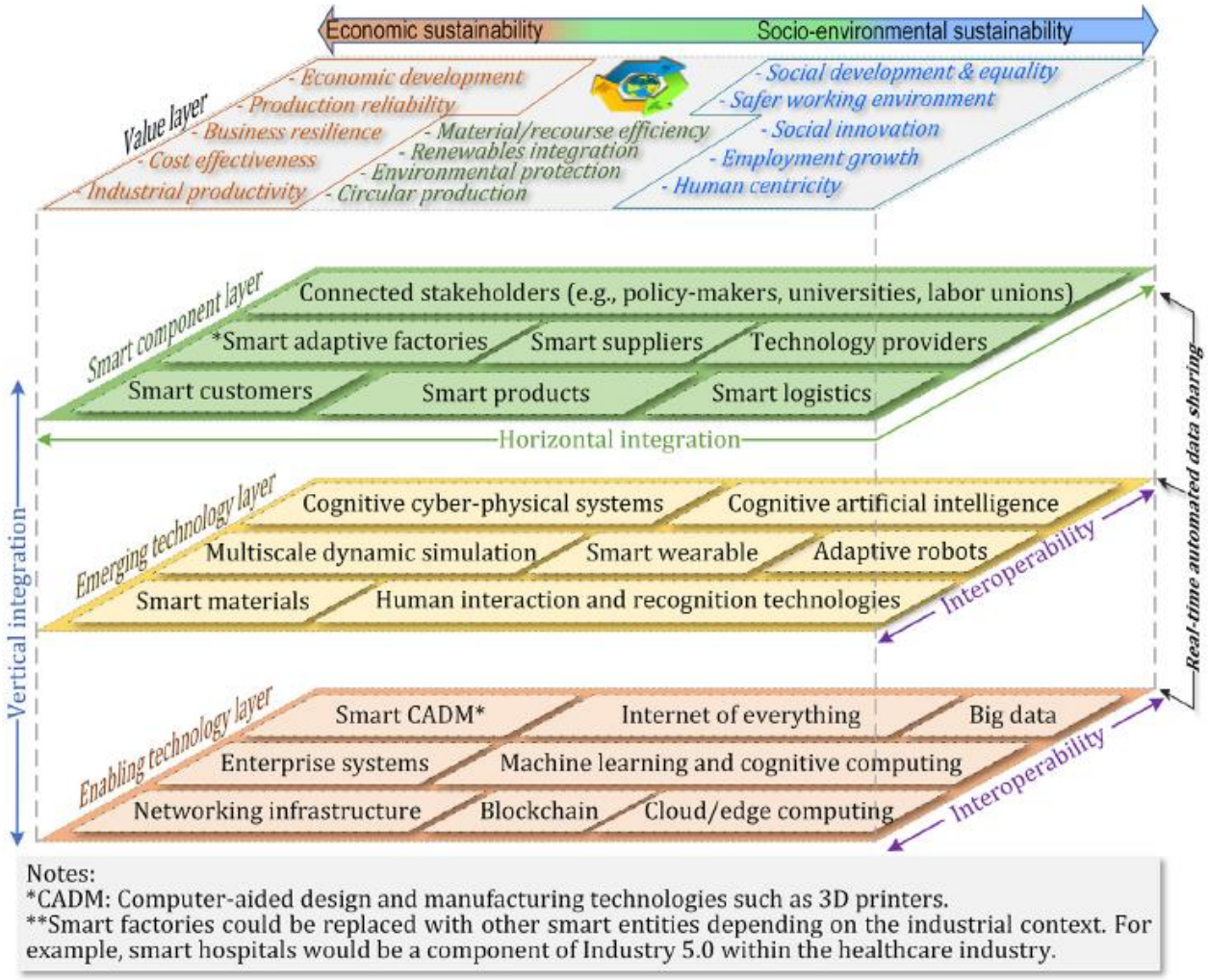

Fig. 4: The reference model of Industry 5.0 (Ghobakhloo et al., 2022, p.4).

The first layer (from the bottom) is made up of the *enabling technologies* that have become significantly more affordable and hence more applicable to enterprises during the Third Industrial Revolution. All of the enablers in this category are designed to increase efficiency, which is a critical feature of digital ecosystems in Industry 5.0.

Nevertheless, with impending technical improvements, the corporate environment is growing denser and more competitive in the developing period of globalisation. This necessitates the use of new inventive ways in existing and prospective initiatives to develop robust resiliency and sustainability in the commercial and industrial sectors (Sindhwani et al., 2022).

As a matter of fact, the second layer of the model, depicts the most disruptive innovations, defined as *emerging technologies* of industry 5.0, which functioning is grounded on the previous enabling technologies.

The second layer technologies deliver the core objectives of Industry 5.0, as will be described in the following paragraph (3 Pillars of Industry 5.0), namely: Human-Centricity, Sustainability, and Resiliency.

Then, the model represents the *Smart component layer*, which reports the essential components guaranteeing the operation of Industry 5.0.

Finally, the top of the reference exhibits the *Value layer*. The double-headed arrow represents the balancing of economic and socio-environmental objectives, derived by the interpretation of the sustainable development within Industry 5.0.

The Industry 5.0 reference model recognises that the various aspects of economic, environmental, and social sustainability within the value layer are interconnected, and for this very reason, highlights the importance of a synergetic complementarity among stakeholders.

Industry 5.0, in addition to enabling and emerging technologies, is dependent on specific techno-functional concepts. These principles define critical technological prerequisites for Industry 5.0 components, such as smart factories or customers, to harness underlying technology and function properly in accordance with the phenomenon's primary objectives. Vertical integration, horizontal integration, interoperability, and real-time data exchange are among the key techno-functional principles of Industry 5.0, as illustrated in the reference model.

When properly developed, techno-functional principles promote the development of Industry 5.0's sustainable development functions, creating conditions that allow smart components to optimally use emerging and enabling technologies to offer the phenomenon's sustainable development values.

In the next paragraph the objectives of Industry 5.0 will be deepened.

3 Pillars of Industry 5.0

1. Human-Centricity

It assumes that business processes should be designed with a focus on the role of man, his needs and benefits. It is a human-centric revolution precisely because it has the task of bringing humans back into production, disengaging them from routine tasks. As a result, from an operational standpoint, Human-Centricity necessitates that man's function be expanded beyond conventional process management to that of decision maker, aided by technology. To this end, the theme of up-skilling and re-skilling, considered crucial in human-machine cooperation, is recalled. (Jafari et al., 2022).

Similarly, according to Leng et al. (2022), the current understanding regarding Industry 5.0 sees human touch back to the industry. It concerns the incorporation of AI into human-supported operations in such a way as to amplify the capabilities of the worker. It is about technology serving man and not the other way around. This justifies the concept of Human-Centricity.

In addition, the present first pillar describes the shift from a progress whose driving force is technology to one in which society plays a key role and therefore places a premium on human needs (Xu et al., 2021).

Hence, it can be argued that the core of Industry 5.0 is the balance that is generated between human, machine, values, tasks, knowledge, and skills, all of which leads to customised and individualised products (Leng et al. 2022).

Finally, it is a priority of Industry 5.0 to create a work environment that is safe and inclusive and that promotes physical and mental well-being as well as acting as a protector of fundamental rights (Xu et al., 2021).

2. Sustainability

Industry, to respect planetary boundaries, needs to be sustainable (Breque et al., 2021). Thus, it is the task of Industry 5.0 to protect the environment and preserve natural resources by promoting economic growth.

Again, industry throughout the use of technologies such as AI and additive manufacturing, must aim to plan and define strategies that empower the development of processes based on keywords such as re-use, re-purpose, and re-cycle of natural resources (Breque et al., 2021; Xu et al., 2021).

Jafari et al. (2022) citing Bruntdland's studies in 1987, proposes the definition of sustainable development, according to which it is defined as such, if it allows the needs of the present society to be met without affecting the ability and therefore the resources of future generations to satisfy their requests. Similarly, Jafari et al. (2022) discuss the importance of reverse logistics, the circular economy, and supply chains in achieving the zero-waste goal.

Therefore, there are several points within the SDGs defined by the United Nations that refer to the need for greater sustainability of industry. It is possible to cite some aspects referring to *Responsible consumption and production* and *industry, innovation, and infrastructure* (Leng et al., 2022).

3. Resilience

This dimension refers to the challenges posed by the pandemic and the war in Ukraine, and how society, but more specifically industry, has responded to and learnt from these shocks. Hence, resilience is defined as the typical ability of a system that is able to resist or react quickly to certain exogenous factors that undermine or may undermine its proper functioning. Thus, Industry 5.0 has the ability to handle uncertainties arising from markets, supply chains, customers, and even entire national industrial systems (Leng et al., 2022), as well as geo-political shifts and natural emergencies (Xu et al., 2021).

From a business perspective, the concept of resilience translates into greater agility and flexibility in responding to consumer needs. Production systems require the participation of consumers in the design stages in order to increase the possibility of product customisation and thus anticipate changes in market demand. Finally, worker-serving robots are being adopted to boost flexibility and minimise time to market. (Jafari et al., 2022).

A Definition for Industry 5.0

Since Industry 5.0 is such a new concept, there is no formal definition. For this reason, the classifications reported by Leng et al. (2022) will be analysed from the perspective of the 3 pillars described above.

The rationale is to establish the most applicable terminology to define the Industry 5.0 phenomenon in order to provide a strong framework for this paper's research. As a result, the definitions are listed and the sections that correspond to the three pillars are underlined based on a subjective assessment.

When referring to buzzwords that remind Human-Centricity, Sustainability, and Resilience, each definition has different coloured underlining, correspondingly orange, green, and blue. The number of times a specific key phrase or concept was recalled within the set under examination is shown at the bottom of the table.

Lastly, it is worth specifying, that the definitions were chosen as they are of recent date and the publication was by an authoritative Journal.

The analysis is presented here:

As cited in Leng et al. (2022).	Definitions:	Human-Centricity	Sustainability	Resilience
Breque et al. (2021).	Recognize the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the center of the production process.	X	X	X
Humayun (2021).	A manufacturing paradigm places a premium on worker well-being throughout the manufacturing process and leverages new technologies to create wealth beyond employment and development, all while keeping conscious of the planet's production restrictions.	XX	X	
Kaasinen et al. (2022).	Recognizes the power of industry to become a resilient provider of prosperity, by having a high degree of robustness, focusing on sustainable production, and placing the wellbeing of industry workers at the center of the production process.	X	X	X
Nahavandi (2019).	Human workforce and machines work together in close collaboration in order to increase process efficiency by utilizing human creativity and brainpower.	X		
Lu (2021).	Humans will be able to rejoin the automated process and cooperate with a new generation of Cobots to add value to products.	X		
Nahavandi (2019).	A synergy between humans and autonomous machines. The autonomous workforce will be perceptive and informed about human intention and desire.	X		
Maddikunta et al. (2022).	A human-centric design solution where the ideal human companion and Cobots collaborate with human resources to enable personalizable autonomous manufacturing through enterprise social networks.	X		X

Longo et al. (2020).	An 'Age of Augmentation' when the human and machine reconcile and work in perfect symbiosis with one another.	X		
Friedman & Hendry (2019).	Force business professionals, information technologists, and philosophers to concentrate on human factors when implementing new technologies in industrial systems.	X		
Javaid & Haleem (2020).	A new business concept using an intelligent manufacturing system with the use of intelligent devices. It will meet & exceed the requirements of customer delight, personalization, improved productivity, efficiency, and quality of the product.	X		X
	TOTAL:	11	3	4

Fig. 5:Industry 5.0 definitions analysis (Own elaboration).

According to the described criteria, the definitions elaborated by Breque et al. (2021) and Kaasinen et al. (2022) as cited in Leng et al. (2022) will be considered as relevant definitions within this theoretical framework.

The total number of times the principle of Human-Centricity has been recorded is greater than any other value. This is hardly surprising, as the literature demonstrates how it is viewed as the main issue of the new Industrial Revolution. As a result, it is judged important to further explore this topic, as detailed in the next paragraph.

The Human touch back

Human-Centricity is the core concept of Industry 5.0, which presents a trade-off between the integration of humans in production processes and automation in order to fulfil value creation goals (Jafari et al., 2022).

According to Burtner & Ho (2019) and Mekid et al. (2007) as cited in Jafari et al. (2022), the aforementioned integration affects the resilience of a logistic system and for this reason, more attention is needed in the area of human-machine collaboration.

The increasing integration of human-machine collaboration has redefined the idea of robots, introducing collaborative robots (cobots). Nonetheless, Kopacec (2018, as cited in Kent & Kopacek, 2019) described human-machine collaboration as follows by delving deeper into cobot qualities:

> *In order to perform collaborative tasks cobots are designed to be safe around humans (using sensors, force limiting and rounder geometries than traditional robots), to be lightweight (for them to be moved from task to task) and to be easy to implement and use without skills in programming* (p.3).

Indeed, Industry 5.0 redefines the concept of the robot, emphasising the principle of Human-Centricity and introducing the perfect companion of the human worker. It can be considered an apprentice, and as such, it

possesses the skills necessary to learn directly from the field while observing human activity (Nahavandi, 2019).

The following picture shows an example of a production line equipped with a cobot.

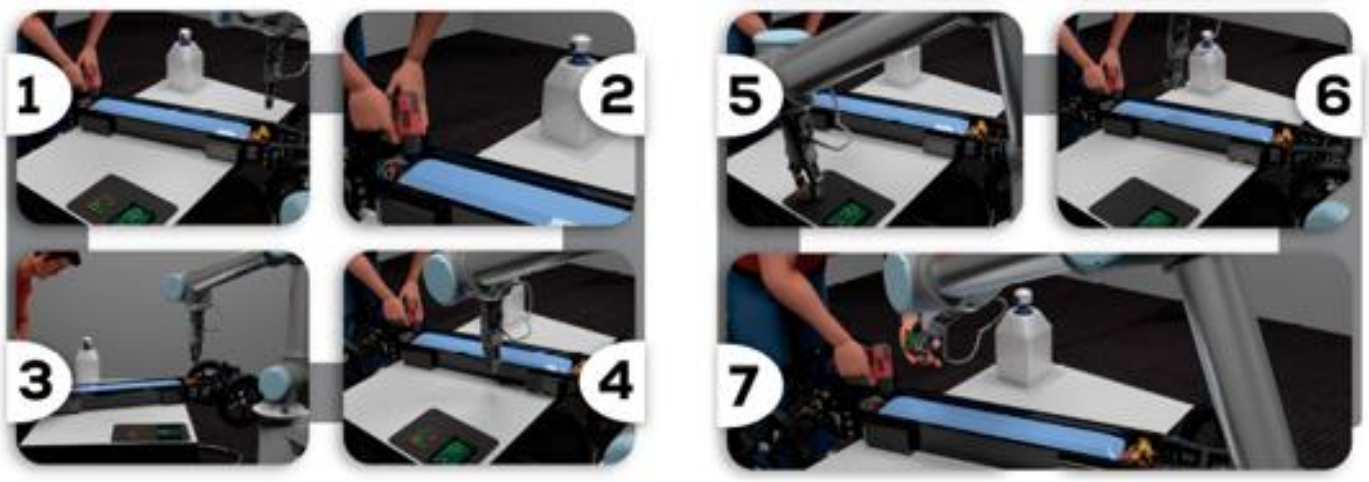

Fig. 6: The case for Industry 5.0: Robots work with humans to increase production efficiency, not to replace the human workers (Nahavandi, 2019, p.4).

In the image number 1 the cobot studies the behaviour of the worker. In image number 2 the cobot through the use of RGB camera and fNIRS sensors is able to generate workflow predictions. In pictures 4 and 5 the cobot starts to help the worker in the manufacturing process. Figure 5 shows the step where the cobot helps the worker, through the selection and lifting of the tool of interest to the worker. In figures 6 and 7, the cobot delivers the worker with the desired tool.

On the other side, the figure of the worker within a logistic system can be summarised via the framework of Operator 5.0, which was created as an evolution of its predecessor Operator 4.0.

The first definition of Operator 5.0 was introduced by Romero & Stahre (2021) as cited in Jafari et al. (2022):

> *A smart and skilled operator that uses human creativity, ingenuity, and innovation empowered by information and technology as a way of overcoming obstacles in the path to create new, frugal solutions for guaranteeing manufacturing operations sustainable continuity and workforce wellbeing in light of difficult and/or unexpected conditions* (p.15).

Operator 5.0 is based on the notion that technology is not seen as a threat. Rather, it is perceived as a direct complement to the empowerment of the worker. Operator 5.0 is based on the promotion of two types of resilience: *self-resilience* and *system-resilience*. The first refers to biological, physical, cognitive and psychological health, as well as worker productivity. The second, on the other hand, refers to the study of methods aimed at maintaining the functionality linked to the relationship between human-machine systems.

Operator 5.0 is thus a demonstration of how, unlike Industry 4.0 focused on automation, Industry 5.0 reintroduces the worker and makes him/her cooperate with autonomous machines (Leng et al., 2022), considering both Resilience and Human-Centricity (Jafari et al., 2022).

According to a 2019 World Bank research study entitled as "*The changing face of work"* (Kent & Kopacek, 2019) the positive societal sentiment towards the introduction of technology in the workplace is depicted. Agreeing to the study, two-thirds of the population believe that technology will bring social and quality-of-life benefits. Furthermore, to adopt technologies and thus make the cooperation between worker and machines effective, it is necessary for industry to make large investments in human capital, by incubating different set of skills (Kent & Kopacek, 2019):

- advanced cognitive skills such as complex problem solving,
- socio-behavioural skills such as teamwork,
- and skills combinations that are predictive of adaptability such as reasoning and self-efficacy.

New technologies also come to the rescue in this respect, through the adoption of virtual training, companies are able to reduce costs in terms of time, quality, and safety, as no interruption of production processes is required.

Therefore, virtual training is a very important technology assisting firms in the education of skilled workers by eliminating the risk of productivity or the safety of workers (Nahavandi, 2019). An example of virtual training is the Universal Motion Simulator (as cited in Nahavandi, 2019) which provides a secure training environment for a variety of professionals, such as drivers, pilots, fire fighters, medical professionals.

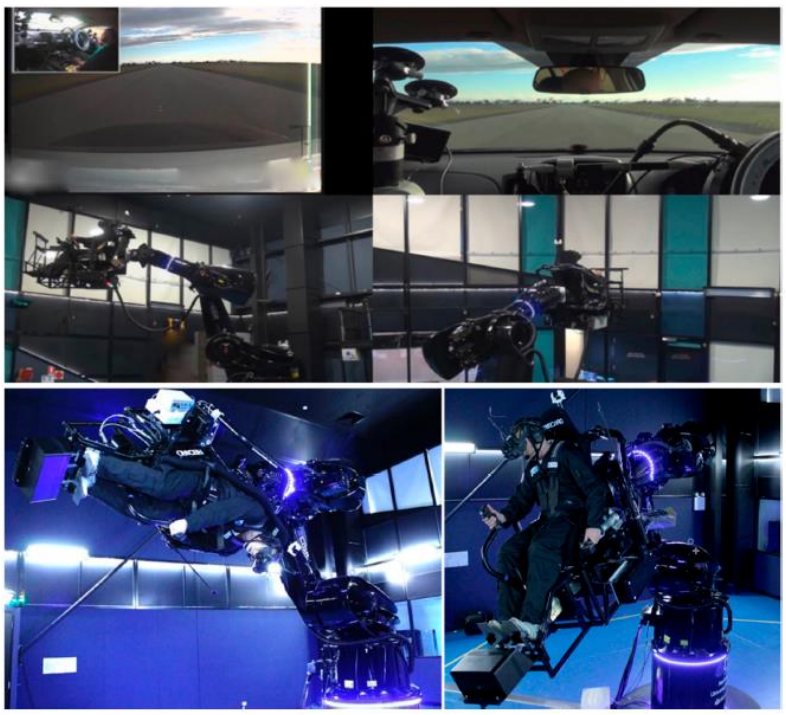

Fig. 7: Universal Motion Simulator at Institute of Intelligent systems Research and Innovation, Deakin University. (Nahavandi, 2019, p.6).

Consequently, the development of new technologies necessitates the need for businesses to seek for individuals who understand how to use them, requiring specific skills.

According to a Deloitte study (Breque et al., 2021), the subject of *up-skilling* and *re-skilling* is a very sensitive issue. As a matter of fact, about 70 per cent of young people do not believe they possess the skill set required by the labour market. As a result, the European Community launched the *SAM* (Sector Skills Strategy in Additive Manufacturing) and *SAIS* (Skills Alliance for Industrial Symbiosis - a cross-sectoral Blueprint for a Sustainable Process Industry) projects, which have been identified as a more intuitive and user-friendly approach to training, with no requirement for specific skills. However, according to Breque et al. (2021), firms will not be able to provide education to every single worker, but rather resources will be focused on ensuring workers have knowledge of AI technologies.

Of interest is the research by the World Manufacturing Forum (as cited in Breque et al., 2021) identifying the list of the 10 top skills that will be crucial in the industry of the future.

Fig. 8: World Manufacturing Forum's top ten skills for the future of manufacturing. (Breque et al., 2021, p.20).

Industry 5.0's socio-technological phenomenon has also demanded adjustments in organisational design. Nonetheless, the Fifth Industrial Revolution envisages the introduction of a new corporate figure, the Chief Robotics Officer (CRO). This role focuses on identifying and studying the behaviour of robots in their relationship and interaction next to the worker. The CRO will be responsible for making decisions on the

insertion or removal of machines/cobots from the factory floor. The decision-making process will be based on the principles of production effectiveness and efficiency to achieve improved performance, as well as increase the sustainability of human civilisation by reducing emissions (Nahavandi, 2019). This is a figure that fully illustrates the values of sustainable development, to which Industry 5.0 aspires.

Bagdasarov et al. (2018, as cited in Demir et al., 2019) explored the organizational considerations of the human-machine integration, that could be synthesised in the following list:

1. Legal and regulatory issues: the difficulties in the realisation of a legal definition of robot binding for businesses and organizations. In addition, the identification of the types of robots that can be used in the workplace. Eventually, the decisions and responsibilities that robot can sustain.
2. Personal preference towards working with robots: the personal preference can vary from worker to worker.
3. Psychological issues resulting from human-robot co-working.
4. Social implications of human-robot co-working: Workers may have difficulty interacting with robots, questioning if they should respect a robot simulating a higher-level role than the worker.
5. The changing role of human resource departments: will have to identify and build the robots' workflow, in addition to the responsibilities already assigned.
6. The changing role of information technology departments and emerging of robotics departments: increasing the responsibilities of the first and creating the preconditions to entrust responsibilities to the second, regarding the purchase and maintenance of robots.
7. Ethical issues resulting from human-robot co-working – ethical status of robots.
8. Preference towards types of robots to work with: considering the presence of the learning-based robots and the rule-based robots. The first could be more unpredictable, while the second are more limited in the learning capabilities.
9. Learning to work with robots: how to relate, hence enabling the cooperation.
10. Negative attitude towards robots due to shrinking human workforce: clash in the discussions among proponents of two different views, who advocates that robots will promote unemployment and vice versa.
11. Humans competing with robots or robots complementing humans.

The characteristics described above must be regarded crucial for Industry 5.0 to bring about substantial changes in the labour market, resulting in higher-value jobs (Kent & Kopacek, 2019).

As a matter of fact, In terms of a manufacturing cell centred on a human being, the workspace expands rather than shrinks. Humans take on greater responsibility, resulting in a larger, lighter environment that is safer than the prior environment. The manufacturing operative within the production cell begins to become more

involved in the design process, allowing for the development of more unique and personalised products (Accenture, 2018, as cited in Kent & Kopacek, 2019)

Hence, refers to the greater potential that organisations embracing Industry 5.0 possess to respond more accurately to the desire of the consumers for the mass personalization (Akundi et al., 2022). Therefore, it can be argued that the Human-Centricity pillar of Industry 5.0 focuses both on the producers and on the consumers. Accenture confirms this vision, according to which the products commercialized within Industry 5.0 will be able to respect the individual requirements, by the adoption of an agile, lean, automated, digital, and data driven manufacturing. Eventually the products will be of outmost quality and available at more affordable prices (Kent & Kopacek, 2019), widening the consumer base.

Finally, as a result of the application of industry 5.0 concepts inside the medical sector, the customisation feature could have a life-changing effect, as demonstrated by the realisation of artificial pancreas. The device facilitates the tracking of the level of sugar in the blood, sending info to another device that can dispense insulin. The level of personalisation is taken to the next level, since the patients will be provided with a mobile app, which tracks the lifestyle of the patients to offer the best treatment (Adel, 2022).

CHAPTER 2. Theoretical framework – Resource Based Theory (RBT)

In the previous chapter the framework describing the evolution of the industry has been reported. Starting from the First Industrial Revolution, the causes and the differences have been highlighted, delving into the paradigm of Industry 5.0.

Nevertheless, the first chapter is the necessary tool to investigate the research question within this thesis. As the thesis's purpose is to find which resources are important for businesses to be able to activate the evolution towards a value-driven business model by implementing Industry 5.0.

To do it though, the Resource Based Theory (RBT) will be introduced as a tool for establishing the *resource* notion that will be used in the work, as well as to inspect the resources that could be essential for the adoption of Industry 5.0.

Origins and the VRIN model

RBT provides a methodology for identifying and estimating organisational performance and competitive advantage fundamentals, by adopting a meso-perspective based on the firm's resources. The framework's goal is to spark discussion regarding the outcomes of focusing on an internally driven approach. Concerning the theory's nomenclature, it is important to note that there is a disagreement among researchers as to whether the term RBT or RBV (Resource Based View) is more appropriate. Although the majority favours the definition used in this paper (Utami & Alamanos, 2022).

The RBT is based on two basic assumptions that describe how different organisations can compete. The first is *heterogeneity*, which is defined as the diverse mix of resources or capabilities that firms possess and which drive the competitive advantage. The second is resource *immobility*, which refers to the complications that arise when firms exchange/transfer resources.

The birth of RBT is ascribed to Jay Barney's most famous work known as *Firm Resources and Sustained Competitive Advantage* (1991). Barney through the research developed by Porter in the latest 1980s, guided the transformation of internally driven approach towards a developed theory of resources.

Starting with the heterogeneity and immobility of resources, Barney (1991) explored the relationship between company resources and sustained competitive advantage. Furthermore, he developed four markers of a firm's resource capacity to build a sustainable competitive advantage, which he labelled as *value*, *rareness*, *imitability*, and *substitutability*.

It is critical for the purpose of the article to understand what is designated as a resource. According to Utami & Alamanos. (2022, as cited in Barney, 1991):

> *In RBT, resources refer to assets, business processes, capabilities, the firm's attributes, knowledge, information, etc. controlled by a company to comprehend and implement strategies aiming to enhance efficiency and effectiveness (*p.2).

The company's resources may be classified into two major schemes, the first of three categories and the second of two (Utami & Alamanos, 2022). The first group divides resources into three categories: *physical capital resources*, *human capital resources*, and *organisational capital resources*. Physical capital resources pertain to the company's equipment, as well as its technology, raw material availability, and geographical location. Human capital resources include all interactions and activities within the human workforce, such as training, re-skilling, and up-skilling, as well as work judgement. Finally, organisational capital resources include both the formal and informal structure of the company, along with the procedures for planning, managing, and coordinating. Organisation capital resources consider the relationships between the actors in the industry as well (Utami & Alamanos, 2022). The second scheme depicts a firm's resources in terms of its tangibility or intangibility. *Tangible resources*, such as products and commodities, allude to economic advantages and visible company contributions. Whereas the assets associated to access to capabilities, knowledge, organisational, strategic, and social advantages are referred to as *intangible resources* (Utami & Alamanos, 2022).

In order to introduce the RBT and the VRIN model it is critical to distinguish between resources and *strategic resources* as the former is commonly used in everyday discourse. While the second statement refers to an asset that possesses the four criteria, namely when it is *valuable, rare, inimitable, and non-substitutable* (Edwards et al., 2014). The four characteristics that define strategic resources can therefore be defined as follows (*Resource Based View - the VRIN Characteristics*, n.d.):

- *Valuable*: When resources can add value to the company, they can be a source of competitive advantage.
- *Rare*: Resources must give a distinct approach to provide the organisation with a competitive advantage over competitors. Consider the instance where a useful resource exists in both competitive firms. Such a resource is not rare in providing a competitive advantage.
- *Inimitable*: If competing enterprises cannot get resources, they can be sources of long-term competitive advantage. Consider the instance where a resource is valued and scarce, yet rival companies can simply replicate it. Such resources cannot be used to gain a competitive advantage.
- *Non-substitutable*: Resources should not be replaceable by other strategically comparable valuable resources. If two resources can be used independently to carry out the same strategy, they are strategic comparable. Because such resources are interchangeable, they are not sources of sustainable competitive advantage.

Furthermore, in light of recent events such as the pandemic crisis and the Ukrainian conflict, the sector has responded by transitioning to Industry 5.0. According to this viewpoint, the development of the sector may have prompted the function of specific types of resources, making them strategically relevant. As a result, the circumstance in which a normal resource becomes a strategic resource may exist and may arise as a result of a significant alteration in the environment (Edwards et al., 2014).

West Jet Case

The aim of this section is to bring a more empirical point of view to the theory. Through the case analysed by Edwards et al. (2014) the investigation of the resources held by the airline WestJet will then be presented. Thus, the purpose of the case is to present the functioning of the framework, showing the VRIN features contained. However, before beginning the resource analysis, the past and present of the company will be briefly summarised as elements for further investigation.

WestJet was founded in 1996 with three planes, five routes, and 220 WestJetters. Today, they serve across over 100 destinations in North America, Central America, the Caribbean, and Europe using five distinct aircraft types. With a fleet of more than 150 aircraft, their 14,000 WestJetters transport more than 22 million guests per year on over 700 flights per day (westjet.com.,n.d.).

WestJet operates a fleet of fuel-efficient Boeing Next Generation 737 Aircraft, allowing the company to remain profitable in a highly competitive field such as the airline industry. As a result, the WestJet fleet is a *valuable* resource since it improves the company's performance and efficiency while mitigating competition risks. The company's vision is to consistently create an excellent visitor experience through strong relationships with staff. In an industry marked by strikes, layoffs, and low morale, it is extremely difficult to establish such a relationship inside the workforce. Consequently, WestJet's culture is regarded as a *rare* resource, as it is difficult to locate a comparable one in the sector. The culture of the Southwest airline came from modest origins. Because the firm had so little money, it had to "borrow" luggage carts from other airlines and occasionally instal magnets with the Southwest brand on top of the rivals' emblems. It took a long time and a lot of effort to build a Southwest or WestJet culture, unless the airline was totally new and has no previous culture. Southwest's "rags to riches" story unfolded over several decades, and the company has been recognised as one of Canada's Most Admired Corporate Cultures for many years, earning admission into the corporate culture hall of fame. As a result, culture can be considered as well as a *difficult to imitate* resource.

Finally, the culture influences employee behaviour in regard to the customer relationship. Approximately 85 percent of eligible WestJet workers own shares of the firm through the employee share purchase plan, demonstrating the company's extensive commitment and trust with its stakeholders throughout the years. In this sense, culture is a *non-substitutable* resource since it is a driver of value for customers and workers, as evidenced by the fact that the culture of other organisations in the same sector is unable to support the same sort of strategy. Again, because to the culture built through time, Westjet is able to generate passenger loyalty through the highest quality of customer-employee relationships (Edwards et al., 2014).

VRIO model

The second RBT concept is about capabilities, which constitute a subset of the company's non-transferable company-specific resources that enable productivity increase by acquiring new assets (Makadok, 2001 as cited in Utami & Alamanos, 2022).

Capabilities can vary widely and generally consist of tangible or intangible procedures and information that assist an organisation in increasing efficiency and productivity (Utami & Alamanos, 2022).

Consequently, the idea of *dynamic capabilities* is introduced, described as the firm's ability to integrate, develop, and reconfigure internal and external skills to react rapidly to changing conditions. In other words, Dynamic capabilities indicate the rate and way businesses' unique resources and capabilities are reconfigured in response to exogenous stimuli. However, because they are not marketable resources/capabilities, they must be created in-house, primarily by entrepreneurial and/or managerial acts (Teece, 2010).

However, the conventional Resource - Based Theory does not go into detail about why and how businesses obtain a competitive edge in situations of uncertain and fast change. As a result, experts have developed a new paradigm in which organisations do not attain competitive advantage by solely utilising the only resources available to them, but rather by developing new capabilities via the acquisition of tangible and intangible assets through time (Utami & Alamanos, 2022).

Accordingly, the VRIN model has been transformed throughout the replacement of the non-substitutability characteristic with the *organisational* feature, denoting the organisational embedding of resources, and pushing towards a new acronym, namely VRIO. The new criterion implies that a firm's operations and structure are crucial in defining the other three resource criteria that attempt to improve organisational performance: value, rarity, and imperfect imitability. (Utami & Alamanos, 2014).

The results of the transformed framework will be analysed in Fig. 9. The graphic depicts the previously introduced components and examines them through the lens of the organisation criterion and its role in defining competitive advantage (Barney, 2007 as cited in Utami & Alamanos, 2014).

		is a resource or capability...			
Valuable?	Rare?	Costly to imitate?	Exploited by organisation?	Competitive implications	Economic performance
No	_	_	No	Competitive disadvantage	Below normal
Yes	No	_	↕	Competitive parity	Normal
Yes	Yes	No	↕	Temporary competitive advantage	Above normal
yes	yes	yes	Yes	Sustained competitive advantage	Above normal

Fig. 9: The RBT framework using the VRIO model for sustained competitive advantage (Utami & Alamanos, 2022, p.5).

Extended Resource-Based Theory (ERBT)

There are numerous business studies in which components of Resource-Based Theory have been applied, covering a wide range of topics such as marketing, operational management, economics, supply chain management, information systems, and entrepreneurship. Furthermore, numerous researches have been conducted to investigate the relationship between RBT and its application for various business purposes.

Nonetheless, the significance of RBT in the analysis of dynamic capabilities possessed by firms based on the capability lifecycle concept (Teece, Pisano & Shuen, 1997 as cited in Utami & Alamanos, 2022) is regarded as critical.

The concept of the enterprise capacity life cycle emphasises the understanding of enterprise resources as product development paths. The transformation of a firm's capabilities into dynamic capabilities articulates the overall direction and pattern of organisational capability evolution through time. Based on the three initial processes of founding, development, and maturity, the dynamic RBT can identify the firm's capability lifecycle, which is then followed by six additional steps of capability transformation, which are as follows: retirement, retrenchment, renewal, replication, redeployment, and recombination. Understanding dynamic capabilities as a source of competitiveness in the RBT framework may complete the joint evolution of the dynamic RBT's critical elements (Utami & Alamanos, 2022).

As a result, the original RBT gave birth to an enhanced version known as *ERBT*. The new model emphasises firm resources and capabilities because of the interaction between internal organisation and the external environment (Lewis et al., 2010 as cited in Utami & Alamanos, 2022).

According to Utami & Alamanos (2022) the establishment of competitive advantage may have more to do with connections with suppliers than the availability of inimitable industrial production resources controlled by the organisation. In consequence, dynamic capabilities are a significant tool in identifying new company collaborations, by the creation of alliances (Teece, 2010).

Defining the Hypotheses

To construct the hypotheses that make up the analysis of the thesis, it will be necessary to refer back to the essential ideas that were covered in the previous two chapters.

The framework of RBT will be used to recognise the elements corresponding to Industry 5.0.

As a consequence, such premises and analogies are offered to clarify and support the logic underlying the hypotheses that will be presented later.

Industry 4.0 has grown outdated and unable to address social and environmental challenges amid pandemics and environmental catastrophes (Ghobakhloo et al., 2022). Nevertheless, Industry 4.0, as mentioned in the Reference Model, is crucial for the creation of a strong foundation recognised as the enabling technology layer, which is needed for the transition to the Industry 5.0 model, despite the absence of a social and environmental dimension.

Müller (2020) mentioned this notion of complementarity as well, viewing Industry 5.0 as a natural continuation of the preceding revolution.

This allows one to claim that the set of resources required for enterprises to move to Industry 4.0 are complimentary to those required for the transformation to Industry 5.0. Additionally, it enables the notion of complementary and organic continuity between Industry 4.0 and Industry 5.0, as suggested by Müller (2020). Therefore, the resources, as defined by the RBT theory (assets, business processes, capabilities, firm's attributes, knowledge, information*)*, which enable a firm to become efficient (Utami & Alamanos, 2022, as cited in Barney 1991) could be considered complementary and thus a starting point for those firms that will have to make the next evolutionary leap.

This point of view contends that as Industry 5.0 is the outcome of an evolutionary process, the resources now available to businesses embracing Industry 4.0 may be seen as complementing those required for the subsequent evolutionary step towards Industry 5.0. Consequently, can be inferred that:

H1: The firms adopting Industry 4.0 are eased in the transition towards Industry 5.0.

Industry 5.0 is envisioned as a non-production-oriented Industrial Revolution that is centred on creating value for society.

A business aiming to adapt the new paradigm must be able to assess the requirements and preferences of society to achieve this goal. Therefore, in order for organisations to adopt the Industry 5.0 framework, they must be able to swiftly adapt to external stimuli and acquire the competence to internally rearrange their resources, which ability is defined as dynamic capabilities. (Utami & Alamanos, 2022).

In the end, as the businesses working within the industry 5.0 framework must be resilient, the capacity to reorganise and handle unusual occurrences might be seen as both a requirement and a goal for the transition (Leng et al., 2022; Xu et al., 2021; Jafari et al., 2022).

To that aim, it can be theorised that:

H2: As the company's dynamic capabilities, grow, so does the possibility that it will be able to transition to Industry 5.0.

Three major pillars—Sustainability, Human-Centricity, and Resilience—form the foundation of Industry 5.0, which represent the value-driven transformation to which the new paradigm relates.

However, they cannot be viewed as the sole variables influencing a company's capacity to effectively execute Industry 5.0. It is crucial to emphasise that a profit-related performance objective is a need for an enterprise-viable model. Considering this, the Reference Model (Ghobakhloo et al., 2022) offers solid confirmation of this claim.

Nevertheless, to achieve a balance between economic and socio-environmental sustainability values, it might be argued that a behavioural transformation, i.e. a shift in company culture, is required. In support of this,

according to Hubert Joy[3], in today's volatile, complex, and uncertain world, corporate culture can be a better tool for achieving firm's goals rather than a prescient strategy that could be carried out predictably (Does Your Company's Culture Reinforce Its Strategy and Purpose?, 2022).

Therefore, it may be supposed that an organization's culture has a significant impact on its ability to adopt a model that balances economic, environmental, and social sustainability.

It is feasible to observe, citing the West Jet case, how a resource like corporate culture might be regarded by RBT as an extremely important variable—almost fundamental—for the success of the airline.

This is accounted by the fact that corporate culture is a non-transferable intangible resource that has grown throughout the course of the company's existence. Therefore, if corporate culture adheres to the core values of Industry 5.0, it may be seen as a valuable, rare, and inimitable resource.

Consequently, is possible to assume that:

H3: The more deeply embedded a corporate culture is in values that are compatible with the basic principles of Industry 5.0, the more likely it is that a company will embrace the framework.

The Industry 5.0 framework's importance of Human-Centricity was emphasised in the literature.

In the previous chapter, it was further stated how important men are becoming to organisations, and this was reinforced by how frequently buzzwords and concepts pertaining to "Human-Centricity" could be found in the definitions obtained.

Considering Operator 5.0's debut and its emphasis on Human-Centricity, many other subjects have been investigated. Consequently, it has also been discussed the effects such changes may have on the HR departments especially likewise considering the future.

The firm would need to pay greater attention to personnel management since the man would be at the centre of the framework. Human resource management might therefore be seen as a key topic in the shift to Industry 5.0. To give evidence in favour of the current claim, according to Pesic et al (2013) the VRIO framework of RBT could be used to examine human resources.

According to the paper, HR can be considered valuable if it allows counteracting threats and exploiting opportunities, making the enterprise efficient.

Again, HR could be regarded as a rare resource, in consideration of the processes related to the development of tacit knowledge through the company, leveraging on the employees' creativity as well as rare knowledges and capabilities.

Furthermore, if the focus is on the intangible resources, as the business culture, which could shape the management of the personnel, HR could be inimitable.

Finally, the firm must be structured to maximise the value of its human resources.

[3] Harvard Business School faculty member and former Chairman and CEO of Best Buy Co.

As a result, it is important to create an HRM system (organisation characteristic) that make employees a resource valuable, rare, and very challenging to be replicated by the competitors.

Therefore, it can be inferred that:

H4: The greater the focus of companies on developing human resources, the better the chances of completing the transition towards Industry 5.0.

CHAPTER 3. Empirical Analysis

Purpose of the research

Due to its recent debut, Industry 5.0 is a topic that is yet undeveloped and lacks an organic structure.

Thus, an attempt is made to understand how certain companies make the transition to the Industry 5.0 construct.

By studying the literature, it was possible to highlight what can be identified as key elements of the framework.

Furthermore, in order to analyse the Industry 5.0 topic mentioned in the first chapter, the RBT framework was then introduced.

Therefore, the aim of the dissertation is to discover which resources, according to RBT, are necessary for a company to adopt Industry 5.0. The hereunder is how the research question is presented.

RQ: What resources, defined by the RBT framework, must firms possess to implement Industry 5.0?

Methodology

Because Industry 5.0 is a multi-disciplinary revolution, as illustrated within the Reference Model (Ghobakhloo et al., 2022), the use of qualitative research will be made since it makes it possible to perform in-depth research on a wide range of topics (Yin, 2015).

To gather empirical evidence, the interview method will be selected as a collection technique for the purposes of the thesis (Yin, 2015). Consequently, an unstructured survey that aims to gather the respondents' motives, thoughts, and perspectives on Industry 5.0 will be created using a qualitative technique to collect empirical evidence.

The questions will be posed to experts that differentiate one another for the business they operate in, the role they play within their organisations, the size of their companies, and the knowledge they derive from it.

The panellists will be firstly described, with the aim to collect narrative data about their perceptions, aspirations, beliefs and behaviours (Yin, 2015).

Due to the vast nature of the Industry 5.0 topic, the deductive method will be used to attempt supporting the previously stated hypotheses and address the RQ.

The Top of Mind Awareness (TOMA)[4] concept will serve as the foundation for the questions since they cover the subject matter very broadly and provide the respondent a substantial amount of flexibility in how they choose to interpret the questions. The purpose of this approach is to gather data based on the subjects that each responder considers to be the most heavily debated and important considering the topic questioned.

The results of the interviews will be firstly described, then they will be interpreted and graphically represented (Yin, 2015).

[4] Concept adopted in marketing and serves to indicate how a particular brand is positioned in the consciousness of consumers (channelsight.com., nd.).

Therefore, the answers will be analysed using the RBT to identify the resources, that, based on the same criterion, may provide a solution to the problem highlighted in the thesis.

Due to the cross-sectoral nature of the study and the wide range of professional figures questioned, it is to be expected that several factors would affect the responses. RBT will thus be necessary to identify and label the inferences drawn in relation to the survey participants' replies.

Eventually, the hypotheses will be verified, and the study's findings and interpretations will be showed in the conclusion (Yin, 2015). Then, in the discussion part the call for new research will be presented, highlighting the deficiencies in the present thesis, as well as describing the methods and the potential insights for both practitioners and lecturers (Yin, 2015).

Due to the interdisciplinary character of the subject under discussion and the respondents' varied professional backgrounds, the accepted hypothesis will be considered if at least one of the respondents verifies it.

Presenting the Panellists

Based on their professional experience, the three interviews were chosen to get a more empirical perspective. They come from varied professional and personal backgrounds.

The three respondents play distinct positions and have duties and obligations that are also diverse.

It is important to reiterate that the decision to interview many individuals was made since the topic under investigation is interdisciplinary; as a result, it is expected that they would have various viewpoints and ideas as well.

To better analyse the responses that have been gathered, the professional figures interviewed will be presented through the table below.

N. of the Interview	**Name**	**Position**	**Company**	**Company size**	**Business sector**
1	Alfredo Cuzzupoli (A.C.)	Senior Manager Business Transformation (Advisory)	Ernst & Young	Multinational Corporation	Financial
2	Canio Pace (C.P.)	CDA member	Frantoio Oleario F.lli Pace	Small and medium sized enterprise	Agro-food sector (Adopting the transition towards Industry 5.0.)
3	X	IT Senior Consultant	X	Multinational Corporation	Information Technology

Fig. 10: Panellists summary (Own elaboration).

Defining Questions

Question n.1: The environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?

The purpose of Question n.1 is to introduce the subject. Recall the ideas of Industry 4.0 and Industry 5.0 as well as the motivations for such a changeover.

In addition, the question of whether businesses have understood the necessity of this transformation is raised in light of recent global crises that have not yet been fully resolved.

Question n.2: According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? if no, which could be the challenges and the required resources for the transition?

The question seeks to explore the relationship between Industry 4.0 and 5.0.

Additionally, it looks for empirical evidence that corresponds to Müller's (2020) statement, i.e. Industry 5.0 should not be seen as a replacement for or an alternative to the current Industry 4.0 paradigm, but rather as an evolution and logical advancement of it.

In consideration of the literature, the idea of Industry 5.0 is not founded on technologies but rather on principles like Human-Centricity, ecological sustainability, or societal benefits. However, technologies can be seen as a tool and a means to exert Industry 5.0-related interventions. Therefore, they are seen as necessary yet insufficient for the transition due to this fact.

Question n.3: Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? why?

The query, in besides emphasizing the need for a balance between economic principles and environmental and social sustainability, it also raises the question of whether a company would be able to support such a transition given the current economic climate.

Therefore, the question is focused on the viability of Industry 5.0.

Question n.4: Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?

The question is intended to make clear what resources a company requires in order to adopt Industry 5.0.

Furthermore, in the process of responding to the RQ, it might be seen as the core question.

Question n.5: If the firms do not have the essential resources, how can they obtain it?
This question focuses on identifying the motivations and strategies that a given company should put in place to obtain the resources it does not possess, and which the respondent believes are necessary for the transition.

Question n.6: Which is your opinion regarding the future challenges of the industry?
Since this is the final question, it was thought to delve deeper into the long-term strategies to be adopted by companies, and thus to understand what trends might be possibly related to the main themes reported in the thesis.

Results

The thesis' appendix contains the responses to the questions that were previously raised.
The respondents answered the questions by asserting points of view characterised by heterogeneity, which can be analysed as a factor revealing both the differences of the professionals interrogated and the comprehensive nature of the subject under discussion.
Indeed, wide-ranging questions were proposed, as it was deemed necessary not to steer towards a specific answer, but rather to obtain unbiased points of view from the survey questions, trying to obtain the respondent's real perspectives on the topic.

Considering the answers to question n.1 all the interviewees agree on the need for a change received by the industry. However, three different points of view were presented referring to the reasons that shaped the motifs of the transition.
Because A.C. focuses on the market aspect, he believes that the shift in demand that results from that change—namely, the social one—is the transition's most crucial element. He emphasises the value of the younger generations, their commitment to sustainability, and their increasing desire for digital products. Additionally, he believes that organisations will need to adapt, maybe modifying their business strategy, to meet the new standards. Nevertheless, he believes that there are other factors that are crucial to the transition. The growth in digitalization's goal of higher efficiency is especially important, as is the practical issue of finding energy supply at lower prices.
C.P. asserts that the sector has recognised the necessity for a transition to sustainability, raising concerns about Industry 5.0's economic viability. The question he formulates is whether businesses will be able to implement Industry 5.0 without jeopardising their financial success: *"The question is not so much whether the industry has the answers to the above-mentioned issues, but whether they are able to implement them in a 'sustainable' way (without undermining the profitability and competitiveness of the companies themselves)."*
The significance of sustainability was also emphasised by the third panellist. However, contrary to the other respondents, he mentioned the idea of Human-Centricity, highlighting the rising trend of repositioning

employees as the company's most important asset and emphasising their creativeness: *"In Industry 4.0, importance was given to the internet of things of hyperconnection. Fundamentally, it was going in a direction of robotization, and now it seems that the man must be considered more as the creative spirit that then leads to control the machine which is deployed for more repetitive tasks."*

Thus, it appears that companies have realised the need for a step change, and Industry 5.0 is recognised as the framework that can make the transformation viable. However, as reflected in the responses, there are also perplexities or difficulties that need to be overcome.

The second question suggests that there is no unified view on how companies will be able to make the transition and especially whether even those that have adopted the previous industry 4.0 will be able to make this evolutionary leap.

A.C. in agreement with C.P. argues that those who have already made the transition to 4.0 will undoubtedly be facilitated in the next step, however they disagree on the resources/challenges needed for the transition. Indeed, A.C. argues that it is the cultural factor that plays a key role: *"What is required is a cultural shift, which is likely the most significant ingredient, and which becomes the defining factor for all changes, allowing a transformation to move from paper to reality."*

Instead, C.P. believes that the discriminating factor is the financial one. Thus, companies that have not made the transition to Industry 4.0 will have to bear a higher financial burden, while those that have made the transition will only be able to implement strategies directed towards sustainability if their business model allows them to be profitable. Recalling the interview, it is also possible to note the clarification that the economic factor must always be considered first before the sustainability factor: *"it goes without saying that sustainability as an objective comes after the ability to generate income, which is the foundation of any business."*

In contrast to the first two interviewees, X thinks that even those who have already implemented Industry 4.0 may not find the transition to be straightforward. Nevertheless, he focuses on the aspect related to human resources and corporate culture, as crucial resources for the transition: *"Therefore, in my opinion, the difficulties lie in valuing young people and placing them in contexts with knowledgeable resources who can effectively teach while also accepting the inventiveness of the young professional figure. So, the key resource is still the cultural change within companies in order to be successful."*

The third query focuses on the level of competitiveness of companies adopting Industry 5.0.

The view of the first two respondents is slightly different from that of the third, as they believe that companies that are able to adopt the transition will gain a competitive advantage from an efficiency boost in production processes. Moreover, C.P. specified that: *"…Companies at the pace of Industry 5.0 will be more competitive and this is due to several factors. The first one is that a more advanced production system trivially allows for a lower Cost per Unit (CPU)… The perceived value of a sustainable business is constantly increasing for*

these stakeholders, who are willing to pay a higher price (for the same product) for a sustainably produced good… company in step with Industry 5.0 is an entity capable of adapting to the needs of the market and consumers." Therefore, he sees other factors that lead to a competitive advantage throughout the adoption of Industry 5.0.

X is slightly less positive on the results of industry 5.0 regarding the competitive advantage, saying that: *"it is a process that cannot be very fast and those who perhaps improvise too much in this process may then have problems to deal with."*

The interviewees regarding the fourth question expressed very different views.

A.C. emphasised the commitment that companies must adopt towards the three pillars that make up Industry 5.0: *"resistance to changes in the external environment is an important component… paying attention to sustainability is essential… being more sensitive to the requirements of the worker, to the human side…is a vital feature."*

C.P., on the other hand, assumes that the resources for adopting Industry 5.0 should be a public sector responsibility: *"It is necessary to intervene at the European level by 'internalising' certain strategic sectors of the modern economy… the energy issue is a very serious problem… the adoption of independent and totally unbalanced fiscal policies create friction and misalignments in European countries… Another problem to be changed into an asset is the management and allocation of public funds… Therefore, ad hoc civil and criminal sanctions should be introduced for those responsible for these huge failures."*

X sees technology as the resource that can push towards a competitive advantage. Specifically, he focuses on the technologies that can most influence the management of human resources: *"A resource could be, for example, the metaverse. In some areas through the metaverse it will also be possible to do almost direct training by exploiting these new technologies, which then also allow human resources to be more ready when they directly enter the world of work.*

Training can, therefore, also become more practical, perhaps at the beginning, by exploiting these new technologies."

The fifth question brings up the issues that occur when businesses lack these resources. The responses in this instance exhibit the same pattern.

Even though A.C. and X also think mergers between smaller businesses are notable, all three respondents agree that the European Union's finances are crucial to securing funding for the implementation of industry 5.0.

According to X, EU tenders may be difficult for small Italian companies to apply for, thus considers merging strategies as crucial: *"The possibility of obtaining European funds as well as the idea of merging with somewhat more structured realities are both undoubtedly options that would help with the transition since, in my opinion, it is very articulated and difficult for a small or medium-sized business to make a straightforward*

transition. In my opinion, merging several companies, having more compact groups with more resources at their disposal, could be one of the key points. However, in terms of the economy, I believe European finances are what matter most."

Finally, the last question concerns the future challenges that the industry will face.
A.C. believes that the goal of companies will be to increase the duration of customer relationships, also by promoting activities aimed at environmental and social sustainability. He also considers the introduction of platform business models to be important.
C.P., on the other hand, still refers to the topic of the public sector, believing that it needs to be overhauled.
While X considers that the answer is linked to the corporate culture prevailing in Italy. Therefore, referring to the answer given previously, he thinks that there is a need for a new cultural model that promotes change:
"I think that Italy's upcoming issues will come from cultural factors, since there is generally, in my experience, a reluctance to change."

To better comprehend the results of the interviews, the topics raised by the panellists will be summarised in the table below.

Question N.1		
The environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?		
	Does the industry have received the change? (First part of the question)	Why the industry needs such a change? (Second part of the question)
A.C.	Yes/Potentially relevant	Changes in the demand, Need for increased efficiency
C.P.	Yes/Potentially relevant	Increased awareness for Sustainability
X	Yes/Potentially relevant	Increased awareness for Human-Centricity
Question N.2		
According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? if no, which could be the challenges and the required resources for the transition?		

	Will all businesses using industry 4.0 be able to innovate? (First part of the question)	Firms need to focus on? (Second part of the question)
A.C.	Yes/Potentially relevant	Corporate Culture
C.P.	Yes/Potentially relevant	Financial aspect
X	No/Potentially irrelevant	Human Resource Management Corporate culture
Question N.3		
Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? why?		
	Will all transforming firms be more competitive? (First part of the question)	Why? (Second part of the question)
A.C.	Yes/Potentially relevant	Increased production efficiency
C.P.	Yes/Potentially relevant	Increased production efficiency
X	No/Potentially irrelevant	They may have several problems during the transition, which might take many years
Question N.4		
Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?		
	Which resources? (First part of the question)	Why? (Second part of the question)
A.C.	Commitment towards resiliency, sustainability, and Human-Centricity	Ability to resist to shocks, Market requires the sustainability aspect, Human-Centricity to reduce the turnover rate
C.P.	Greater accountability of the public sector	Energy crisis, Dissimilar fiscal policies Management of public funds

X	Innovative technology for Human Resource Management	Enhancing human resources
Question N.5		
If the firms do not have the essential resources, how can they obtain it?		
A.C.	EU public funds and M&A strategies	
C.P.	EU public funds	
X	EU public funds and M&A strategies	
Question N.6		
Which is your opinion regarding the future challenges of the industry?		
A.C.	Extending customer relationships throughout the promotion of social and environmental sustainability initiatives, Adoption of platform business models.	
C.P.	Monitoring and inspection of public management procedures for transferring funds to companies	
X	Adoption of a corporate culture that fosters innovation through the HRM	

Fig. 11: Interviews results (Own elaboration).

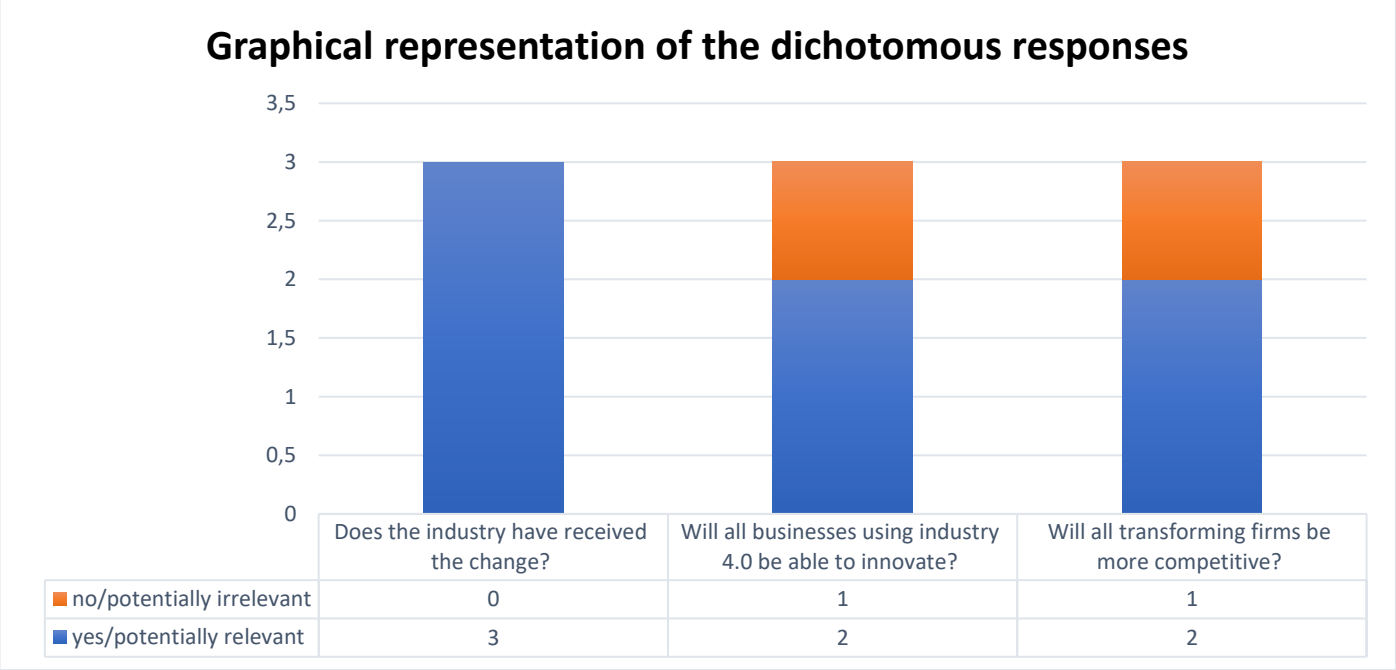

Fig. 12: Graphical representation of the dichotomous responses (Own elaboration).

The study clarified several facets of Industry 5.0, expanding upon well-established concepts and adding new ones. The respondents' perspectives, as could be expected given the variety of professional paths they took, provided for a variety of viewpoints.
The recent emergence of the Industry 5.0 paradigm, in many cases did not allow for the certainty of statements, as these were clearly personal opinions, however, they can be considered as views based on personal experience relevant to defining the aspects and needs of companies and the market as a whole.
Therefore, the results will be examined to accept/reject the hypotheses and then provide an answer to the research question.

Based on the comments, there is some disagreement over how challenging a switch to the more modern framework would be for businesses employing the Industry 4.0 framework. In fact, responses to question N.2, which is related to H1, show that two out of three respondents think that a business embracing Industry 4.0 would find it much easier to go to Industry 5.0. As a result, 67% of the interviewees support H1.

Different points of view need to be analysed regarding H2, which focuses on the importance of dynamic capabilities (firm's ability to integrate, develop, and reconfigure internal and external skills to react rapidly to changing conditions) for the adoption of Industry 5.0. There is agreement, as shown by Question N.1, that businesses must evolve to remain competitive. In his response to this matter, A.C. is extremely clear: *"firms are reviewing their business model to respond to these market needs."*
In response to Question N.3, C.P. highlights the need for businesses to be aware of how to adapt: "*company in step with Industry 5.0 is an entity capable of adapting to the needs of the market and consumers."*
Once more, A.C.'s response to question N. 4 recalls the three Industry 5.0 pillars, including resilience, which is connected to the idea of dynamic capabilities since denotes a company's capacity to adapt to change. Finally, X's answer to question N. 4 may also be viewed considering the concept of dynamic capabilities since he stresses the need of training human resources to help the organisation respond to market shocks. Consequently, understanding questions N.1, N.3, and N.4, each respondent highlighted a company's capacity to interact with change as a crucial component for adopting Industry 5.0, thus supporting H2.

The responses to questions N.2 and N.6 include consideration about company culture, which is addressed in H3. In response to question N.2, A.C. makes the following argument that Industry 5.0 adoption requires a cultural shift: *"What is required is a cultural shift, which is likely the most significant ingredient, and which becomes the defining factor for all changes."*
In response to the same question, X asserts that cultural change was the primary factor in enabling transformation. However, he focuses much of his attention on one specific cultural shift issue in reference to human resources management: "*the key resource is still the cultural change within companies in order to be successful."* The solution also has to do with H4's verification, which will be examined later.

Furthermore, according to X's response to question 6, cultural transformation will be Italy's biggest struggle in the future: *"I think that Italy's upcoming issues will come from cultural factors, since there is generally, in my experience, a reluctance to change."*
Therefore, two thirds of the respondents agree with H3.

Given that industry 5.0 is thought to place a strong emphasis on Human-Centricity, H4 stresses the rising importance of people in businesses. Therefore, it has been theorised that human resources are crucial for the implementation of Industry 5.0. The results of the interviews, however, reveal that only X shares the opinion that human resources are an important factor in the transformation process. The findings might be the consequence of the respondents' different priorities.
As a matter of facts, participants were asked in question N.1 to provide the justifications for why they believed businesses needed to embrace a new framework. According to X, differently from the other panellists, the factor that has the most impact is Human-Centricity, which lays more emphasis on the role of people in businesses: *"now it seems that the man must be considered more as the creative spirit that then leads to control the machine which is deployed for more repetitive tasks."*
In response to questions N.2, N.4, and N.6, X once more stresses the role of human resources: *"Therefore, in my opinion, the difficulties lie in valuing young people and placing them in contexts with knowledgeable resources who can effectively teach while also accepting the inventiveness of the young professional figure."*
Thus, H4 is supported by one out of three respondents, considering human resources crucial for the transition to Industry 5.0.

Hypothesis Testing		
H1	The firms adopting Industry 4.0 are eased in the transition towards Industry 5.0.	Supported
H2	As the company's dynamic capabilities grow, so does the possibility that it will be able to transition to Industry 5.0.	Supported
H3	The more deeply embedded a corporate culture is in values that are compatible with the basic principles of Industry 5.0, the more likely it is that a company will embrace the framework.	Supported
H4	The greater the focus of companies on developing human resources, the better the chances of completing the transition towards Industry 5.0.	Supported

Fig. 13 hypothesis testing outcomes (Own elaboration).

The empirical findings allowed to test the hypotheses, which makes it possible to respond to the **RQ**: What resources, defined by the RBT framework, must firms possess to implement Industry 5.0?
According to H1, it might be claimed that companies using the Industry 4.0 framework already have some of the resources needed to embrace Industry 5.0. It is now plausible to claim that dynamic capabilities, which are

also mentioned in the Industry 5.0 framework under the title resilience, are essential for businesses to understand emerging social requirements and be able to resist market shocks, thus verifying H2. The requirement for businesses to establish a corporate culture that enables them to embrace Industry 5.0 ideals is confirmed by H3's verification. Finally, with the acceptance of H4, Human resources can now be seen as important resources for a business that seeks to complete the transition to Industry 5.0.

RQ: What resources, defined by the RBT framework, must firms possess to implement Industry 5.0?
1. All the resources available to businesses embracing Industry 4.0. 2. Dynamic capabilities to strengthen firm Resilience. 3. A Corporate culture that enables to embrace the values of industry 5.0. (Sustainability, Human-Centricity, Resilience) 4. A HR management that values the role of the workers according to the principle of Human-Centricity.

Fig. 14 Results of the thesis (Answer to the RQ) (Own elaboration).

Discussion

Neo-liberal capitalism's failure, which was a result of preceding Industrial Revolutions' inability to foresee and manage social and environmental issues as well as the pandemic crisis and the Ukrainian war, gave rise to Industry 5.0.

Questions concerning how historically profit-driven companies might adapt are raised by the peculiarities of the most recent Industrial Revolution. The thesis therefore sought to identify the resources, as described by RBT, that a firm needs in order to manage the Industry 5.0 framework.

To provide a resolution to the problem, it was decided to use the RBT for the understanding of the research study. This allowed for the creation of four research-relevant hypotheses:

H1: The firms adopting Industry 4.0 are eased in the transition towards Industry 5.0.

H2: As the company's dynamic capabilities grow, so does the possibility that it will be able to transition to Industry 5.0.

H3: The more deeply embedded a corporate culture is in values that are compatible with the basic principles of Industry 5.0, the more likely it is that a company will embrace the framework.

H4: The greater the focus of companies on developing human resources, the better the chances of completing the transition towards Industry 5.0.

An empirical inquiry that entailed interviewing three people with varying professional backgrounds was then used to validate the claims.

Thus, the outcomes of the empirical analysis allowed for verification, resulting in the support of the entire set of four assumptions.

Concerning the limitations of the study, since it is qualitative and seeks to dive further into the subject at hand to understand the motives, thoughts, and predictions of the respondents, the conclusions of the thesis were supported by a limited statistical sample. Given this, it is believed that a quantitative study conducted in addition to the one for this thesis will produce more insightful data.

The curiosity sparked by the interviewees suggests that a full examination of Industry 5.0 in connection to HRM, EU accountability for public spending, and M&A strategies may ultimately be helpful to both academics and practitioners.

CONCLUSION

The thesis has strongly analysed the framework of RBT to inspect the resources that could be essential for the adoption of Industry 5.0.

To accomplish the objective of the research, a set of four hypotheses have been developed after a comprehensive representation and analysis of Industry 5.0 and Resource Based Theory.

H1: The firms adopting Industry 4.0 are eased in the transition towards Industry 5.0.

H2: As the company's dynamic capabilities grow, so does the possibility that it will be able to transition to Industry 5.0.

H3: The more deeply embedded a corporate culture is in values that are compatible with the basic principles of Industry 5.0, the more likely it is that a company will embrace the framework.

H4: The greater the focus of companies on developing human resources, the better the chances of completing the transition towards Industry 5.0.

Thus, empirical evidence has been gathered through a series of three interviews with various professionals, by delving into their understanding and point of view regarding the aspects of Industry 5.0, to verify the veracity of the assumptions.

Then, the results have been analysed to find an answer to the RQ: What resources, defined by the RBT framework, must firms possess to implement Industry 5.0?

Therefore, the resources that, as identified by the RBT, may be necessary for businesses to enact Industry 5.0 include:

- All those available to businesses adopting Industry 4.0,
- Dynamic capabilities that strengthen firm resilience,
- Corporate cultures that enable the adoption of Industry 5.0's principles (Sustainability, Human-Centricity, and Resilience)
- HR management practices that value the role of the employees in in line with the principle of Human-Centricity.

Appendix:

Interview n.1: Ernst & Young - Senior Manager Business Transformation Advisory, Dr. Alfredo Cuzzupoli.

1. The environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?

   according to my interpretation, the industry is transforming itself because this is what is increasingly being demanded by the market.
   End consumers, in particular Generation Z is an increasingly interesting market. Then, it clearly depends on the type of consumers and the type of business.
   However, it is apparent that in the mass market, and thus for sectors that provide a big number of end customers with their products, being able to fulfil the demands becomes an additional value.
   furthermore, new generations of customers are particularly concerned about sustainability and digital concerns. As a result, the capacity to portray themselves as sustainable and digital from the standpoint of usability, as well as from a mobile standpoint, obviously becomes an important and, let's say, vital additional value that organisations are going towards. So, it is certainly quite a reactive response to these inputs coming from the market.
   As a matter of fact, firms are reviewing their business model to respond to these market needs.

   Q: Is it therefore society that drives change? [5]

- It is possible to assess that society has the main role. Nonetheless, there is another cause that drives the change, namely the objective for a greater efficiency, which may lead to automation and digitization of the activities.
  Therefore, what is offered by technology allows firms to be more efficient, reduce time to market, improve the traceability of their products and thus improve the effectiveness and efficiency of their internal processes.
  The third element is connected to the production costs, since by achieving a greater level of efficiency, firms can lower the human resources costs as well as energy costs. For example, considering what it may

[5] During the interview, a request for clarification was made. It was so chosen to report this question as well, even though it is a one-time occurrence and hence does not appear in following interviews.

mean to be self-sufficient in renewables at this moment, it is evident that being independent of the energy or petrol supply, which has witnessed rising augmentations over the past year, becomes even more crucial.

2. According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? if no, which could be the challenges and the required resources for the transition?

- Certainly, companies that have moved to Industry 4.0 are at an advantage compared to those that have done nothing in those terms in moving to 5.0, precisely because it is a gradual path of transformation, and it is easier to make incremental improvements or evolutions rather than using particularly significant jumps in technological evolution.
  Having said that, what is needed? What is required is a cultural shift, which is likely the most significant ingredient, and which becomes the defining factor for all changes, allowing a transformation to move from paper to reality.
  So, here the cultural shift means that there has to be no longer just a reactive approach, as we were saying before, by companies to the market, but transforming it into a proactive approach; therefore, making sure that there can be a real and true attention and interest of other companies towards, precisely, Industry 5.0 issues.

3. Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? why?

- It clearly depends on how much companies invest in one area rather than another.
  I would not see them as, I repeat, two opposing worlds, but as two phases of an evolution that the company is taking. Consequently, in my opinion, there certainly cannot be Industry 5.0 if there has not been 4.0.
  Therefore, I would not put them in opposition, but rather in an evolutionary temporal flow, and I think that the companies that go from 4.0, improving productivity and therefore optimising their internal processes through the use of technology, can reap, to the maximum, the benefits of this further step namely Industry 5.0, since they have improved, already started and implemented, this path of improvement within them.

4. Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?

- Certainly, resistance to changes in the external environment is an important component.
  Because being able to absorb and react to the evolutions of the external context, such as the energy crisis, conflict, and inflation, are factors that require resilience to cope with.
  Undeniably, paying attention to sustainability is essential, as well, since the market requires it.
  Furthermore, the notion of being more sensitive to the requirements of the worker, to the human side, to the human centric, which is specifically necessary within industry 5.0, is a vital feature.
  Because the working population evolves in tandem with the market. People can be employees on the one hand and customers on the other.
  Hence, not surprisingly, these generational changes apply to the working population, and managing new sorts of requirements is critical in order to avoid an increase in turnover rate, which has occurred significantly in the previous two years.
  People desired a challenge even before the pandemic, and the paradigm of working at a firm for many years has also shifted.

5. If the firms do not have the essential resources, how can they obtain it?

- There are several methods to access this sort of source, from the conventional financing model to accessing European calls for proposals, which promote this type of initiative.
  Arguably there is room for improvement in this area, particularly for Italy as we are aware of how infrequently it uses EU funding. This is one component; however, alternative partnership-based growth routes could exist.
  Working with third parties, creating revenue sharing models rather than cost sharing, and switching to so-called platform-based business models may frequently assist gain a competitive edge while also lowering the initial financial investment.

6. Which is your opinion regarding the future challenges of the industry?

- Developing a long-lasting trusting relationship with clients, in my opinion, is the key determining factor.
  Since the average turnover rate has gone up along with the churn rate, the industry's challenges are to boost customer loyalty.

The second is to choose a type of business model that interlocutors may carefully consider with respect, and with a role of direction and leadership, in order to aid the attainment of the first aim. Pushing topics like sustainability and linkages to society naturally becomes an important and decisive element in this situation.

The development of these platform business models and the manner in which alliances may be established to create a single, comprehensive, integrated solution for the end user may also be seen as a third factor. however, it would be essential to raise the loyalty rate since a high churn rate would indicate that customers must be leaving not just a service but also a series of related services.

Interview n.2: Frantoio Oleario F.lli Pace - CDA member, Dr. Canio Pace.

1. The environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?

- The crises of our times demonstrate the limits of globalisation. The pandemic, the climate crisis and the war in Ukraine have highlighted how the globally interconnected production and supply chains are currently the main problem of the modern economy.

  Industry 4.0 was a first concrete step to innovate and modernise the industrial fabric of our country, and the very solid tax credit measures were a driver for private investments in the direction of productivity and thus competitiveness.

  Industry 5.0 wants to add to the measure that preceded it the central theme of sustainability, which is also fundamental, necessary and cannot be postponed. Integrating sustainable processes and products is a complex and very costly challenge, and industry is trying to provide answers in terms of packaging, finished products, raw materials, and traceability. The question is not so much whether the industry has the answers to the above-mentioned issues, but whether they are able to implement them in a 'sustainable' way (without undermining the profitability and competitiveness of the companies themselves).

  To make this possible, companies need specific and concrete measures, each sector for its particularity needs ad hoc tenders, which have at their centre the sustainable integration of processes and products as a measurable and clear objective, which can clearly discriminate the companies that want to follow this path with a serious and valuable approach.

  Unfortunately, the Italian system has a history of inefficient public spending, not to mention the failure to disperse and subsequent restitution of European funds not designated for Italian enterprises. To make the challenge of Industry 5.0 more equitable than our European and international peers, a significant

intervention in the administration of public finances is required, since these procedures constitute a significant expense to the community.

2. According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? if no, which could be the challenges and the required resources for the transition?

- The companies that have implemented Industry 4.0 are clearly in the front row for 5.0, if the measures to come will have a real impact on competitiveness without damaging profitability, it goes without saying that sustainability as an objective comes after the ability to generate income, which is the foundation of any business.

  All companies that, on the other hand, have not participated by choice or delay in Industry 4.0 will have to make an even greater effort in terms of financial exposure; this reduces the pool of potential beneficiaries, who are gradually pushed to the margins of the market, letting natural selection operate.

3. Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? why?

- It is correct to argue that companies at the pace of Industry 5.0 will be more competitive and this is due to several factors. The first one is that a more advanced production system trivially allows for a lower Cost per Unit (CPU) by allocating competitive advantage to both the company and the consumer.

  The second factor concerns external stakeholders such as consumers, investors, regulators, etc. The perceived value of a sustainable business is constantly increasing for these stakeholders, who are willing to pay a higher price (for the same product) for a sustainably produced good.

  The third factor is more of a logical observation, a company in step with Industry 5.0 is an entity capable of adapting to the needs of the market and consumers, this obviously guarantees greater longevity than companies that do not.

4. Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?

- The resources required to achieve the success factors listed above are more the responsibility of the public system. It is necessary to intervene at the European level by 'internalising' certain strategic sectors of the modern economy.
  First and foremost, as is evident, the energy issue is a very serious problem; to date, nothing or almost nothing concrete has been done to solve the problem that companies have placed on their shoulders (and budgets). As well as the adoption of independent and totally unbalanced fiscal policies create friction and misalignments in European countries, making the resilience of companies operating in the same markets unfair and losing competitive advantage.
  Another problem to be changed into an asset, partly announced in answer 1, is the management and allocation of public funds. In a G7 country, it is not possible for there to be funds earmarked for private investments, with projects and initiatives deposited with the competent bodies, which are not allocated, or rather, on expiry, return to the sender because they have not been spent.
  Therefore, ad hoc civil and criminal sanctions should be introduced for those responsible for these huge failures.

5. If the firms do not have the essential resources, how can they obtain it?

- I believe this answer is included in the previous ones, I would add that the way resources are credited can also be improved, more objective conditions need to be included in the tenders and clickdays.
  The latter are the anti-meritocracy par excellence, thus, need to be avoided.

6. Which is your opinion regarding the future challenges of the industry?

- As anticipated, the biggest challenges are for the public administration, if it succeeds in being more efficient and more meritocratic, Italy will play a strong role in the market and in the world.
  Companies are typically 10 steps ahead of public services because they find themselves competing in a super-globalised market facing challenges that do not belong to us (Ukraine).
  The industry changes and evolves chasing the market and its needs, while the country wonders where to locate the regasifier and energy-intensive companies close production areas. Italy and Europe face a huge challenge, industry will play its part.

Interview n.3: Multinational IT company - Senior Consultant.[6]

1. The environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?

- In my opinion, the pandemic crisis led to a change that should already have been implemented in the system for years. As a result, at least in the consulting industry, certain dynamics, particularly those related to sustainability, have accelerated.
  Consequently, in various companies there has been a change in the approach of how resources might be considered in the world of industry. In other words, there is increasing digitization, although it prioritises people over machines.
  In Industry 4.0, importance was given to the internet of things of hyperconnection. Fundamentally, it was going in a direction of robotization, and now it seems that the man must be considered more as the creative spirit that then leads to control the machine which is deployed for more repetitive tasks.
  Hence, I certainly think that companies necessarily needed this transition, and they are getting it, they are getting changes. Getting up to speed will take some time, certainly several years.

2. According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? if no, which could be the challenges and the required resources for the transition?

- I believe that not all of them will be successful, primarily because all human resources require extremely strong training; hence, at least for the Italian model, young people must be given greater credit for this change because they are the ones who are digital natives. Additionally, I believe that businesses with a greater average age may struggle more.
  Therefore, in my opinion, the difficulties lie in valuing young people and placing them in contexts with knowledgeable resources who can effectively teach while also accepting the inventiveness of the young professional figure. So, the key resource is still the cultural change within companies in order to be successful.
  As a result, I think that not all businesses will prosper; in fact, I think that some may even fail for this reason.

[6] The respondent requested that neither his entire name nor the name of the business he works for be disclosed.

3. Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? why?

- Not all of them, because it is a process that cannot be very fast and those who perhaps improvise too much in this process may then have problems to deal with.
  Thus, to truly comprehend the competitive advantage of switching to this 5.0 model, in my opinion, will take some time.

4. Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?

- I saw that after the pandemic, with smart working you can maybe work more easily with human resources that are also far away from each other.
  Especially in Italy we still had a little bit of the idea of working on site and instead remotely you can have an inventory of skills that you don't necessarily have in your own room, basically.
  A resource could be, for example, the metaverse. In some areas through the metaverse it will also be possible to do almost direct training by exploiting these new technologies, which then also allow human resources to be more ready when they directly enter the world of work.
  Training can, therefore, also become more practical, perhaps at the beginning, by exploiting these new technologies.

5. If the firms do not have the essential resources, how can they obtain it?

- The possibility of obtaining European funds as well as the idea of merging with somewhat more structured realities are both undoubtedly options that would help with the transition since, in my opinion, it is very articulated and difficult for a small or medium-sized business to make a straightforward transition.
  In my opinion, merging several companies, having more compact groups with more resources at their disposal, could be one of the key points.
  However, in terms of the economy, I believe European finances are what matter most.

6. Which is your opinion regarding the future challenges of the industry?

- I think that Italy's upcoming issues will come from cultural factors, since there is generally, in my experience, a reluctance to change.
  I mentioned earlier that young people, who have a more flexible mind and are used to digitalization, could make the process smoother.
  On the other hand, those who work with somewhat more traditional models may struggle more in these passages of radical change.
  Thus, I consider necessary to update those who will still have to contribute with their expertise, hopefully in the coming years, and in addition by fully capitalise young people.

SUMMARY

The thesis examined the difficulties associated with the adoption of Industry 5.0 through the perspective of Resource Based Theory by studying the crucial resources that businesses need to accomplish the change. The work presents a literature study of the Industrial Revolutions in chronological order, highlighting the differences between them. The RBT framework will be explained, and the hypotheses that will serve as the foundation for the empirical study will be presented. The research's purpose and methodology will next be clarified, followed by a presentation of the findings. Eventually, a solution to the RQ will be revealed.

Chapter 1:

The First Industrial Revolution began in the 18th century with the advent of mechanisation. However, companies, due to the rising complexity brought on by new technologies, had to implement diverse strategies such as the division of labour and a lean production process.

In the 19th century, the discovery and gradual adoption of electricity, which facilitated the development of the assembly line, marked the start of the Second Industrial Revolution.
Through the creation a global market dominated by the rising significance of capital, assembly lines and interchangeable parts have played a crucial role in allowing economies of scale, rising the competitiveness of the firms. Furthermore, during the same period, manufacturers advanced research and development departments, which helped the heavy steel sector advance and gave rise to the chemical sector.

Industry 3.0 began in 1970 when manufacturing companies began using automated machines, resulting in a more routinised sort of labour. Because of the adoption of new technologies, manufacturers started considering relocations in developing countries, motivated by the desire to save costs. However, because of the restricted capability for automation, several issues emerged, that were ultimately resolved with the introduction of Supply Chain Management.

The term Industry 4.0 was originally labelled during the German federal government’s High-Tech Strategy in response to the digitization of manufacturing, yet the codes were firstly pronounced in 1940 within the Albert Carr’s publication labelled “America’s Last Chance”.
The premise behind the Fourth Industrial Revolution was to enhance performance by encouraging connections between stakeholders, through the adoption of production techniques that included leading technologies. In light of the revolution's nature, BCG developed a framework that divides the technologies into 9 pillars, which represents the drivers of Industry 4.0: Additive Manufacturing, Augmented Reality, Autonomous Robots, Big

Data and Analytics, Cloud, Cybersecurity, Horizontal and Vertical System Integration, Industrial Internet of Things, Simulation.

A range of consequences in manufacturing processes, outputs, and business models were documented by the literature because of the adoption of Industry 4.0. Such results were grouped into four components that shaped manufacturing vision.

First, the advanced factory became a "smart factory," defined as the integration of all the company's resources to enable internal communication. Second, the business shifted towards the requirement of an ever-increasing level of communication among businesses, manufacturers, suppliers, logistics, resources, and customers. Third, products became smart as they were fitted with sensors and processors that sent data to the manufacturing system and gave customers useful advice. Eventually, customers benefited in several ways from payment methods, after-sales services, and participation in the design processes.

The consequences of these changes were assessed by the Picasso Project of the German Federal Ministry of Education and Research, revealing the variations in the cost structure: inventory costs -30/40%, production costs -10/30%, logistics costs -10/30%, complexity costs -60/70%, quality costs -10/20%, and maintenance costs -20/30%.

While Industry 4.0 has been successful in optimising manufacturing processes and improving stakeholder interactions, it is no longer able to meet societal needs due to global shocks like COVID-19, the Ukrainian conflict, and the environmental crisis. As a result of new needs and shifting lifestyle preferences, industry required a redesign that prioritised new objectives.

It has been shown that the economic aspect cannot be the only factor. Indeed, the 2030 Agenda's Sustainable Development Goals (SDGs) have indicated that a shift in strategy is imperative, given three types of inadequacies that Industry 4.0 has shown: regenerative features of industrial transformation, a social dimension, and an environmental dimension.

By concentrating on the main goals of the SDGs, the United Nations' (UN) foundational principles have helped people in satisfying their new requirements, sparking the most recent concept of Society 5.0. The two main components of the shift to Society 5.0 are management ideas and Japanese culture. Fewer formal links come from the culture and managerial practises, illuminating the necessity of collaboration between individuals and institutions. The value of the individual is crucial, and the new society's focus on the individual is essential for comprehending how it has evolved. In fact, this thesis gave a list of effective interventions developed by the public and the private sector in Japan.

Even though Society 5.0 had produced positive outcomes, it was evident that a new industrial paradigm, that could transcend neo-liberal capitalism, was necessary. Therefore, in addition to a hyper-connected industrial ecosystem that enriches and absorbs the principles of sustainable development, it is necessary to execute a new model that capitalises on the lessons learned and advancements achieved to overcome the pandemic crisis.

In contrast to past revolutions, industry 5.0 understands the function it must provide within society. Albeit cost-cutting remains an important factor, the promotion of sustainable development is an equally important component of the competitiveness of the firms.

Therefore, the terms "Society 5.0" and "Industry 5.0" are related, not just in the sense of a change in procedures, manufacturing techniques, technologies, or corporate internal structures, but also as the beginning of a new economic and social vision.

Due to the fifth revolution's emphasis on values rather than technology, Industry 5.0 should not be considered as a replacement for Industry 4.0 but rather as an evolution or a natural continuation.

To clarify, given that the framework is grossly understudied, a Reference Model has been developed to represent the entity of Industry 5.0 and to show the technical aspects, concepts, components, and fundamental value objectives. The latest are defined as the 3 pillars of Industry 5.0: Human-Centricity, Sustainability, and Resilience.

The first pillar presumes that the role of the individual, its demands, and benefits should be taken into consideration while designing business processes, with the goal of reintegrating people into the workforce and free them from routine tasks. According to the second pillar, protecting the environment and preserving natural resources while fostering economic progress is the responsibility of Industry 5.0. Eventually, according to the third pillar, firms must be able to resist or react to exogenous factors that could harm its proper functioning.

Considering the recent dawn of Industry 5.0, has been judged crucial to understand which could be the correct definition for the paradigm. Therefore, a set of definitions has been collected and analysed, considering the pillars just mentioned. Thus, the results identified the correct definitions for the thesis.

Furthermore, this study showed the prevalence of the Human-Centricity pillar, justifying what most of the researchers claimed.

To understand the focus on the pillar of Human-Centricity, this thesis delved into the integration of humans in production processes and automation to fulfil value creation goals.

On one hand, automation and the increasing human-machine collaboration have redefined the idea of robots, while introducing collaborative robots (cobots).

On the other hand, the framework of Operator 5.0 – which was developed as an extension of its predecessor Operator 4.0 – could be used to describe the figure of the worker within a logistic system.

The premise of Operator 5.0 is that technology is not viewed as a threat. Instead, it is seen as a natural extension of worker empowerment. Thus, Operator 5.0 serves as an example of how Industry 5.0, differently from Industry 4.0, takes both resilience and Human-Centricity into consideration.

The changes in the labour market, brought by the introduction of new technologies, have shed light upon several issues.

Firstly, industry must spend heavily in human capital through the cultivation of talents that will enable the company to embrace technology and effectively collaborate with machines. Secondly, changes in

organisational design have also been mandated by the socio-technical phenomena known as Industry 5.0. The Chief Robotics Officer is a new business position that will be introduced because of the Fifth Industrial Revolution. Furthermore, in the literature has been collected additional organizational considerations of the human-machine integration: legal and regulatory issues, personal preferences, psychological issues, changing role HR departments, changing role of IT departments, emerging of robotic departments, ethical issues, preferences towards types of robots to work with, learning to work with robots, negative attitude towards robots, humans competing with robots or robots complementing humans.

Chapter 2:

Albeit the introductory chapter is a crucial element for the discussion, the goal of the thesis is to identify the resources that organisations need to activate the development towards a value-driven business model, by putting Industry 5.0 into practise.

To accomplish this, the Resource Based Theory (RBT) has been presented as a tool for defining the resource concept that will be employed in the task and for inspecting the resources that may be necessary for the adoption of Industry 5.0.

Porter's study in the late 1980s helped Barney to move from an internally driven strategy to an established resource theory, which eventually led to the development of RBT.

The theory proposes a technique that focuses on an internal driven approach for discovering and estimating organisational performance and competitive advantage.

Two primary schemes, the first of three categories and the second of two, are utilised to categorise the company's resources. The first category classifies resources into three groups: organisational capital resources, human capital resources, and physical capital resources. The company's equipment, technology, raw material accessibility, and geographic position are all considered physical capital resources. All interactions and activities that take place inside the human workforce, including training, re-skilling, and up-skilling, as well as work judgement, are considered human capital resources. Finally, organisational capital resources comprise the company's formal and informal organisational structures, planning, management, and coordination processes, as well as the relationships between stakeholders.

The second scheme shows the tangibility or intangibility of a firm's resources. Products and commodities are examples of tangible resources that point to economic benefits and visible firm contributions. In contrast, intangible resources are assets like as competencies, knowledge, organisational, strategic, and social advantages.

At the basis of the RBT are two fundamental assumptions that define how various organisations might compete.

The first is heterogeneity, which is expressed as the varied combination of resources or capabilities that organisations have and that underpins competitive advantage. The second is resource immobility, which describes the issues that arise when businesses exchange or transfer resources.

The aforementioned categories served as the foundation for the analysis of the connection between corporate resources and long-term competitive advantage. Consequently, Barney developed the idea of strategic resources as the ones that possess the four VRIN characteristics of being valuable, rare, unique, and non-substitutable, in the following lines.

A resource is considered valuable if it has the potential to benefit the company or provide it a competitive edge.

A rare resource must offer a distinct viewpoint to give the organisation a competitive advantage over rivalry.

An inimitable resource is one that other companies are unable to get.

A resource that cannot be replaced by other valuable resources that are strategically comparable is referred to as being non-substitutable.

The second RBT paradigm described the concept of capabilities, which are a subset of the non-transferable company-specific resources that allow for increased productivity through the development of additional resources.

Thus, the procedures and information – whether tangible or intangible – that help an organisation increase production and efficiency are known as capabilities.

Furthermore, it has been presented the concept of dynamic capabilities, defined as the firm's capacity to integrate, develop, and reconfigure internal and external talents to adapt swiftly to changing situations.

Since the traditional Resource-Based Theory does not go into great depth regarding why and how firms gain a competitive edge in environments of uncertainty and rapid change. Thus, experts have created a new paradigm in which organisations gain new skills through the gradual acquisition of tangible and intangible assets. According to this paradigm, organisations do not achieve competitive advantage by using just the resources that are now at their disposal.

The non-substitutability characteristic was therefore replaced with the organisational feature, signifying the organisational embedding of resources, and the VRIN model underwent a transformation, leading to the development of a new acronym, namely VRIO.

The new criterion suggested that a firm's operations and structure are vital in determining the other three resource criteria: value, rarity, and imperfect imitability.

Subsequently, the thesis has defined the hypotheses considering both the first and second chapter.

The notion of complementarity and organic continuity between Industry 4.0 and Industry 5.0, along with the concept of resource as described by the RBT, have served as the foundation upon which to build the first hypothesis (H1): The firms adopting Industry 4.0 are eased in the transition towards Industry 5.0.

The second hypothesis has been defined by taking in consideration the value-driven nature of Industry 5.0, because of the changes within the society. Therefore, the reasoning has been built considering the need of a business that tries to adapt to the new paradigm. Thus, it has been conceptualised that, in order for organisations to embrace the Industry 5.0 framework, they must be able to quickly respond to external stimuli and have the skills necessary to internally reorganise their resources, referred as dynamic capabilities. So, it has been hypothesised that (H2): As the company's resources, known as dynamic capabilities, grow, so does the possibility that it will be able to transition to Industry 5.0.

Furthermore, it has been analysed, from the perspective of RBT, the relevance of the corporate culture to promote a change within the firms, aimed at balancing economic sustainability with socio-environmental sustainability. As a result of the study, it has been identified the third hypothesis (H3): The more deeply embedded a corporate culture is in values that are compatible with the basic principles of Industry 5.0, the more likely it is that a company will embrace the framework.

Finally, through the exploration of the first chapter, the concept of Human-Centricity has been explored, analysing the role of HR from the perspective of the RBT. In consideration of the literature, it has been considered relevant the HRM to make employees as a resource that possesses VRIO characteristics. Therefore, it has been conceptualised that (H4): The greater the focus of companies on developing human resources, the better the chances of completing the transition towards Industry 5.0.

Chapter 3:

The third chapter regarded the empirical analysis through which assess the research question: What resources, defined by the RBT framework, must firms possess to implement Industry 5.0?

The methodology has initially been described. The deductive approach has been utilised to verify the previously stated assumptions to respond to the RQ. Empirical data has been employed has a means of verification to validate the theories (previously featured in the thesis). To acquire empirical data, an unstructured survey that collect the respondents' motivations, ideas, and opinions on Industry 5.0 has been developed using a qualitative approach.

Industry 5.0 is a multi-disciplinary revolution, consequently the questions have been directed to a variety of individuals, considering their business, their position within their organisations, the scale of their businesses, and the knowledge they possess.

Since the objective was to leave room for interpretation, the principle by which the questions were built was the Top-of-Mind Awareness (TOMA). This strategy was used to collect data based on the topics that each respondent thought was the most essential and debated in relation to the issue at hand.

As a result, the replies were collected and subjected to scrutiny with the lenses of RBT theory to pinpoint the sources capable of validating the hypothesis.

In addition, because of the respondents' different professional backgrounds and the multidisciplinary nature of the issue under debate, it has been determined to accept a hypothesis if at least one responder would have confirmed it.

Thereafter the panellists have been presented.

A.C. is a Senior Manager of the Business Trasformation Advisory at Ernst & Young.

C.P. is a CDA member of the Frantoio Oleario F.lli Pace, a small and medium sized enterprise operating in the agro-food sector, that is adopting the transition toward Industry 5.0.

Last but not the least, X is an IT Senior Consultant working in a multinational corporation operating in the information technology sector.

The first question presented to the panellists was: the environmental crisis and the covid 19 pandemic crisis have triggered the awareness for a change in the industry. Industry 4.0 was based on a productive centric vision, while industry 5.0 values both productivity-driven competitiveness and sustainable-development. In this sense, do you think the industry have received this change? If yes, why do you think the firms need this transition?

Regarding the first part of the question the answers were almost identical, thus they recognized the importance for the firms to make the transition. However, the reasons behind were different. A.C. thought the motifs were the changes in the demand coupled with the need for increased efficiency. C.P. focused on the increased awareness for Sustainability, while X on the increased awareness for Human-Centricity.

The second question was formulated as follows: According to the European union, industry 5.0 is considered as a logical continuation of industry 4.0, so do you think that all the firms that have adopted industry 4.0 will be able to innovate, sooner or later, towards industry 5.0? If no, which could be the challenges and the required resources for the transition?

A.C. and C.P. considered relevant the previously adopted Industry 4.0, while X did not have the same thought. A.C. thought that firms would need to focus on Corporate Culture, C.P. expressed the commitment of firms upon the financial aspect, while X highlighted both the HRM and the corporate culture.

Question number three asked: Considering that Industry 5.0 balances economic and socio-environmental sustainability, while industry 4.0 focuses on the productivity, do you still think that all the firms that are now transforming towards industry 5.0 will be more competitive? Why?

Again, A.C. and C.P. have been in accordance with the fact that all the firms that will transform will be more competitive, while X considered it irrelevant. Regarding the reasons, A.C. and C.P. focused on the increased production efficiency, while X thought that the firms may have several problems within the transition.

The fourth question was formulated as follows: Considering the previous question, which are the resources that could drive the competitive advantage? And why are they so important?

A.C. individuated the commitment towards Resiliency, Sustainability, and Human-Centricity since the firms would need the ability to resist to shocks, market requests for sustainability and firms’ need to adopt human-centricity value as a solution to reduce the turnover rate.

C.P. discussed about the need for greater accountability of the public sector. The reasons he highlighted were the energy crisis, dissimilar fiscal policies, and the problems regarding the management of public funds.
X described the innovative technology for human resource management as the crucial resources that could drive the competitive advantage, since the purpose of the firms should be on enhancing the human resources.
Question number five: if the firms do not have the essential resources, how can they obtain it?
All the panellists expressed their viewpoint regarding to the relevance of the EU public funds, while A.C. and X, in addition, highlighted the role of M&A strategies.
Finally, it has been asked: Which is your opinion regarding the future challenges of the industry?
A.C. answered with the need for extending customer relationships throughout the promotion of social and environmental sustainability initiatives and adopting platform business models. C.P. focused on the monitoring and inspection of public management procedure for transferring funds to companies. Last but not least, X highlighted the future role of a corporate culture that fosters innovation through the HRM.
Later, the research expanded on previous ideas and introduced new ones to clarify numerous aspects of Industry 5.0. Given the range of professional paths of the respondents, it was to be expected that their perceptions would have been diverse.
Since these were unmistakably personal opinions, the recent advent of the Industry 5.0 paradigm did not always allow for the certainty of statements. Nevertheless, they can be seen as views based on personal experience relevant to defining the aspects and needs of businesses and the market.
The empirical findings allowed the hypotheses to be tested, highlighting the following results:
Companies employing the Industry 4.0 framework may already have some of the resources required to adopt Industry 5.0, according to H1. In order for organisations to understand new social demands and be able to resist market shocks, it is feasible to declare that dynamic skills, which are also known as resilience in the Industry 5.0 framework, are required. This confirms H2. H3's verification supports the need for companies to create a corporate culture that enables them to adopt Industry 5.0 concepts. Finally, with the adoption of H4, human resources are now recognised as crucial assets for a company looking to complete the shift toward Industry 5.0.
Therefore, the resources that, as identified by the RBT, may be necessary for businesses to enact Industry 5.0 include:

- All those available to businesses adopting Industry 4.0,
- Dynamic capabilities that strengthen firm resilience,
- Corporate cultures that enable the adoption of Industry 5.0's principles (Sustainability, Human-Centricity, and Resilience)
- HR management practices that value the role of the employees in in line with the principle of Human-Centricity.

Given that the study was qualitative and aimed to delve further into the topic at hand to understand the respondents' motivations, ideas, and predictions, its limitations included the fact that just a small amount of

statistical data was used to support the thesis's results. As a result, it is expected that quantitative research conducted in addition to that for this thesis will produce data that are more insightful.

Therefore, it has been concluded that a thorough analysis of Industry 5.0 in relation to HRM, EU responsibility for public expenditure, and M&A strategies may eventually be beneficial to both academics and practitioners, according to the interviewees' piqued interest.

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