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A conceptual review of the higher education system based on open innovation (OI) perspectives

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The open innovation paradigm has evolved from its incipient form, namely Schumpeter's new production function from 1912, to the current context of a global network of societies, including virtual communities that produce innovative ideas and industry applications through knowledge transfer. The role of industry-university cooperation and networks is widely recognized within the current academic approach. However, the context of higher education, its characteristics, and business application are not thoroughly explained from the Open Innovation (OI) perspective. The debate and further understanding of OI, industry-university cooperation, and the accurate application of academic knowledge to the business world and society are academics' main concerns nowadays, our research being a beginning step. The research objective is to present the evolution of the innovation concept from the higher education perspective through a qualitative review of existing studies. The contribution of this paper is linked to the proposed higher education service life cycle framework for academics based on the current needs for innovation, accessibility, and global integration.

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Introduction

In a global society, knowledge is the reason behind cooperation and collective work (van Krogh and Roos, 1996); networks created through knowledge have increasingly become a source of ideas and innovation. The dimension of cooperation, which involves knowledge and knowledge transfer, is mainly discussed in relation to the business sector. Companies can generate knowledge and innovation at the process level as well as at the human resources level. The knowledge transfer and the generated innovation partly determine this evolution of the business sector from agriculture to services. From this perspective, the higher education system did not manage to evolve at the same pace as the industry/business sector. The main objective of this research is to underline the areas where the higher education system can apply business-like strategies to generate innovation and to manage to enter the next level of development through access to the OI.

To achieve the standard for success[1], the industry is focused on learning how to use this collective knowledge, often called the "wisdom of the crowds" (Wardyn-Runiewicz, 2022). Considering the Triple Helix (Government - Industry – University) Innovation paradigm, the third element within the equation supports the learning process: universities. The paradigm of open innovation (OI) argues that ideas are often implemented by people or companies who did not necessarily generate them initially (Wardyn-Runiewicz, 2022). The discussion then arises of how OI and its different forms of industry-university cooperation are applied and create meaningful results for society. The following chapters of this study will debate the concept of OI and its forms, the new value constellations, and the importance and influence of academia on the new paradigm.

The paper aims to present the evolution of the innovation concept from a higher education perspective. The study will propose a framework for academics under the need for innovation, accessibility, and global integration.

Literature Review

The concept of innovation. First introduced by economist Joseph Schumpeter in 1912, the term "innovation" has been identified as a critical dimension of change and applied to product development for many decades (Schumpeter, 1912). Schumpeter observed that increased productivity was instilling discontinuities. Innovation was proposed as a source for new industries; over time, combining innovation and new industries played a significant role in accelerating global economic development.

Within the equilibrium model of change, long periods of small incremental innovation are accompanied by short periods of radical innovation. Applied to organizational theory, the equilibrium model of change translates to a chain of limited modifications to products, services, processes, and functions intertwined with significant process discontinuities. This rhythm permits exploring new technologies, markets, products, services, and business models. Ultimately, the goal of change and innovation remains to improve the efficiency, effectiveness, and overall profitability of technologies, production methods, and distribution channels, amongst many other factors.

Table 1 . Innovation types.

Innovation types	Market	Business model	Technology
Incremental	established	established	established
Disruptive	new	new	established
Radical	new	new	new

Source: Adapted from Fasnacht, 2018.

There are three main types of innovation, as shown in Table 1: incremental, disruptive, and radical.

Incremental innovation involves relatively minor changes and exploring different ways of using established technologies (Fasnacht, 2018); the focus remains on cost efficiency and smaller improvements of existing products, services, and processes. Incremental innovation is well represented by the concepts that pushed Japan to become an industrial power – total quality management concepts, Kaizen (the art of continual improvement), just-in-time inventory management (Lind, 2011), and lean production philosophies, all of which, over time have transformed business and even influenced more modern industries such as agile software development. Incremental innovation is planned systematically in every organization and industry, using prescriptive strategies for long-term business concepts (Cagnetti et al. 2021).

Disruptive innovation shifts the focus from technology to business models, following the perspective that to be disruptive, the technology does not need to be new. This type of innovation is often common in start-ups with limited resources that challenge the status quo by searching and finding solutions for specific segments that are underserved or neglected from the bigger picture (Christensen and Bower, 1996; Chauca et al. 2021). Over time, the disruptive change creates erosion to products and services in an industry, and while new entrants succeed, established businesses experience decreases in their market share, profitability, and reputation (Kivimaa et al. 2020). This phenomenon is visible when customers move from established providers to new companies due to more suitable products or better customer service, support, and greater service customization. Disruptors often develop business models on the "pain points", failures, and gaps from existing organizations within the market. This allows disruptors to create value in the lower-end or least profitable market segments first; in other cases, they create demand in a non-existent market.

Radical innovation is based on a completely different environment, where new markets, new business models, and new technology are created. For it to be created, radical innovation must first have the necessary ecosystem and conditions for change, which cannot always be easily planned. To sustain such changes, continuous improvements cause market mechanisms to move, increasing competition, driving the need for differentiation, and challenging the status quo (Holloway et al. 2021).

Innovation types and their relations are presented in Fig. 1 (Fasnacht, 2018).

The new paradigm – Open innovation. The term paradigm is often presented as a social context comprising generally accepted rules, standards, and practices that connect individuals and entities across the globe. Within a changing environment, individuals and organizations are forced to transform and create value by combining available resources in new ways (Reschly and Ysseldyke, 2002). The wave of transformative change instigates superior value creation and brings out the redundancy of current products, services, processes, and technologies. In short, the implementation of new strategies affects the entire ecosystem. This paradigm shift of firms to evolve with changing environments spurred a wave of specialization, localization, and integration along the value chain, thus forming the "value creation network" (Kothandaraman and Wilson, 2001).

The industry is open to new ideas and business models, especially those that increase revenues or decrease costs. The open innovation (OI) paradigm has dynamically transformed the global landscape – from small businesses to large companies and entire industries and economies (Payan-Sanchez et al. 2021). Some examples of open innovation are: at the industry level, the GE Open Innovation Manifesto, which proposes the collaboration between experts and entrepreneurs for solving problems, and at the higher education level, the NASA collaboration with Harvard Business School, London Business School, and Top Coder to create a mathematical algorithm for determining the optimal content of medical kits for future human-crewed missions.

Services are the largest and most profitable sector in modern, developed economies, including financial services, health care, consumer services, information technology, and higher education. Specifically, higher education is part of the knowledge-based industry, which continuously facilitates innovation through labor productivity and the adoption of new information technology such as smart data, big data, algorithms, artificial intelligence (AI), and machine learning. The higher education sector is helping organizations through research and development and knowledge creation dimensions, offering insights into predictive models, consumer behavior analysis, and other market-relevant aspects (Quarchioni et al. 2020).

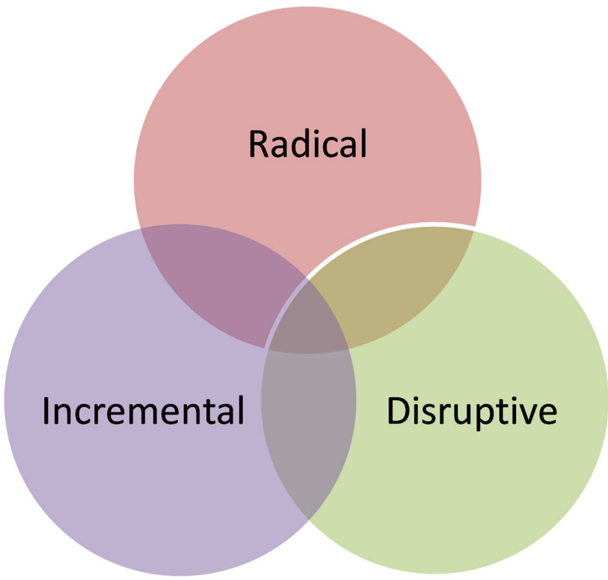

Fig. 1 Innovation types.

Innovation is often attributed to manufacturing, while services are frequently associated with incremental solutions. However, the services dimension is the main contributor to the global economy and continues to capitalize on prospective solutions offered by OI. Since many academics have linked their studies about innovation to the manufacturing industry, focusing on services is paramount (Suchek et al. 2021). Organizations worldwide have started to increase their participation in the services sector to stay relevant and strive for profitability margins to reinvest in radical innovation.

The paradigm shift refers to changing perspectives from innovation as initially understood (mainly focused on product development and R&D - incremental innovation) to open innovation (mainly focused on knowledge creation - radical innovation). The paradigm shift showcases that developments in services have increased in number and significance and created a bridge between technology and knowledge. In many industries, competitive advantage is achieved through information-based, knowledge-intensive, and service-driven organizations. The drivers of strategic change balance the short-term effectiveness of day-to-day operations with flexible long-term strategic exploration. The combination of both elements is the main goal and driver of change.

Table 2 shows a compact overview of the impact of innovation on the entire ecosystem (Fasnacht, 2018). Since this paper focuses on the higher education system, the following part will apply examples from the education sector. Although services may not be associated with the main source of innovation, the higher education system showcases some disruptive trends. Some external factors contributing to this are globalization, international competition, consolidation, and convergence; increasing regulations, technology, and digitalization; shifting demographics; new user expectations and behaviors; and high connectivity; extremely complex ecosystem dynamics, namely markets, users, regulation, and technology.

As discussed, the research problem arising here comprises various aspects, including the lack of equilibrium between the employment market and higher education, the minimal contribution of academia to the business market and vice-versa, and the slow absorption of knowledge and digitalization of higher education and industry.

The World Economic Forum recently published an article asking, “What is next?” for higher education and presenting an

Table 2 Innovation types and their impact.

Types	Impact			
	Finance	Client and market	Competition	Time
Incremental	Short-term revenues	Improves existing products and services	Keeps business competitive to remain in the game	Continuous activity
	Efficiency gains	Improves operational processes	Transparent implementation and execution	
	Cost reduction	Improves the customer experience	Easy-to-copy designs	
Disruptive	High investments	Creates value where none existed	Hard to copy business models	Next business cycle
	Financial risks	Changes the client's journey	Competitive advantage	
	Involvement of venture capital/private equity	Starts with untapped client segments	Start-ups to challenge incumbents	
Radical	High investments (recapitalization)	Replaces existing business models	Consolidation	Next generation
	Takes time to pay back	Offers a new value proposition	Rendering competition obsolete	
	Resource deployment	Transforms industries and social behavior	Establishes new market leaders	

Source: Authors synthesis based on Fasnacht, 2018.

alternate learning model for the future (Sarma, 2022). The article explains the gap between the employment market and higher education and delves into various problems, from increasing tuition fees to students gaining practical experience. On one side, there is the concern that more young people are graduating without applicable skills for the labor market. On the other side, universities and professors are unable to keep up with the changing paradigm. Today, putting skills first, training students for the digital world, and building on diversity, equality, and inclusion is far more critical than ever.

Some universities have not considered the digital transformation issues and do not proceed with any changes. The business has emphasized the importance of computer science at the employee level and the adoption of new technology. To address the industry transformed by digitalization, high-skilled job openings must be filled by workers with competencies per the new requests.

Sanjay E. Sarma, professor of Mechanical Engineering at MIT, has worked alongside his colleagues on a model (Sarma, 2022) for change at pedagogical, curricular, and structural levels within an updated higher education system called the "new educational institution" (NEI). The NEI underlines the high efficiency of the availability of online content for students while proposing a global partnership of all higher education institutions in the hope of providing high-quality study materials and teaching. Moreover, the article argues the importance of hiring qualified employees from various organizations to demonstrate specific areas of knowledge.

Perhaps the most important and innovative element of NEI is the opening of courses, focusing on multidisciplinary approaches, online materials rather than lectures, and in-person study groups to contextualize the real world. This means that a computer science student would combine courses on AI, statistics, and ethics and be presented with concrete examples from real organizations. Sarma (2022) argues it is time to "move from a one-size-fits-all model of education". At one time, people were expected to hold on to a job for life. However, nowadays, it is increasingly improbable. The implication is that new generations will need to continuously reskill and upskill by learning and accumulating knowledge in different facets throughout their lives.

NEI is an example of a *disruptive trend in higher education*. Some universities have already been transformed for the future. For instance, some universities offer modular, digital-only courses, with available materials in the form of written, video, and recorded content, offering double certifications in partnership with other universities. These universities understand the non-existent likelihood of students participating in scheduled courses, allowing them to study at their own pace, considering different circumstances such as working at other jobs, preferences to study at night, or living in other countries. Such digital universities often collaborate with other universities and offer double accreditation, financial aid, connectivity to the employment market, special guest appearances, case studies, and special work terms with participating companies.

Moreover, research proposes the introduction of AR and VR technologies for their potential to facilitate the learning process (Al-Ansi et al. 2023), online learning, and ICT integration in higher education (Al-Ansi and Fatmawati, 2023), as well as the application of Internet and electronic devices in the higher education for interactivity and social learning (Al-Ansi, 2022).

Methodology

The analysis method used for the current research is a qualitative discourse analysis of scholarly work on OI and its application to the higher education system. This method analyses various texts and makes interpretations connected to the reviewed material and the contextual knowledge forwarded. The data was collected by analyzing various papers covering topics such as OI, higher education, and the contribution of OI to developing higher education perspectives and applicability. In this particular study, at first, there were 48 bibliographic sources analyzed, the majority being written in the 2020–2023 period of time, randomly selected upon keywords and titles as a base to select the most relevant 21 articles based upon content. In order to consider a source relevant to this study, the texts have been combed for keywords such as open innovation, higher education, knowledge transfers, knowledge networks, and disruptive trends in education, and they have been grouped based on the QH map of innovation proposed by Wardyn-Runiewicz (2022). In Table 3, the repartition of the

Table 3 Discourse analysis of selected research and category allocation.

	Research paper	Category allocation based on the QH map of innovation
1	Al-Ansi (2022).	Market and social trends generated by society
2	Al-Ansi and Fatmawati (2023)	Technological knowledge generated by industry
3	Al-Ansi et al. (2023)	Scientific knowledge generated by universities and R&D institutions
4	Avelino (2020)	Market and social trends generated by society
5	Baleeiro Passos et al. (2023)	Managerial knowledge generated by companies
6	Cagnetti et al. (2021)	Technological knowledge generated by industry
7	Chauca et al. (2021)	Technological knowledge generated by industry
8	De Jong et al. (2022)	Scientific knowledge generated by universities and R&D institutions
9	Grigorescu et al. (2021)	Managerial knowledge generated by companies
10	Holloway et al. (2021)	Managerial knowledge generated by companies
11	Ion (2022)	Market and social trends generated by society
12	Interreg Europe (2022)	Technological knowledge generated by industry
13	Kivimaa et al. (2020)	Technological knowledge generated by industry
14	Payan-Sanchez et al. (2021)	Market and social trends generated by society
15	Quarcioni et al. (2020)	Scientific knowledge generated by universities and R&D institutions
16	Sarma (2022)	Scientific knowledge generated by universities and R&D institutions
17	Sharma and Sharma (2021)	Scientific knowledge generated by universities and R&D institutions
18	Suchek et al. (2021)	Managerial knowledge generated by companies
19	Theeranattapong et al. (2021)	Scientific knowledge generated by universities and R&D institutions
20	Wardyn-Runiewicz (2022)	Managerial knowledge generated by companies
21	Yang et al. (2021)	Technological knowledge generated by industry

Source: Authors' synthesis.

Table 4 Frequency analysis.

Category allocation based on the QH map of innovation	Frequency	%
Market and social trends generated by society	4	19
Managerial knowledge generated by companies	5	24
Technological knowledge generated by industry	6	28.5
Scientific knowledge generated by universities and R&D institutions	6	28.5

Source: Authors' synthesis.

research articles has been performed based on the allocation of topics to the QH identified categories: market and social trends generated by society, managerial knowledge generated by companies, technological knowledge generated by industry, and scientific knowledge generated by universities and R&D institutions.

The frequency analysis showcased a balance between the dimensions of the QH map of innovation in terms of their distribution across the available research papers (Table 4). Based on this finding, the study could proceed in the understanding and approach from each quadruple helix element of the OI perspective and network, showing strong confidence in including each direction within the research.

The scope of the study was to underline the previously discussed vision for higher education within the context of a networked world. Some authors have identified the lack of equilibrium between higher education and the industry/government. At the same time, the focus on this matter has become more pertinent in the last few years, hence the limited number of available papers for analysis. The studies included in this research were interpreted based on their contribution to the academic environment. They were chosen for their unprecedented and innovative approaches to the topic of higher education within the OI model perspective.

The research question is: What dimensions of OI can be introduced in the higher education system to generate radical change and to determine the alignment of the higher education scope to the industry and the government's new perspectives? The paper initiates the discussion with the historical dimension of innovation and determines the terms for the new paradigm (i.e., open innovation). Moreover, the research develops the concept of strategic partnerships between the government, industry, and academia. The following chapters of the study construct the theoretical framework for the research (i.e., the concept of innovation, OI, historical moments of OI, and knowledge networks) and reflect on the content of various studies by identifying the common themes and patterns relevant to the research question (i.e., strategic partnerships, OI ecosystem). Based on the reviewed data, the paper forwards a new framework in the form of a new higher education services life cycle model. The latter combines the life cycle model's structure with OI's elements. This new model manages to answer the research question and presents the dimensions of OI that can be applied at the higher education system level.

Results

Innovation dimensions. As previously mentioned, Joseph Schumpeter (Schumpeter, 1912) introduced the innovation concept to the economic sciences and defined it as the aiding process for creating a new production function. As expected, the idea of innovation was comprehensive, and it was mainly linked to introducing a new product, a new method of production, or any other change in the structure of a business, processes, and partnerships. Later, Drucker (1985) and Larson (2000) attributed innovation to entrepreneurship, giving it a more abstract conceptualization than before and portraying it as a process meant to facilitate and implement opportunities beyond the status quo. Entrepreneurship became a new standard within societies worldwide, and entrepreneurs were seen as purposely searching for opportunities to innovate with the ultimate scope of value creation. Moreover, the widely cited business books "The Innovator's Dilemma" (1997) and "The Innovator's Solution" (2003) by Clayton Christensen heightened the concept of *disruptive technologies* in innovation. The thirst for innovation started assimilating into micro and macro-level strategies, making it applicable to novelties and unknown solutions (Meyer and Goes, 2017).

As mentioned, innovation refers to any progressive action adopted by an organization or an individual, including production methods, behaviors, or physical products. In the 2010s, innovation reached a new level of definition, meaning that the term would be attributed to any new idea or solution facilitating value creation and efficiency. In 2018, scholars (Hopp et al. 2018) have defined and categorized economic innovations as organizational, technical, marketing, and eco-innovations while being either radical (e.g., significant technological advancements) or incremental innovations (e.g., refining and exploiting the potential of existing technologies). Innovation is complex and multidimensional; it is difficult to define and has many purposes. However, at its core, innovation is a dynamic process that should ultimately benefit society.

The innovation process can be compared to a brain or a microchip in that it flourishes within a network of connections and synapses where the knowledge flows freely between different entities. Returning to the 1950s, Rothwell (1994) aimed to classify five generations of innovation models, as listed in Table 5.

The first model was based on linear-sequential innovation, which followed an already established sequence of steps – basic research, applied research, development phase, production, and diffusion. As expected, it was linked to creating and marketing a new product. The second model emerged a decade later, known as the technology push innovation and the market pull innovation. They were the result of the fast-paced growth of the economy in the United States.

In the 1980s, the third model overcame the limitations of the previous ones, considering the innovation process was ostensibly born in harsher economic conditions. At this point, the innovators focused on bringing the technologies with the market needs based on an interactive process. The fourth innovation model was introduced in the 1990s by Japanese electronics and automobile manufacturers, who integrated innovation activities within the company and across the supply chain. This model is based on the organization's human resources and knowledge and requires high R&D expenditures. This was when innovation stopped being considered a linear process and instead multi-sequential and interdependent (Dias et al. 2014), occurring at technological, scientific, and economic levels (Leydesdorff and Strand, 2013) with little opportunity for containment.

Today, innovation happens at a societal level and is deeply connected to knowledge transfer and the active participation of various entities striving to create value. Innovation is a collective, collaborative, and cross-functional process, creatively combining generic knowledge and specific competencies (Avelino, 2020). The OI paradigm was postulated (Chesbrough, 2003; Kovács et al. 2015; Hossain et al. 2016), underlining the positive inflows and outflows of knowledge to accelerate internal innovation. Thus, the sixth innovation model concerns the high interdependency of system integration and extensive networking worldwide.

This new paradigm proposes a business model based on sharing intellectual property with other organizations before entering the market. The knowledge-based economy forces all entities across the

Table 5 Rothwell's five models of innovation.

Model	Description	Focus	Example
First	Linear model – market pull	Emphasis on marketing-related activities, as the market is the source of inspiration; incremental innovation, with no technology research	Small but short projects to promote various products/services
Second	Linear model – technology push	Emphasis on R&D and science; simple, radical innovation, with no market feedback and interaction	NASA space projects from the 1950s based on product research and engineering
Third	Interaction between different elements and feedback loops between them, the coupling model	Integration between marketing and technology; both radical and incremental innovation	During the inflation and stagflation phases of the economy, the technology push and market pull intertwined to reduce operational costs.
Fourth	The parallel lines model, integration within the firm, upstream with critical suppliers and downstream with demanding and active customers, emphasis on linage and alliances	Emphasis on external linkages, networking	Connection between the customers, suppliers, and manufacturers – streamlined products and services for the contemporary market
Fifth	Systems integration and extensive networking, flexible and customized response, continued innovation	Emphasis on knowledge creation and accumulation, extensive networking, sophisticated technology use	Inclusion of competitors, government, and other external inputs under the integrated network – driven by knowledge creation and transfer (i.e., KIBS)

Source: Authors' synthesis Entekhabi and Arabshahi (2012).

market to search for easier and quicker access to knowledge while being active online, accessing the wisdom of the crowds, and being part of the networked society. This has been the birthplace of OI. As previously mentioned, an essential tenet of OI is that ideas and knowledge are passed to others who create and implement new products and technologies (Wardyn-Runiewicz, 2022).

One of the most critical forms of OI is the cooperation and networking between industry and universities. The primary partners in the open innovation models include customers, suppliers, competitors, R&D units, and universities (Yang et al. 2021). The traditional innovation model was closed; new ideas were created and implemented internally. However, the traditional model was flawed from the beginning as it presumed that innovation could be contained. While some legal protection may be offered through patents and other intellectual property mechanisms, it is not always possible to fully contain innovation. For example, employees take their knowledge and experience when they leave, allowing them to build on former innovations and potentially commercialize new products or services at other organizations. OI considers simple correlations between R&D and innovation futile and constantly searches outside its environment to find new ways of effectiveness and efficiency (De Jong et al. 2022).

Strategic partnerships with higher education institutions. Collaboration between industry and universities ranges from R&D partnerships to university-centered clusters and joint research centers. Beyond these formal commitments, there are several other informal interactions such as conferences, training of business employees by academics, joint supervision of PhDs, joint publications, sharing of R&D facilities, academic spin-offs, transfer of patents, and the sharing of hardware, software, and databases. Public policy programs incentivize such collaborations. In specific sectors, it is pretty standard to find industry-sponsored research. For instance, GlaxoSmithKline and British Nuclear Fuels support the Cambridge Research Laboratory, while Rolls-Royce has created a network of University Technology Centres (Wardyn-Runjewicz, 2022).

The most common types of collaboration between universities and industry are consultancy, contract research, joint research, training, conferences, meetings, and informal knowledge exchange. These common types of collaboration are some of the most effective partnerships; for instance, scholars (Baleeiro Passos et al. 2022) showed that interactions between universities and industry professionals have improved the organization's performance and competitive advantage in the market. Human resource mobility is one of the most essential elements of such partnerships, having long-term benefits for the organization.

The European Union (EU) has funded various programs, including Interreg Europe, interregional cooperation with the scope of reducing disparities between European regions regarding development, growth, and quality of life. The program encourages sharing solutions, policy learning, and innovative, integrated, and sustainable solutions. The project achieves its mandate through various means, including technology parks, science parks, research centers, innovation centers, and technopolis. These are important policy components of research and innovation within the local ecosystems (Interreg Europe, 2022). This construct is an organization managed by specialized professionals with the scope of increasing the community's wealth through innovation and competitiveness. The science park is meant to stimulate the knowledge transfer between universities, R&D centers, and markets that stimulate start-ups and value creation for the community. The objectives of such technology parks are the re-industrialization of regions, the economic development of communities, and the formation of synergies across different innovation players. Such a place will inevitably attract foreign direct investment (FDI), generate employment opportunities, determine reforms, and inform public policy.

The European Commission policies define knowledge-intensive clusters as R&D-intensive science parks or smart specialization platforms. These parks are organized in various forms; sometimes, universities are the major stakeholders and are purely focused on science, and in other set-ups, universities hold a minor stake and are purely focused on technology development. A recent study (Theeranattapong et al. 2021) found that pure science park organizations showcase the highest performance in technology generation but have the lowest product innovation levels. The pure technology park organizations are the best at product innovation sales but worst at patenting. Another study (Sharma and Sharma, 2021) underlines the role academic institutions play in university-industry collaboration, where the former is the main source of knowledge and competence in science parks.

Such developments offer the opportunity to create well-functioning ecosystems for OI and collaborative innovation.

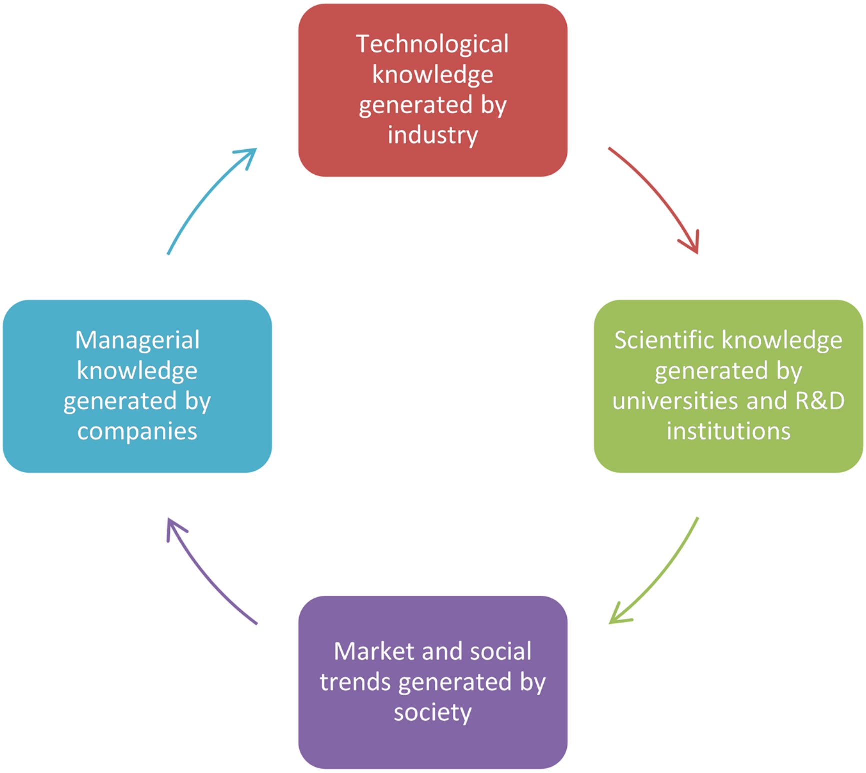

Fig. 2 The QH map of innovation.

Over time, the world witnessed an evolution of the Triple Helix (TH) model of innovation – university, industry, and government – to the Quadruple Helix (QH) model, where users are the fourth group of participants. This gives way to a new outcome – an interactive and transdisciplinary process involving all stakeholders – in stark contrast to the linear connection from the past. This four-party system resembles an interconnected map of rapidly growing new services, products, ideas, and technologies. Figure 2 presents the interactive map of the QH, adapted from Wardyn-Runiewicz (2022).

The QH is an innovation and collaboration model focused on the citizen and end-user perspective. The model particularly applies to processes where societal needs are central (i.e., education, health, public services). One example of the QH approach refers to living labs, which entail a user-centered innovation environment within a real-life context. This means that ideas, experiences, and knowledge are networked to stimulate and challenge the development process of products/services and their applications. User feedback is constantly reviewed, technology is tailored to users' needs, and innovation gains traction. As suggested below, the idea of the usability of a QH model is based on the iterative process of trial and error, which entails the step-by-step approach: prepare > explore > understand > improve > implement.

The OI paradigm focuses on establishing as many qualitative interactions and relationships between the elements presented in Fig. 2 by exploiting the knowledge. Universities are no longer a publicly funded category that stands apart from the market and focuses only on theory. Today, the model follows a completely different pathway, with universities as the fundamental link between knowledge creation and knowledge transfer. Universities that do not take part in this new ecosystem will face the context of limited connectivity with the industry, market, and users, thus facing problems such as unused human intellectual potential, low R&D expenditure, low quality of higher education, theoretical programs with little practical application, lack of funding and budget constraints, human resources working several jobs, lack of focus and stunted development opportunities.

The universities of this new world are deeply rooted in the entrepreneurial culture, highly valuing the interaction between society and business and the interconnectivity at a regional level, which only brings more potential for innovation and development. Thus, universities are sources of disruptive ideas, drivers of high-quality disruptive technologies, promoters of an open innovation culture, and spaces where students, professionals, scientists, and entrepreneurs meet to inspire each other. Universities and their ecosystems are natural environments for local knowledge spillovers. An open innovation ecosystem creates a symbiotic environment of academic units and other organizations, especially companies (see Fig. 3).

In this context, one important aspect is represented by geography. Geographical proximity facilitates knowledge exchange and social interaction, causing local character to emerge within innovative solutions. For instance, OI collaborations are optimized amongst agglomerated organizations, helping clusters to grow steadily and sustainably. Nevertheless, long-distance knowledge flows are supported by advances in communication and technology, allowing for the development of long-distance partnerships.

Knowledge transfers between universities, organizations, governments, and users are fundamental in the innovation process, as they become integrated throughout the product/service development life cycle. The users allow for the enrichment of information before and throughout the creation of new ideas and innovation processes, leading to user-driven innovation and co-creation. It is important to mention that the user's involvement must benefit the innovation process and stakeholders by removing barriers to understanding and prioritizing accessibility to outcomes. At this point, it is of paramount importance to achieve synergy between users and technology (Hienerth et al. 2013).

Human capital is fundamental to the OI ecosystem through expertise and training (Grigorescu et al. 2021; Ion, 2022). The

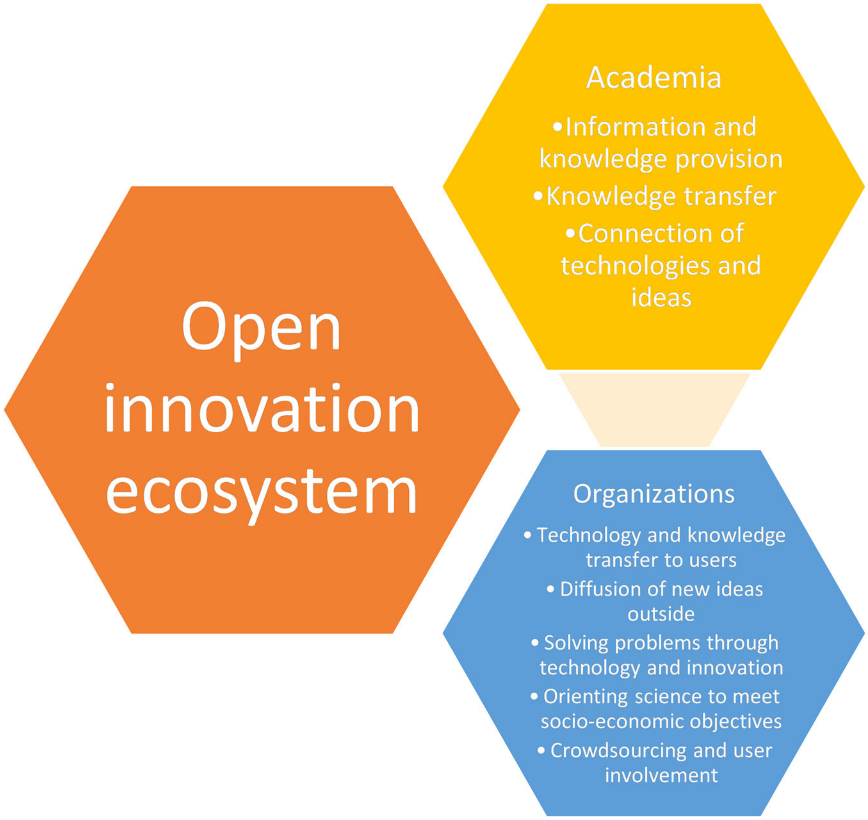

Fig. 3 The Open Innovation Ecosystem - Attribution to Academia and Organizations.

synergy between open science and OI determines knowledge flows and the success of commercialization of both technologies and scientific research. At an EU level, the scientific R&D, professional, and technical activity sector represents 9% of the total number of employees and 20% of the total number of companies, with highly specialized countries such as Sweden, Ireland, Belgium, the Netherlands, Cyprus, Malta, and Luxembourg. At the other end, Poland, Romania, Lithuania, and Latvia have been the lowest performers, with almost no technological parks, no connections between academia and industry, low educational efficiency, and lagging performance in innovation.

Discussion and Interpretation

According to Simonton's research, an innovative idea is generated at a ratio of 2000 to 1 (Utley and Klebahn, 2022). So, to generate innovations, one must generate a high volume of ideas. This seems excessive and hardly feasible for the real world, where efficiency is primordial. Establishing a robust innovation process to cope with such volumes is important. The first step in any transformative context is the regression of the entire system. At this point, the system's collapse is sometimes the most significant catalyst for change that pushes the system forward in new directions. During times of collapse, academics and entrepreneurs worked together to solve colossal problems. For example, the oil crisis and the fatal effects its use has on planet Earth have pushed technology towards disruptive innovations for the betterment of humankind. From this perspective, disruptive and radical innovation can be somewhat facilitated through obsolete systems, ideas, technologies, processes, and businesses.

Today, the traditional higher education sector faces the challenge of remaining relevant. At the same time, many open learning institutions push forward education offers that cultivate ideas, skills, and professional competencies that align with market trends. Sensing the distress affecting this sector, it is mandatory to use tools to understand the system better and monitor and evaluate it and its elements. The next and final part of the research translates the notorious product life cycle (PLC) tool for assessing and evaluating product innovation and technology change to the context of higher education offers.

The 1950s were a golden age for most marketing-related scientific models and theories. Among the latter, the theory of a product life cycle was birthed by Harvard Professor Raymond Vernon, who explained the expectations of a product's life cycle, from its initial concept/design to its sunset period (Vernon, 1979). Initially, this timeline was divided into 3 phases, but later, the model was implemented based on 4 phases: introduction, growth, maturity, and decline.

Vernon's model can be translated to existing and OI-based higher education services using the proposed model below.

The first phase of the model comprises radical innovation of the service, while the innovation process remains at the incremental level. At this stage, the new higher education service, including study programs, curricula, and associated technology, is introduced on the market. The service would be modular to provide testing and comparative evaluation opportunities. In all its variations, the new program is presented to the targeted audience for observation and monitoring of feedback in a higher education service that will consider the market trends and input from students and professors. Ideally, the new program would include a module associated with practical activities in partnership with members of the OI network from industry and government. This would have application to all the fields of study, from business to medicine and engineering to visual arts. The end of the introduction phase should culminate with selecting the dominant design.

As the growth phase begins, the service innovation will become incremental, the process innovation will be radical, and the

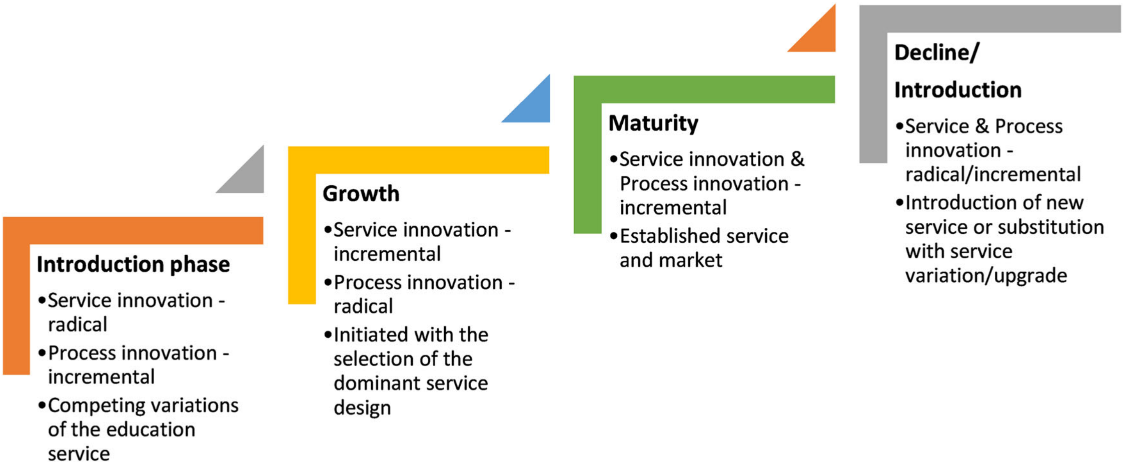

Fig. 4 The Higher Education Service Life Cycle.

education service will be adopted on a large scale by various universities and education institutions, private and public.

While the service arrives at the maturity level, the innovation, both in terms of service delivery and process concept, will be incremental. During the first phases of the service life cycle, it should have been enough time to understand the benefits and errors of the higher education service provision to introduce either a new service or the substitution of the service with an updated version. The entire process is visible in Fig. 4.

The technology change and technological convergence in higher education services will be determined based on the technical parameters and the application timeline. This means that between each service life path and the next, a gap will be covered by R&D activities based on continuous monitoring and control of the market trends and targeted audience needs.

Conclusions

In conclusion, the higher education system will no longer be able to abide by the traditional model and rules, as it must cope with the principles of the OI paradigm, which has slowly but surely encompassed the entire industry and society. In this new world, the higher education system should not be oblivious to the developments outside its boundaries, as the traditional vertical integration model is redundant. The higher education services can no longer be developed from within the system but rather with the aid of the other market players – namely the industry, government, and society. The relevancy of higher education studies increases exponentially with the development of OI networks. The principle is simple – one must use the purposive inflows and outflows of knowledge with the scope of accelerating the internal innovation process, making use of already established technologies, borrowing from other market players, making use of ideas (internal and external), and turning them into systems and architecture that follow market trends and society needs. This exchange of technology, knowledge, and human capital will determine value creation and help organizations capture and sustain their position in the value chain over longer timeframes.

The study proposes applying a service life cycle model to higher education perspectives to align the latter to societal needs. The proposed model includes an initiation phase, where the service suffers from a radical innovation approach. The market is now ready for the introduction of a new higher education service. At this step, the latter will be tested and evaluated. Various services are released on the market, and the targeted audience will provide feedback. At the same time, the industry and government will actively participate in the provision of higher education services through the OI network. This will ensure cooperation between the parties and the real-life application of the OH model. The end of the introduction phase should culminate with selecting the dominant design. During the growth stage, the service innovation will become incremental, the process innovation will be radical, and the education service will be adopted on a large scale by various universities and educational institutions, private and public. The cyclical model has the advantage of never missing opportunities for restructuring and improvement in line with the market and societal needs.

Implications and Limitations. The research forwarded a framework for the higher education system based on OI perspectives and the connectivity between education, industry, and government. This first study is based on following the existing research and identifying elements that could adhere to the OI paradigm with the scope of determining an evolutionary development of the entire higher education system. The qualitative approach of this article will be repurposed into a framework for new quantitative research that will focus on finding the exact position of higher education services globally. The limitations of this study include the lack of primary data and subjective interpretation of existing research.

Data availability

Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

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Note

1 The standard for success is the ultimate goal within the open innovation function, where all the needed variables (R&D investments, infrastructure, technologies, social skills, cognitive skills, financing options, etc.) are implemented and deployed for the deliverance of innovative activity that produces value for the society.

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The authors declare no competing interests.

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