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Chair of Strategic Management and Innovation

Master thesis

Analysis and Strategies to Promote the Innovation Ecosystem of Autonomous Systems in the Canton of Zurich

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Abstract

The Autonomous Systems (AS) industry has the potential to revolutionize various sectors such as transportation, healthcare, finance, and logistics, and has gained significant attention in recent years. However, despite the obvious successes of the technology, most developments remain within the confines of laboratories and test fields. Autonomous Systems are of great interest to the national economy. Along the entire value chain, AS create highly qualified jobs, open new markets, and provide solutions for social challenges in mobility, digitization, for shortage in skilled workers, resource conservation and energy generation.

To explore and understand the challenges of autonomous systems development, adoption, and commercialization, I am looking at the problem from an ecosystem perspective. A Silicon Valley innovation ecosystem has proven that a successful ecosystem can inspire entrepreneurs and industry to collaboratively develop cutting-edge technologies and create new value for consumers. Unfortunately, since ecosystems are unique structures with many influencing factors and own dynamics, there is no universal approach that would fit to all ecosystems. Literature does not provide with comprehensive, multi-stakeholder study that would examine a regional innovation ecosystem development in the context of autonomous systems.

The core of the thesis is the analysis of the innovation ecosystem in the Canton of Zürich with the focus on autonomous systems (drones, self-driving cars, robotic platforms). The analysis showed that Canton of Zurich has a strong heritage in engineering and technology. Its universities, research institutions have world-renowned expertise in robotics, artificial intelligence, and autonomous systems. However, there are some challenges that should be addressed to foster the ecosystem growth. A qualitative analysis of 25 interviews conducted with key ecosystem stakeholders applying extended Six Helix model identified the drivers of the ecosystem as well as potential barriers and weak linkages impeding its rapid development. The analysis contributes to the insights on how to leverage the strengths of the ecosystem and what strategies can navigate to the innovation ecosystem sustainable growth.

1 Introduction

Technological innovation and an innovative activity are the most important components of long-term economic growth (Grossman & Helpman, 1994: Abrahamson & Rosenkopf, 1993). Emerging technologies have the potential to drive transformations and responses to crises, but they also pose risks and additional challenges. An appropriate technology governance to address the high uncertainty, risk, and complexity associated with emerging technologies, as well as coordinated, aligned effort of actors involved in the developing, deployment processes can ensure the fast and successful innovation technology adoption. (OECD, 2023)[1]

The approach adopted in this thesis is focused on investigating the drivers and constrains of innovation ecosystem development. An image of Silicon Valley as a highly successful entrepreneurial region is the main reference point for many ecosystem developers. However, there is no ecosystem that could perfectly re-create its success. One of the reasons is the high variability of factors and the stakeholders' unique relationships influencing the ecosystem that makes it very difficult to imitate. Collaboration between government, universities and industries has been an integral part of this ecosystem (Piqué et al., 2020; Etzkowitz & Leydesdorff, 2000). Initially, such collaborations are centred around technology transfers, accelerators, incubators, research and development and joint ventures. These collaborations offer a platform for stakeholders to generate and exploit new knowledge. According to Nonaka and Toyama (2003), new knowledge comes from direct experience from organizations in a socialization phase. In the internalization phase this new knowledge is generated by university-government collaboration supported by industry that aims to acquire new knowledge for practical applications - commercialization.

Any technological development, especially disruptive, not a linear or isolated process (Hekkert et al., 2007). Looking at innovation process from an ecosystem perspective can help to better understand these interactions and their impacts on the development processes (Amitrano et al., 2018).

[1] OECD Science, Technology and Innovation Outlook, 2023

Literature research on ecosystems showed that there is no holistic approach to design an ecosystem. The models differ depending on surrounding conditions and socio-economic environment (Iansiti & Levien, 2004; Jacobides et al., 2018). Most ecosystem scholars adopt a narrow view and focus on private sector firms (Adner, 2006; Adner & Kapoor, 2010) or specific regions (Pique et al., 2019; Helman, 2020; Huang et al., 2020). Furthermore, since the innovation ecosystems are highly complex structures, there is no universal strategy that would fit to all ecosystem's development. The Triple Helix (TH) (Etzkowitz, 1993) and Technopolis Wheel (TW) (Smilor et al., 1989) models are fundamental theoretical frameworks that highlight the collaborative relationship between universities, industries, governments and supporters in creating a conducive environment for innovation. While these models have been widely accepted and used to analyse various innovation ecosystems globally, it falls short when it comes to specifically understanding the unique characteristics and dynamics of the innovation ecosystem of the specific region and demands of a deep tech technology. Case studies showed that an ecosystem often involves a wider range of stakeholders, interacting and influencing each other in complex ways (Budden & Murray, 2019; Carayannis et al., 2012). Besides universities, industry companies, government, private/public financial institutions, policy makers, entrepreneurs and end-users (society) play a very important role in the emergent technology development and adoption. Without financial support from the private-public sector and the adoption of appropriate policies, it would be difficult for universities to initiate research projects and for companies to develop their products; without acceptance of innovation by society, it would be impossible for entrepreneurs to commercialise and deploy their innovative technology. It is therefore important to take these stakeholders into consideration for the innovation ecosystem modelling and analysis.

Despite numerous scientific studies of ecosystems, there is currently no theory that can explain ecosystem functionality as a holistic process. This study fills this gap by providing an ecosystem analysis that highlights the relationship between all of the relevant stakeholders and factors contributing to its success or failure in one coherent theoretical framework. The research offers a new perspective by focusing on the practical implications of the fundamental theories and models and incorporating new elements corresponding to the assessed ecosystem characteristics.

The thesis provides with analysis of innovation ecosystem in autonomous systems in the Canton of Zürich. Applying Triple Helix and Technopolis Wheel models as conceptual frameworks. The study identifies main barriers and driving forces demonstrating the interdependencies between stakeholders, providing a comprehensive description of the entire ecosystem. Drawing on empirical research and theoretical analysis, the strategy framework was proposed aiming to bridge the existing gaps in the innovation ecosystem and provide actionable insights for strategists, policymakers, and involved stakeholders.

The main motivation for selecting this ecosystem is that the Canton of Zürich plays a pivotal role in Switzerland's robust economy, boasting a unique blend of cultural, social, technological and economic backgrounds. Zürich houses the most prestigious educational institutions, such as the Swiss Federal Institute of Technology (ETH), has strong entrepreneurial ecosystem and has been at the forefront of technological advancement, particularly in the field of autonomous systems. A deeper understanding of the ecosystem driving forces, possible obstacles and relationship dynamics between key players can provide valuable insights, and help stakeholders to make strategic decisions, allocate resources more effectively, promote innovation, and stay competitive in the global market.

The research showed a great potential of innovation ecosystem growth in the region, however the identified weak linkages in stakeholders' relationships, in particular between startups and venture capital firms and industry, as well as limited investments in innovation and regulatory constrains can jeopardize the overall ecosystem performance. Key findings of the study include the pivotal role of the government, venture capital, the catalytic role of networking, the importance of entrepreneurial culture, and the public technology acceptance for the ecosystem sustainable growth. Ensuring the long-term success of the ecosystem and addressing its vulnerabilities requires an integrated approach that involves the proactive, aligned and coordinated participation of multiple stakeholders, assurance of optimal regulatory and financial flows, alongside fostering an entrepreneurial culture.

The research question that will be answered in this research is:

"What are the critical constrains and the success factors of innovation ecosystems when applied to autonomous systems, and what strategies can be employed to foster innovation in the Canton of Zürich?"

The empirical part of the research consists of a qualitative analysis of interviews with identified key ecosystem stakeholders, expanding the theoretical understanding of how various factors interplay to drive or hinder innovation in deep-tech technology ecosystem.

The thesis is structured as follows: It starts with a literature background (Chapter 2) reviewing basic ecosystem concepts, defining innovation ecosystem models, common strategies, briefly introducing the most successful innovation ecosystems to understand the major success factors and concluding with identified challenges and gaps. Chapter 3 is dedicated to the research design, which consists of two parts: a theoretical overview of the innovation ecosystem of the Canton of Zurich and the qualitative analysis of 25 interviews conducted with selected groups of ecosystem stakeholders. Chapters 4 summarises the results of the study. Chapter 5 is focused on the discussion of the results and identification of the strategy framework. Chapter 6 concludes with a description of the thesis contributions, limitations and future work.

2 Literature background

An ecosystem, in the broad sense, refers to a community of organisms interacting with one another and with their environment. The term "ecosystem" has also been adopted in other disciplines, notably in business and technology, to describe a community or network of interconnected entities that function collectively, influencing each other. An ecosystem approach can provide a coherent view on technology development and deployment. It helps to recognize the interconnected nature of innovation and can leverage the strengths and capabilities of different actors enabling development processes, increasing impact and mitigating risks. What makes ecosystems unique is the interdependencies among actors, creating the need for a new set of skills (Helfat & Raubitschek, 2018). However, growing systems can become highly complex and challenging that requires a deeper understanding of the key features and mechanisms of the ecosystem.

2.1 Ecosystem concept

There are many definitions on ecosystem proposed by various authors. The term ecosystem was first introduced by Amos Hawley. He described an ecosystem as *"arrangement of mutual dependencies in a population by which the whole operates as a unit and thereby maintains a viable environmental relationship"* (Hawley 1986, p. 26). Later Shaw and Allen (2018, p.90) defined the ecosystem as "recycling flows of nutrients along pathways made up of living subsystems which are organised into process-orientated roles". Jacobodies (2018, p. 10) defines an ecosystem as *"set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled"*, where unique or supermodular complementarities lead to co-specialization.

Several authors agree that the essence of the ecosystem concept is to create a shared value proposition for the customer that an individual firm cannot realize in isolation (Adner, 2017; Autio & Thomas, n.d.; Kapoor, 2018; Parente et al., 2019; Moore, 1993; Shipilov & Gawer, 2020). Adner (2017, p. 40) defining the ecosystem as *"the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize".* Alignment inside the ecosystem is the result of various decision-making processes and coordination activities of multiple actors. Author introduced a conceptualized view on ecosystems identifying two main streams: ecosystems as affiliation and ecosystems as structure.

Ecosystems as affiliation (focused on actors) are viewed as communities of companies and as actors that are associated with membership in a particular geographic region or industry networks around main players (Scaringella & Radziwon, 2018; Agrawal & Cockburn, 2003) or platforms (Gawer & Cusumano, 2014). A concept explores how different entities (individuals, organizations, companies, etc.) form alliances or associations based on shared interests, common goals, or mutual benefits within a particular ecosystem. In other words, these entities affiliate with each other to form a cohesive network of collaborations. The emphasis places on the breakdown of traditional industry boundaries, the rise of interdependences, the potential of relationships and network density. The aim of affiliation is to leverage the

collective resources, knowledge, and influence of the ecosystem to drive innovation, manage risks, and create value.

Ecosystem as a structure is focused on activities and viewed as a configuration of processes with a common purpose. Companies and other actors are part of such an ecosystem because their innovation processes directly or indirectly lead to innovation and new value creation. The structural ecosystems align with the technological innovation system perspective (Hekkert et al., 2007; Musiolik et al., 2012) with open, dynamic boundaries and implementation of new technologies, rather than geography or industry. Those structures imply a systemic arrangement and interrelationships of various entities within a given ecosystem. These entities may include businesses, research institutions, regulatory bodies, investors, and end-users.

Literature reviews have identified several different varieties of ecosystem types, such as industrial, innovation, business, digital and entrepreneurial ecosystems (Pilinkienė & Mačiulis, 2014); other authors diversify into business, knowledge and innovation ecosystems (Clarysse et al., 2014; Valkokari, 2015) or business, innovation, entrepreneurial, platform and service ecosystems (Aarikka-Stenroos & Ritala, 2017); and business, innovation, entrepreneurial and knowledge ecosystems (Scaringella & Radziwon, 2018). While the focus of the thesis is innovation ecosystem, I will further elaborate on this term and give a definition.

2.2 Innovation Ecosystem (IE)

An "innovation ecosystem" emphasizes the role of innovation in the network. This ecosystem includes all the stakeholders involved in the creation, development, production, and distribution of new products, processes, or services. The literature does not provide one universal definition of the innovation ecosystem. One of the most widely used according to Granstrand and Holgersson (2020) study, was published by Adner (2006, p.2), where he defines the innovation ecosystem as *"the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution*". Klimas and Czakon (2022, p.6) see the innovation ecosystem more broadly, as a *"cooperation environment surrounding the innovation activities of its co-evolving actors, organized across co-innovation processes, and resulting in co-creation of new value delivered through innovation."*

Granstrand and Holgersson, after systematic review of 120 publications on innovation ecosystems, identified in overall 21 definitions. Based on this research they proposed the following generalized definition of Innovation ecosystem: *"the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors"*(Granstrand & Holgersson, 2020, p.3)

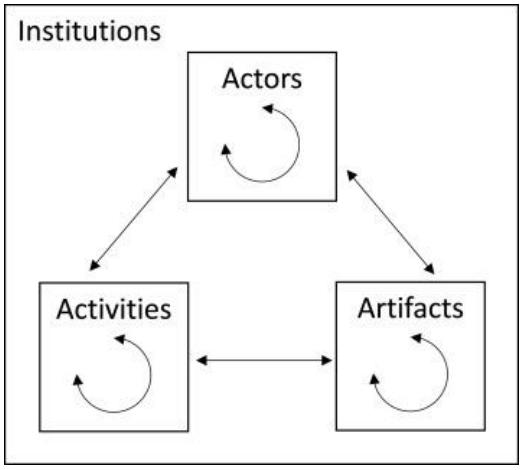


Figure 1. Innovation ecosystem definition (Granstrand & Holgersson, 2020)

Figure 1 shows the generic model of this innovation ecosystem. Artifacts in this definition are products and services, technological and non-technological resources, and other types of inputs/outputs, including innovations. Actors are the stakeholders or participants who perform various activities. The relations (arrows) within entity types include collaborative and competitive aspects, including ownerships and transformative behaviour. The institutional relations evolve nature of the innovation ecosystem as well as the relations between multiple innovation ecosystems.

Other scholars differentiate IE based on value creation and value capture mechanisms. Porter (1985) states that new value is created when companies develop new ways of performing tasks, new methods or technologies. Value creation was defined by Ritala et al. (2013, p.5) as *"the collaborative processes and activities that create value for customers and other stakeholders."* This process requires relationship-specific assets, knowledge sharing, and the establishment

of effective governance mechanisms (Dyer et al., 2018). Value creation can occur in open innovation by providing resources to an external organizational partner who values or uses this resource in its processes (H. Chesbrough et al., 2018). Thus, the value created can be economic, social or environmental (Ben Letaifa, 2015; Oskam et al., 2021). Within the ecosystem, value creation may vary between value co-creation: *"a network of interconnected organizations … focusing on the development of new value through innovation"*(Autio & Thomas, 2014, p.3.) and value co-innovation: *"the network of interconnected actors, organized around a particular value chain/industry, where the actors include public agencies, firms, intermediaries and any other actor that contributes to the production and use of a product or service stemming from that value chain/industry"* (Mazzucato & Robinson, 2018, p. 3).

Value capture represents the value created by the ecosystem that is captured by a particular actor. To increase value capture, organizations can implement isolation mechanisms, which are physical or legal knowledge barriers preventing a competitor from imitation or substitute of product or service (Lepak et al., 2007).

2.3 IE models and key Stakeholders

Current innovation ecosystem models still lack a clear method of creating a holistic collaborative environment (Asefi et al., 2020; Broszeit et al., 2019). In the recent study (Gu et al., 2021) authors identified five streams on innovation ecosystem research: technology innovation; platform innovation, regional ecosystem development (city, cluster, national, industrial level), innovation ecosystem conceptualization and theorization, and entrepreneurship. There are also two main directions identified: 1) approach that examines innovation ecosystems from the perspective of a focal firm (Adner, 2006; Adner & Kapoor, 2010; Autio and Tomas, 2014), and 2) approach that views the innovation ecosystem as a regional cluster development consisting of group of actors who create value in a geographical context (Etzkowitz, 1993; Piqué, 2019).

The model of Adner and Kapoor study (2010) relates to the first approach and shows different relationships between supply and complementors entities, as well as different industries that contribute to the value creation of the focal company. Figure 2 illustrates the concept.

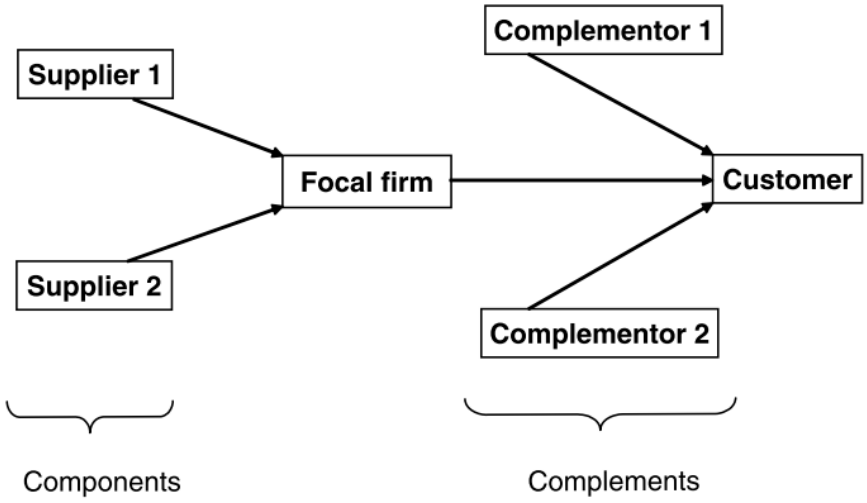


Figure 2. Generic schema of an ecosystem (Adner & Kapoor, 2010)

Value is defined as resulting from company innovations in products/services offered to the market. Authors state that with high innovation challenges in components the higher learning opportunity for the company and market share. At the same time, the components' performance, cost or scarcity can negatively influence the focal firm's value proposition and growth. Whereas high challenges in complements reduces the benefits due to slower adaption of technological change. The value offered by a firm to its customers highly depends on the complementary products and services, therefore, a company must consider complexity and challenges in coordinating activities. (Kapoor, 2018).

This approach, where the IE is organized around a focal firm or a platform can be too narrow and may not be sufficient to describe conceptual developments (Arora et al., 2019; Jucevičius & Grumadaitė, 2014). The regional innovation ecosystem concept consists of multiple technological innovation organizations and multiple technological innovation environments in a region (Huang et al., 2023), including universities, government, businesses, and civil society.

One of the most fundamental models in this approach was introduced in 1993 by Etzkowitz called Triple Helix (TH) model. This concept has been described as a university-industry-government relations model (see Figure 3) and became a reference framework for analysing innovation systems and became a background to describe interrelationships between the three main actors. The TH model assumes that the most important role plays university, while innovation stems from the intersection of industry, research and government (Etzkowitz & Leydesdorff, 2000).

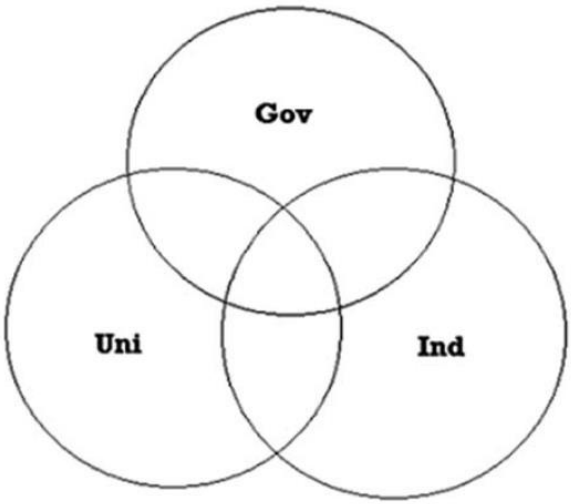


Figure 3. Triple Helix Model (Etzkowitz & Zhou, 2017)

The model is designed as a spiral innovation model that reflects the complexity of activities and the multiple reciprocal relationships that occur at different stages of the knowledge capitalization process in the science and technology sector (Etzkowitz & Zhou 2017). The TH is effective at both national and regional levels (Deakin, 2010), where its cross-sectoral interactions are recognised as a key force for the ecosystem sustainable development (Scaringella & Radziwon, 2018; Ye & Wang, 2019), and R&D collaboration between industry, academia and government contribute to the success of business innovation (Hernández-Trasobares & Murillo-Luna, 2020).

The predecessor of this model was an approach named “Technopolis Wheel” (Smilor et al, 1989) (Figure 4). This model promotes economic development by encouraging R&D and

technology commercialisation through public-private partnerships. The Technopolis framework represents a wheel with segments consisting of research university, large and small technology firms, government; and support groups (e.g., chamber of commerce, venture and angel capital, IP lawyers and other business professionals). It identifies three key dimensions to define and measure a high-tech region: the achievement of scientific performance; the development of new technologies for emerging industries, and the attraction of major technology companies (Gibson & Rogers, 1994). Authors state that the success within the Technopolis framework comes from key influencers in each sector or sub-sectors working together to connect and leverage sectors for a common purpose (Gibson & Butler, 2013).

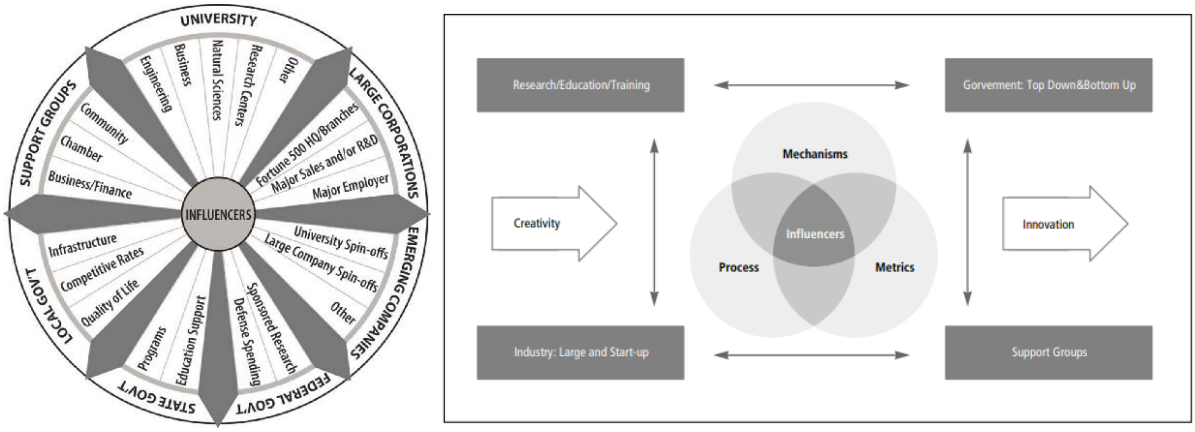


Figure 4. The Technopolis Wheel Framework (Smilor et al, 1989), Source: IC2 Institute, The University of Texas at Austin (Gibson & Butler, 2013)

Figure 4 shows a Technopolis wheel and its main mechanisms of identification key ecosystem roles. University, industry, government, and support groups are linked through mechanisms, processes and metrics, which identify the influencers. Mechanisms include policies, processes focus on how these policies and structures are managed and metrics define how the results are measured and determine the influencers behaviour.

The efficacy of the Triple Helix innovation model has been doubted due to the fact that some of the regions were not able to achieve the expected growth (McAdamet al., 2016). The

Quadruple Helix Innovation Model was introduced by the inclusion of another actor of innovation–society/media (Carayannis et al., 2018). This approach is consistent with an 'open' innovation models (Chesbrough et al., 2018) as a result of collaboration between stakeholders to enhance regional innovation, requiring maximum engagement and alignment of all stakeholders. Brad Feld in his book "Start-Up Communities" (2012) suggested that entrepreneurs are the only actors who can lead the ecosystem on the frontlines. Mazzucato in the "Entrepreneurial State" (2015) argued about a central role of the government and policy makers in the ecosystem. Kenney & von Burg (1999) stated about the critical role of universities (e. g. MIT, Stanford). Other studies observed (Ferrary & Granovetter, 2009) that there is a strong influence of venture capital firms on the effective ecosystem development. The MIT researchers (Budden & Murray, 2018) argue that five key stakeholders needed for success of innovation ecosystem: entrepreneurs, risk capital, university, government and corporate.

The review of literature reveals a lack of consensus on a standard approach to modelling an innovation ecosystem and identifying the key stakeholders, their roles and relationships. Therefore, it necessitates a systematic examination of individual case studies to establish the evaluation criteria.

2.4 Success factors of IE (benchmark)

Successful ecosystems can be understood as a set of seamlessly integrated value-creation businesses that create innovative new offerings for society (Adner, 2012). In the study (Komorowski, 2019) authors investigated more than 247 ecosystems in Europe. The results showed that around 70% innovation ecosystems that operate on both national and international levels were most successful; around 80% of innovation ecosystems that had incubators, cluster organisations, projects and technology parks as central entity showed the highest performances. More than 60% of ecosystems have been reported to be successful if the focus of their goals were on innovation, nascent technology development and industry growth. Other researches argued (Van Looy et al., 2011; Saxenian, 1996, 2006) that the localization of innovation

ecosystem in geographical hotspots, centred around leading universities and public research organizations were key success factors.

According to (Etzkowitz & Zhou, 2018), typical successful models of innovation ecosystem from the Triple Helix perspective are: 1. the university-led model - represented by the Stanford science park in the United States, which is known as the "silicon valley model"; 2. the corporate-pushed model - from industry to university, such as Ideon Science Park in Sweden, Cambridge ecosystems (the ecosystem attracts powerful private enterprises to invest and collaborate with entrepreneurs, supported by the government initiatives); 3. the government-pulled model, where government or political party takes the lead even without university involved in the beginning of the project.

One of the most successful and fast grown ecosystems became: Tel Aviv, Israel (total value is $235 billion, 11 billion of VC funding and value growth 58%), Singapore (total vale $ 128 billion, 6.8 billion of VC funding and growth 61%) and Stockholm (total value is $88 billion, 4.3 billion of VC funding and value growth 114%). The main factors contributed to this success were the proactive involvement of government, strong financial programmes (investment laws, grants), tax incentives and diversity of highly skilled talent.

2.4.1 Silicon Valley ecosystem

Silicon Valley (SV) has consistently ranked among the top startup ecosystems in the world since its launch. The ecosystem total value is USD 2400 billion, where USD 44 billion invested of early stage funding startups, total VC funding USD 344 billion and value growth 28%[2] (data between 2020 and 2022). SV is a home to several world-class research institutions, including Stanford University and the University of California. The most fundamental dynamics comes from collaborative activities between university, industry and government. Dual academic and business experience provides an understanding of technology and its commercial potential. Thus, some serial entrepreneurs have become “university angels,” with the ability to judge both technical and market potential, and invest in their colleagues’ startups (Etzkowitz, 2007).

[2] https://startupgenome.com/ecosystems

It is a multicultural region with a dense network of entrepreneurs and investors (Shih, 2004). Talent pool is coming from all over the world. The insecure employment (non-compete agreement) assists in labour high mobility from one company to another without any obligations. The business infrastructure consists of law firms, accounting firms, mentor networks serving entrepreneurs on beneficial conditions. Silicon Valley is also famous by its highly competitive industries, culture of accepting failures and entrepreneurial spirit (Lazonick, 2009). Research budgets are allocated through multiple different agencies, with evaluations of grant approval based on blind peer reviewed boards. Many of the large firms have established branch offices in SV to gain an access to the network and information. According to D. Wise (2019) an increasing internationalisation of research and development activities promoting collective forms of innovation (open innovation) becoming a major success factor. The innovativeness of Silicon Valley is considered as an economic phenomenon supported by a complex network. The ecosystem consists of networks of heterogeneous, complementary and interdependent agents. Michel Ferrary and Mark Granovetter (2009) identified twelve agents involved in the creation and the development of startups, among them: universities, large firms, research institutions, VC firms, law firms, investment & commercial banks, certified public accountants (CPA), consulting groups, recruitment agencies, public relation agencies and media. These twelve agents actively interact with each other during the startup life-cycle. Hwang and Horowitt (2012) state that the presence of creative, spontaneous, uncontrolled connectivity between key players is an important success factor of Silicon Valley. Authors highlighted four "hardware" (skilled talent, professionals engagement, infrastructure networks, legal system) and five "software" (diversity, extra-rational motivation, social trust, norms, punish violations) aspects of Silicon Valley's successful recipe.

Recent development of SV includes the rise of acceleration programs (from 2 in 2007 to 170 in 2017 (Pique et al., 2018), with raised funding, trainings, access to powerful networks, resulting in high rates of startup formation and increase of seed deals. Silicon Valley has a large concentration of venture capital firms and angel investors who heavily invests in startups. Large venture capital firms (VCs) are mainly concentrating their investments in later stages of startup development. The major ecosystem enablers are venture capital firms, technology transfer offices and large corporations. A minority of high-tech startups are funded by venture

capitalists at the seed stage, while almost all the large high-tech firms in SV have been backed by venture capital. (Ferrary & Granovetter, 2009). Authors state that presence of VC firms in creates potential for specific interactions with other agents in the network (universities, corporates, research institutions) that determines a particular dynamic of innovation. Various studies of high-tech clusters outline that the main difference between Silicon Valley and other high-tech clusters around the world is not the size of universities, the presence of large companies, but the presence of VC firms.

The challenges for entrepreneurs are mostly related to the infrastructure, the lack of an integrated or well-funded public transportation system because of the fragmented conglomeration of counties. That was one of the reasons why Uber business model was successful there. There is no centralized "Silicon Valley government" while the region is a collection of counties. Silicon Valley is a unique ecosystem for technology creation, but it fails in terms of functioning as an urban place: economically polarized, crowded and car-dependent, that lowers the quality (O'mara, 2011).

2.4.2 Boston ecosystem

Boston ecosystem total value is USD 356 billion, USD 12 billion of early-stage funding startups and value growth 28%[3] (period 2020 - 2022). The ecosystem focuses on the fields of biotechnology, healthcare, and robotics with world-renowned research institutions such as Harvard and MIT. It includes Seaport, South Station, Kendall Square, and Back Bay/South End. The city government is working closely with entrepreneurs, developers, and leaders across various sectors. The area takes advantage of innovations from the broader Boston community in public transit and open-access technology. The ecosystem prioritizes research on community space and transportation improvements, aiming to leverage new technologies to attract tenants and (Rissola et al., 2019)

The innovation ecosystem is organized around industry clusters, such as biotechnology, medical devices, and information technology. These clusters facilitate collaboration between individuals and organizations with similar interests and expertise. Moreover, the region has a

[3] https://startupgenome.com/ecosystems

history of successful manufacturing and technology development, as well as proximity to venture capital firms and other resources. The ecosystem has access to a range of resources to support innovation and entrepreneurship, including coworking spaces, funding opportunities, and mentorship programs. Boston ranks third worldwide in venture capital investments with focus on rapidly growing sectors. Government plays an important role in briging the right parties together, it has a reputation for being startup- and innovation-friendly. An entrepreneurial approach emerging from the local governments, eliciting risk taking and bottom-up civic participation in tackling key issues in the city. There has been strong support from the city mayor and mayor's civic research team providing funding and facilities to entrepreneurs.

The networking works both horizontally and vertically, creating local international linkages that activate the circulation of knowledge and generate spillovers beyond the Boston metropolitan area. Moreover, higher education institutions continuously nurture the entrepreneurial environment. The key success factor of this ecosystem is that macro-innovation is composed by a variety of interconnected micro-innovation ecosystems, mutually reinforcing each other and making the whole region successful (Etzkowitz & Dzisah, 2008). Similarly to SV, the strategy of this ecosystem is to leverage the strengths of the region's research institutions, industry clusters, entrepreneurial spirit, talent pool, and supportive infrastructure (Rissola et al, 2019).

2.4.3 Cambridge ecosystem

Over the past four decades, the Cambridge sub-region has demonstrated an impressive record of innovation across a range of sectors. It has been recognized as a key contributor to the UK economy. The local ecosystem is home to two major universities, the University of Cambridge and Anglia Ruskin University. The ecosystem is home to several R&D centres of world-renowned industrial giants that are actively engaged in horizontal collaborations and regional partnerships with top-notch research groups and emerging high-tech businesses (Viitanen, 2016). Key players in the innovation ecosystem: public sector actors, the Cambridgeshire County Council and five District Councils. The national funding programs were actively promoted and engaged public actors in joint innovation platform development. The Greater

Cambridge Partnership (GCP) was established to coordinate the regional public sector activities and related initiatives for public–private–third-sector partnerships. It orchestrates cross-domain collaboration, information exchange, and joint regional programs. Ecosystem hosts eleven science and technology parks, several R&D centres of global industrial companies. The strong technology clusters have attracted both professional service providers, venture capital companies and business angels. St John's Innovation Centre is considered the leading provider of incubation support services in the sub-region. It incubated over 300 high-tech ventures and became an important linkage among industry–academia networks. It collaborates with nine European incubation partners and supports all the main regional programs. The regional strategies include an open communication between key actors resulting in a shared vision and goals. In overall, the ecosystem has a critical mass of businesses and research institutions involved in high-tech and technology commercialization, generating a dynamic innovative culture.

The challenges of the ecosystem are similar to as in Silicon Valley, the local roads are often congested, affordable housing has become a scarce resource with a booming real estate market. The resident science parks within the ecosystem are not very active in developing the local cluster structures. Given that they operate under strict financial control as for-profit organizations, they execute an almost pure real estate business model, limiting open possibilities for complementary service development. The majority of testing and measuring facilities are located within universities and national research institutes, which are equipped and set up primarily for scientific research purposes. Their use produces the highest-quality research results, but their context of use remains relatively closed, especially to SMEs and converging, industry-level technology platforms.

Summary

Analysing the case studies several similarities were identified. Government initiatives, venture capital, dense network and private-public partnerships play key roles in the regions operating in synergies of multiple stakeholders, producing innovations that is widely shared across industries. Common characteristics of the ecosystems are concentration of skilled, international talent; presence of highly ranked universities; availability of venture capital; government R&D,

funding support complemented by procurement of advanced technology and giving access to the resources, including lands; contribution of big corporations. MIT, Stanford and Cambridge universities play a significant part in the development of those ecosystems. The universities have an entrepreneurial nature with the knowledge capitalization models (Etzkowitz & Dzisah, 2008). Silicon Valley stands out by its dense, complex and dynamic social network and business culture that is characterized by a willingness to take the risks (Lee, et al, 2000), culture of failure (Saxenian,1996), trust (Castilla et al.,2000) and real-life entrepreneurial role model examples (Gold, 2018).

2.5 Autonomous Systems (AS)

To understand the ecosystem functioning, it is important to recognize the complexity of the technology we are dealing with. Autonomous system technology offers immense opportunities for society, but also brings many challenges. It belongs to nascent, deep tech technology that is often associated as disruptive incorporating additional risks to entrepreneurs.

The product is an aggregated system that can incorporate many elements including mechatronics, drives, sensors, data communication systems, computer software, multi-agent technologies, signal processing technologies, artificial intelligence and many more. The development of the hardware & software and/or intellectual properties are capital and time intensive. In addition, new validation and verification methods are required alongside simulation and real-world trials to be able to assure the failure free functioning, safety and certainty of system's capabilities. Figure 5 shows main elements of the value chain from the development to implementation phase. Entrepreneurs in AS face a difficult value chain, in which incumbents can be very powerful. To keep the novelty and competitiveness entrepreneurs should constantly stay alert and be able to react in accordance with the market change (S-curve, Christensen, 2009).

Besides the technical risks, there is a risk associated with market demand: if market demand is proven, startups have stronger defensibility from the competition. However, it is one of the biggest uncertainties of the new technologies to predict how the market will react to the introduction of a new technology. Kapoor and Klueter (2021) identify further key sources of

technology uncertainty: *ability to achieve the performance-cost threshold, the surrounding ecosystem support, and the business model sustainability to reach the revenue.* To overcome these uncertainties would require significant resources investment over long period of time until the technology can reach the mainstream. Furthermore, performing R&D in high-tech sectors can be very expensive and the result is fraught with financial risks from various sources. Spending on scientific research may fail to discover new knowledge with potential utility and may never result in a new marketable product. Thus, there is a high risk, that even after a long period of investment on design, development, and production of new technology, it can result in not profitable business. The AS also require sophisticated sales processes, protection from imitation, which makes more complex the partnerships with large incumbents.

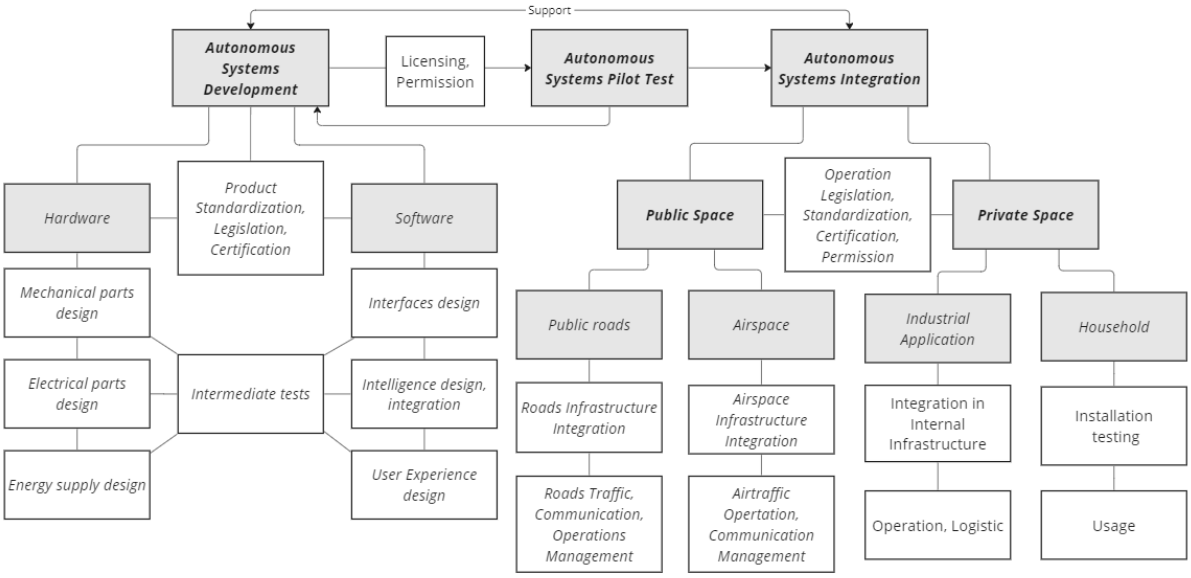


Figure 5. Autonomous systems value chain

The market dynamics of innovative new products is explored by G. Moore in his book Crossing the Chasm (1991). Author discovered a psychological gap ("chasm") between early and mainstream markets, between customers - visionaries and customers - pragmatists. This phenomenon is also known a "valley of death" (VoD) and described as inability to breakthrough or breakeven or fail in commercialization (Ford & Dillard, 2018). The concept is

closely related to technology adoption lifecycle[4] with five main segments: innovators, early adopters, early majority, late majority and laggards. About 90% of the emerging tech startups fail at this chasm[5]. Founders can easily understand innovators and the early adopters because they are usually part of that group. However, the early majority are more sceptical about the new technology because they are not familiar with it. What will help to bridge the chasm will depend on the type of technology and the market share. According to Geoffrey A. Moore, the most important is the understanding that the needs of early adopters are differ from early majority and to be able to meet those needs. The challenge is that the product can often involve changing customer behaviour or business processes. Many ventures reach the market by acquiring or partnering with small companies that have established names and customer relationships in the target sector. Existing customer relationships give initial credibility to new product launches because customers already trust the company they know (Kiefer & Clarysse, 2011). Ventures that chose operating in this environment need to raise substantial venture capital in multiple rounds of funding to be able to survive. Usually, these startups are supported by multiple stakeholders involved in de-risking at each stage, however there is often a gap between development phase and scaling up due to lack of sufficient financing (European Deep Tech Report, 2023[6]). Authors (Gbadegeshin et al., 2022) suggest that the most important strategies to cross the VoD would be *to provide sufficient funds, early commercialization, engaging relevant stakeholders, strategic collaborations, having a qualified team, applying different management strategies, new knowledge and relevant policies.* Additional challenges are related to regulations, which can also impact the market entry. Nascent technology can develop faster than the issue of the new policies. Furthermore, as AS evolve, there will be more data liability, security, safety and privacy issues that will require new policies, laws and mechanisms to address. Societal acceptance is another very important factor for autonomous systems wide adoption. Involving the public in development and deployment processes can build trust and technology consent (Sifakis & Harel, 2023).

[4] https://en.wikipedia.org/wiki/Technology_adoption_life_cycle

[5] Source: Crossing the Chasm for Emerging Technologies, 2019, Hemi Ventures, https://medium.com

[6] https://dealroom.co/uploaded/2023/01/Dealroom-European-Deep-Tech-2023report.pdf

2.6 Ecosystem strategies

A good strategy can help ensure that the ecosystem remains resilient and at the same time agile and responsive to new opportunities and threats.

In the literature on innovation ecosystem strategies some authors give an importance to an open innovation as a main source of innovation (Holgersson et al., 2018) and define and open innovation as *"the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*" (Chesbrough, 2006, p. 1). Other scholars focus more on the importance of actors' alignment within the ecosystems and related strategies (Autio & Thomas, 2014; Walrave et al., 2018; Adner, 2017). Adner (2017) points out that alignment is a heart of ecosystem strategy and that companies should be clear whether they want to take responsibility for shaping ecosystem alignment with partners or follow the lead of others. Building an ecosystem involves finding a balance between interests, and the ability to align these interests becomes a key ecosystem success factor. The authors argue (Shipilov & Gawer, 2020) that stakeholders must mutually agree on a specific configuration of activities characterized by multilateral complementarities that create synergistic value and that individual contributions cannot be valued in isolation. An adaptive ecosystem strategy for open innovation was proposed by MIT research (Furr & Shipilov, 2018), where the focus is always on the one particular problem ("battlefield"), the area that needs to be explored. An orchestrator connects multiple uncommon stakeholders, including competitors, by "bat signal" (announcing the challenge) to jointly create new tools to solve the problem. This decentralised approach is suitable if the solution is uncertain and encourages cross-fertilization. Having uncommon partners helps explore unfamiliar terrain and see at the problem differently. Authors state that the adaptive ecosystem strategy is the most suitable for the emerging industries with high uncertainty.

Strategies can vary depending on the ecosystem's maturity stage, product development phase, stakeholders' interrelationships, chosen ecosystem model, value creation or capture mechanisms. The properly defined tangible (premises, IP) and intangible (motivation, vision, trust) mechanisms can attract relevant stakeholders and maintain the business goals (Ritala et al., 2013).

Malherbe & Tellier (2022) provide insights from twelve-year study into the conditions limiting the harmonization of actors' actions. Authors identified three sources of non-alignment: an overly ambitious and vaguely articulated value proposition, value distribution risks and incoherence in the multiscale institutional context.

One frequently adopted strategy is to make use of the firm's innovative capabilities (Teece, 2007) or complementary assets (Tripsas, 1997) to build a position in the ecosystem. The convergence of multiple industries can expand the development of multilateral relationships (Teece, 2018), resulting in complex, not just technological interdependencies. Big companies bring in their influencing market position and reputation as long as they see the benefits of new products and services offered by smaller partners. The focus of startups and small companies is on building a visible innovative image, being a frontrunner in innovative technologies to become an attractive partner for knowledge institutes, government agencies and larger companies. Interactions within innovation ecosystems can be highly complex due to the diversity of actors involved, the uncertainties of new technologies and constantly changing customer needs. To deal with this complexity authors suggest a strategy to capture ecosystems on macro and micro levels (Meynhardt et al., 2016) or niche-level (Geels, 2002). Olsson & Bosch (2016) defined twelve innovation ecosystem strategies, encompassing different kinds of collaborations with different external parties. Those strategies are: to select the most promising internal innovation and bring it into the market alone or together with the external partner; to focus on collaboration with downstream, upstream actors or another internal unit to create new or improved products; to co-create the products in collaboration with science and networks, cooperate with academia to test new solutions or to take an active part in their creation; to take the most promising external innovations and build it yourself or include it in the product portfolio (cherry-picking); to orchestrate external innovation network to maximize the value created; to select external partners/suppliers for the long term relationship with involvement in joint development; to create alliances with selected external stakeholders to increase control and become part of the differentiation ecosystem or acquire companies with promising innovations and integrate these into the company.

Ecosystems with dominant central players could open up also the opportunities for direct and indirect network effects (Jacobides et al., 2018; Parker & Van Alstyne, 2005), however can

also lead to resource dependencies that limit the freedom to explore alternative pathways for innovation (Christensen & Bower, 1996; Pol & Visscher, 2010). Other authors argue that internal mechanisms may affect the outputs, e.g. too much formality slows down innovation processes, and less formalized mechanisms supported by independent bottom-up structures of symbiotic relationships are suggested to maintain ecosystem resilience (Still et al., 2014).

In the recent research (IDIA, 2020)[7] it is suggested to engage government at all levels from the very beginning to maximise the sustainability and strengthening initiatives with constant dialogue between government and the scientific community to foster mutual understanding and trust. Porter (1998) underlined that successful policies work in sectors where the basic determinants of national advantage are present and where the government reinforces them. In this regard, researchers (Sun et al., 2019) propose a hybrid approach (top-down and bottom-up) of government policy in building an innovation ecosystem.

To summarize, the innovation ecosystem strategies highlight the importance of both open innovation and the alignment of actors within the ecosystem. These strategies involve various collaborative models, the adoption of different roles by large corporations and startups, managing the complexity of interactions, understanding the role of policies, and often incorporate macro and micro-level considerations to maintain agility, resilience, and response to opportunities and threats. In overall, an innovation ecosystem strategy should be a deliberate and coherent approach through which companies can align their innovation activities at different levels and secure their position in relation to other actors and the ecosystem as a whole.

2.7 Identified gaps and challenges

To conclude this chapter, I summarize the key challenges that the research on innovation ecosystem is currently facing.

Recent literature on IE has shown conceptual inconsistencies and shortcomings regarding the definition (Adner, 2017; Klimas & Czakon, 2022; Oh et al., 2016; Ritala et al., 2013; Thomas

[7] https://r4d.org/wp-content/uploads/IDIA-Insight-Guide-Strengthening-Innovation-Ecosystems.pdf

& Autio, 2020; Tsujimoto et al., 2018).The structural approach of IE recognises the actors as constitutive elements, but there is no agreement on the types of the actors and their engagement in the ecosystem (Granstrand & Holgersson, 2020). Depending on the criteria used, ecosystems may be defined differently in terms of scope and structure. Despite fundamental research and numerous studies on the development and application of ecosystem models, there is no universal tool for describing an innovation ecosystem or identifying a set of key stakeholders and collaborative frameworks that can be adopted to build a successful innovation ecosystem. Recent literature reviews showed that many empirical studies *"are characterized in most cases by a one-on-one relationship between the focal firm and its partner. Inter-organizational relations involving multiple partners are rather rare"* (Yaghmaie & Vanhaverbeke, 2020, p. 3). Furthermore, scholars have not reached a consensus on who are the key stakeholders in the ecosystem. The Triple Helix model was further developed by many scholars (Budden & Murray, 2019; Carayannis et al., 2018), however no agreement is achieved, which approach should be widely adopted.

Benchmark of successful ecosystems showed that the success factors, as well as constrains are different for each ecosystem, as well as stakeholders and their roles. The case studies revealed the importance of the government, university, venture capital engagement, as well as the robust networks and partnerships. A case study based on Silicon Valley ecosystem over ten years (Pique et al., 2018) showed that as an innovative ecosystem evolves, the role played by the Triple Helix agents is changing. Thus, the role of university, business angel and accelerators are more important during the initial stage, while government is getting closer to both universities and industry enlarging the collaboration area. Universities and industry are strengthening their ties in the launching stage, while government adopts a secondary role. During the growing stage, public administration influence is growing, allowing companies to showcase their solutions in cities and through policy regulations. During maturity phase, industry remains the most important stakeholder, while government keeps its role as a regulator. Universities continue to supply talent and new ideas, while getting closer to industry, offering a wide variety of programs and initiatives aimed at helping students pursue an entrepreneurial path. VCs are mainly concentrating their investments in later stages, with larger

investments in fewer companies. Universities and startups become a source of knowledge for financial and corporate investors to keep track of disruptive technology.
Authors argue that not fully understanding the complexity of innovation and the specific functions of VC firms in complex innovation network leads to failure of many innovation ecosystems (Ferrary & Granovetter, 2009). The technological challenges add an uncertainty of the ecosystem development and involve additional risks. Furthermore, the societal acceptance is a very important factor for autonomous systems wide adoption, especially for the growth and maturity stages of the venture company (Yuen et al., 2020). New companies face great challenges in developing effective strategies for optimal ecosystem functioning while they are still in their nascent stages. Therefore, it is important to develop a holistic, in-depth understanding of the dynamic and complex nature of an ecosystem and its key features.

To address the challenges of conceptual inconsistency and variety of the innovation ecosystem models definitions, I am going to undertake a theoretical and empirical, qualitative analysis of the selected for the case study innovation ecosystem (Canton of Zürich), and by applying the fundamental theoretical models, categorize key ecosystem stakeholders with their roles, relationships, and key characteristics.

3 Research design

The research design will be divided into two parts. It starts with a theoretical analysis of the innovation ecosystem of the Canton of Zurich, identifying main characteristics and success factors, challenges, as well as key stakeholders and their roles. The second part will be dedicated to the qualitative research, based on the interviews analysis with the selected groups of stakeholders.
The study is focused on the regional ecosystem development of the Canton of Zürich built around an autonomous systems technology. For the ecosystem initial assessment two fundamental models have been selected: Technopolis Wheel (Smilor et al, 1989) and Triple Helix model (Etzkowitz, 1993).

3.1 Analysis of IE of Canton of Zürich (Switzerland)

Population of Switzerland is almost 9 million, in Canton of Zürich 1.6 million (City of Zurich 497,000 inhabitants). The national GDP is CHF 800 billion, where more than 20% belongs to Canton of Zürich. Canton has more than 116,000 companies with active network of big international corporations, innovative medium-sized firms and highly specialised small businesses. Swiss expenditure on R&D accounted in 2022 CHF 22.9 billion (3.2% of GDP). About 70% of R&D carried out by private companies and 30% by higher education institutions [8]. The positive dynamics of investment in R&D, as well as corelation with other countries, can be seen in the Figure 6. Switzerland leads several international rankings in research and innovation. According to the European Patent Application Index[9] (number of European patent applications per million inhabitants) Switzerland takes the first place with 968.6 applications in 2021, where in USA only 139.8.

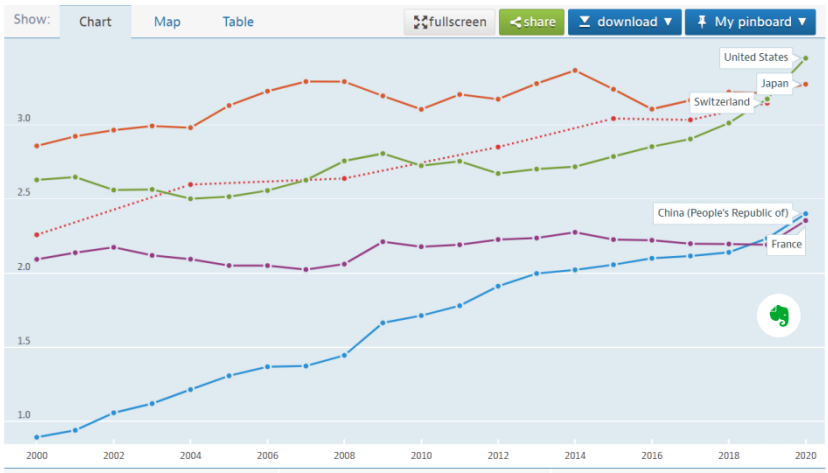


Figure 6. Gross domestic spending on R&D (Total, % of GDP, 2000-2020)[10]

[8] Federal Department of Economic Affairs Education and Research EAER, BFI-2021-2024_Factsheet_Kennzahlen_FR.pdf

[9] https://www.epo.org/about-us/annual-reports-statistics/statistics/2021/statistics/patent-applications.html#tab2

[10] https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

Switzerland ranks first in the Global Talent Competitiveness Index in 2022[11]. Basic scientific education mainly takes place at the federal institutes of technology and at universities. Canton of Zürich has a very strong academic and research institutions, including top-ranked universities and research centres with highly skilled workforce and expertise in science, engineering, and technology. Swiss Federal Technical Institute (ETH) accounts 25'000 students, N°1 University in EU, N°7 in the world in Engineering and Technology field (QS ranking)[12]; University of Zürich (UZH) with 28'000 students is a top 10 EU University. At ETH Zurich, 350 students received their PhD in engineering (ca. 150 students received MSc and PhD degrees with specialisation in robotics and control)[13].

Canton of Zürich ecosystem has a strong relationship and cooperation between universities and industry, this collaboration is an important success factor for Swiss research and innovation, characterized by a high and efficient knowledge and technology transfer. For instance, Wyss Zurich in collaboration with ETH Zurich and the University of Zurich is a student project accelerator created in 2015 by Swiss entrepreneur Dr. Hansjörg Wyss. PSI (Paul Scherrer Institute) is the largest research institute for natural and engineering sciences in Switzerland, conducting innovation research and hosting annually 2500 local and foreign students, financed by federal government. EMPA (Swiss Federal Laboratories for Materials Science and Technology) and CSEM (Centre for Electronics and Microtechnology) are public-private, non-profit Swiss technology research institutions specializing in research, development, and technology application. Around ETH there have been formed a strong entrepreneurship ecosystem[14]. It consists of university spin-offs, accelerators, incubation centres, foundations, knowledge transfer offices, private-public research labs and other associations aimed to support students in their entrepreneurial journey. Since 1973 ETH founded 540 companies and 26 in 2022. Companies received around CHF 1.2 billion of capital investment, which is 30% from

[11] https://www.insead.edu/sites/insead/files/assets/dept/fr/gtci/GTCI-2022-report.pdf

[12] https://www.topuniversities.com/subject-rankings/2023

[13] https://ethz.ch/staffnet/en/finance-and-controlling/facts-and-figures/students.html

[14] https://ethz.ch/en/industry/entrepreneurship/discover-entrepreneurship-ecosystem.html

the total investment in startups ecosystem in Switzerland (CHF 3.9 billion[15]). Three ETH spin-offs in 2022 attained unicorn status. ETH University created the most spinout value among top Universities in Europe in 2022[16]. In 2022 the venture capital investment in canton Zurich accounted CHF 2,1 billion (see Figure 7). Zurich startups attracted a larger share of total funds invested in Switzerland, with 53.7%. The total Zürich ecosystem value is CHF 30 billion[17]. Around 300 startups and 50 000 new companies have been founded in 2022 in Switzerland (FSO, 2022, see Appendix Figure A1). Most Swiss startups are financed by family and friends, Business Angels and Federal Institutions. Some banks (mainly cantonal banks) provide financing for companies in the startup early phase.

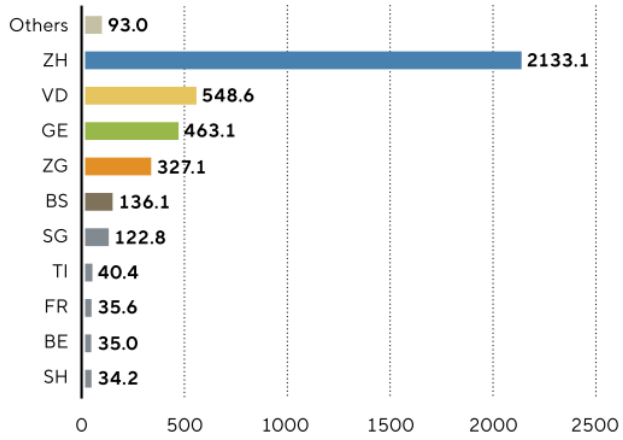


Figure 7. Distribution of Venture Capital per Canton[10]

Public funding of research and innovation is essentially the responsibility of the federal government. It is mainly coordinated by the Federal Department of Economic Affairs, Education and Research (EAER) and its State Secretariat for Education, Research and Innovation (SERI). The Federal Act on the Promotion of Research and Innovation (RIPA)[18]

[15] https://www.startupticker.ch/en/swiss-venture-capital-report

[16] https://www.s-ge.com/en/article/news/20231-ranking-european-deep-tech-report-2023

[17] https://startupgenome.com/ecosystems/zurich

18 https://www.fedlex.admin.ch/eli/cc/2013/786/de

generally regulates the tasks and structure of federal support for research and innovation at both national and international level. RIPA also sets out the tasks, procedures, and responsibilities of funding institutions. Swiss National Science Foundation (SNSF) is the most important source of public funding for Swiss research institutions, which provides about CHF 1 billion annually (with approved 2,732 new grants). The Swiss Innovation Agency Innosuisse promotes the highly qualified individuals, entrepreneurship, the transfer of knowledge and technology between companies and universities. As an important innovation hub, Canton Zürich attracts highly qualified foreign researchers (e.g. 35% of ETH are foreign students), and a home of several international research centres, such as IBM Research Laboratory, Google Research Centre, Facebook Meta, Amazon and the Disney Research Lab. Canton Zürich is also a location for top big tech companies as Swiss group ABB, headquartered in Zurich the world's top performer and number one in the Robotics Business Review 2017 ranking.

3.1.1 Key challenges

Switzerland lost points on the rating scale compared to previous years, due to a lower rating of government support for R&D in business, employment in knowledge-intensive activities, the export of knowledge-intensive services and environment-related technologies[19]. Access to venture capital is still the weak link in the Swiss high-tech (see Figure 8). The World Digital Competitiveness Ranking 2022 (WDCR) positions Switzerland in fifth place overall, but only twelve in terms of startup financing. Venture capital financing accounts for only 17% of the amount spent on R & D, compared to 114% in Singapore (See Appendix, Figure A2).

[19] European Commission, European Innovation Score Bord 2021, page 74, https://ec.europa.eu/docsroom/documents/46013.

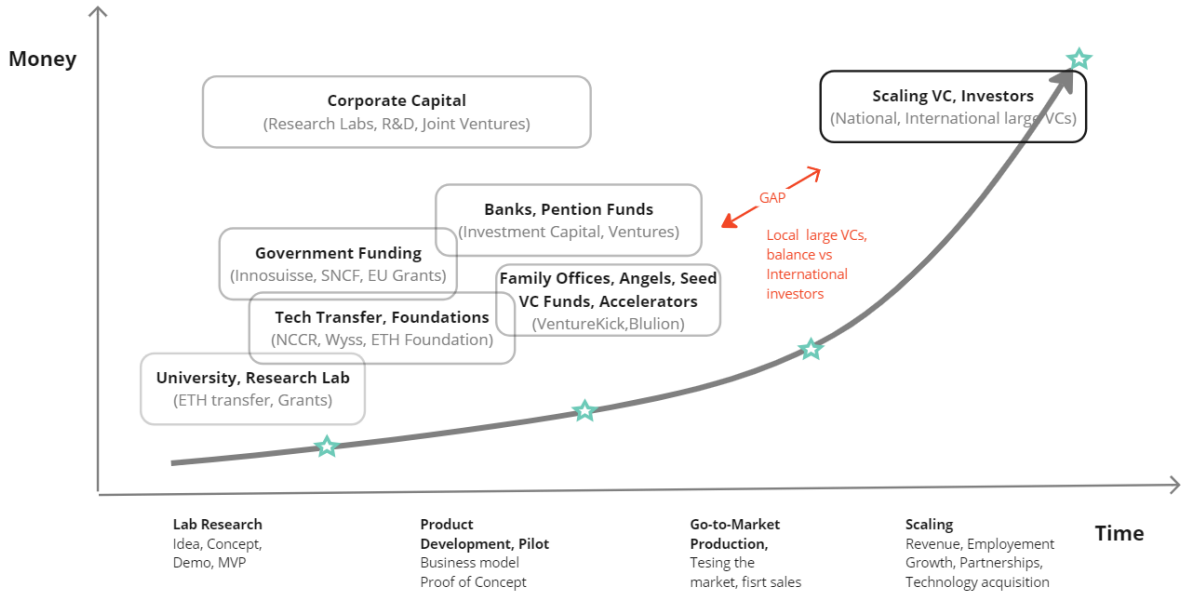


Figure 8. Map of funding size versus venture development stage in Switzerland (adapted)[20]

From the CHF 22.9 billion per year for public and private research, only CHF 3.9 billion goes to financing of the commercialization of innovations by venture capital. Pre-seed to Series A rounds are still the main drivers behind VC investment in Swiss startups. Figure 8 shows the gap in investment capital with respect to the venture development stage.

There is an imbalance between the initial startups funding that comes from Swiss academy, industrial R & D, startup support institutions, business angels and small VC funds, and the late financing rounds, scale-ups. 86% of VC investment in Swiss startups comes from abroad, mostly from Europe and the US (See Figure 9).

[20] European Deep Tech Report, 2023, https://dealroom.co/uploaded/2023/01/Dealroom-European-Deep-Tech-2023report.pdf

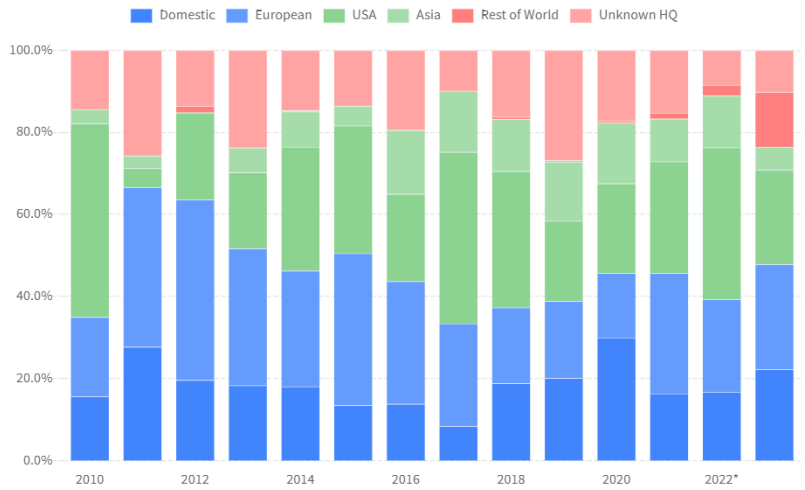


Figure 9. Distribution of venture capital, Source: Dealroom.co

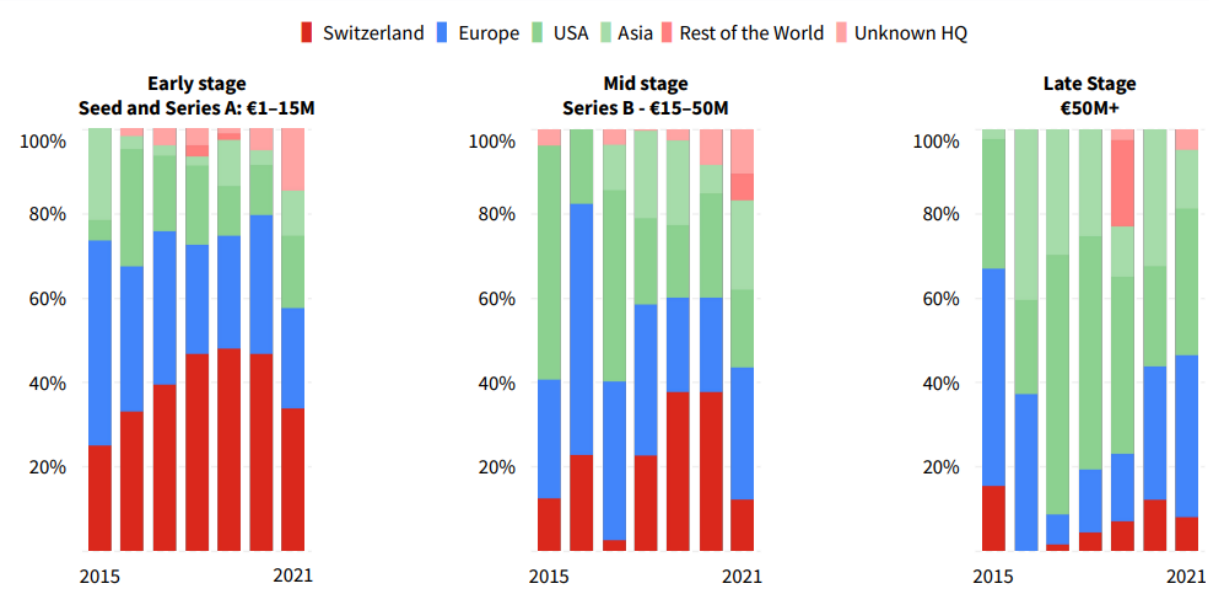


Figure 10. Investment distribution per country per stage[21]

[21] Source: The Swiss startup ecosystem in numbers, 2021, dealroom.co

Domestic investors are most active at early stages. European investors and US investors are closing the gap on late stages in recent years. More than 70% of Swiss investors focus on the seed and early-stage startup phases. Graphs on Figure 10 illustrate three stages and the countries involvement. Switzerland allocates more fund to existing infrastructure and less to new innovation to test and deploy. R&D activities at SME companies decreased steadily since the year 2000. In high-tech industries the share of R&D active companies fallen by 3%[22]. This means that companies are spending less on innovation and more into operation.

According to Global Innovation Index (GII)[23], ranks as Business and Market sophistication are only on the positions 7 and 8 respectively. Switzerland is number one in policies making and creating business environment; however the entrepreneurship policies and culture are on the 7th position (see Annex, Fig. A6). Among the 20 countries with the most sustainable startups, Switzerland ranks eighth in the number of Series A financing rounds. It ranks 11th for Series B rounds and 14th for Series C rounds. It performs even worse for acquisitions, at only 17th place. Furthermore, according to Global Entrepreneurship Monitor (GEM)[24,] Swiss entrepreneurs are less confident about their entrepreneurial abilities (perception of capabilities rate at 36.5%), paired with a fear of failure (32.3%). The percentage of who believe they have the required skills and knowledge to start a business is below the European and US benchmark. This means that the conditions for entrepreneurship in Switzerland still need the improvements. From 2021 Switzerland was excluded from "Horizon Europe" (2021-2027). That might have serious consequences for Swiss research and Switzerland as an attractive place for researchers.

3.1.2 Key success factors

Switzerland has the assets of a world-class innovation region including R & D infrastructure, highly qualified personnel, a high-tech industry cluster and reputation for quality and stability.

[22] https://kof.ethz.ch

23 https://www.wipo.int/global_innovation_index/en/

[24] https://www.heg-fr.ch/media/3sqoxxad/gem-switzerland_2022-2023_en.pdf

Switzerland consistently ranks highly on global innovation indices[25], driven by strong R&D, high levels of patenting, and a focus on high-value, knowledge-based industries. Switzerland has the most high-performing Institutions (2nd worldwide), is a global leader in innovation outputs in knowledge, technology and creative outputs[26]. According to the European Innovation Scoreboard[27] Switzerland is an Innovation Leader with performance at 142.4% of the EU average. According to this study, the country' strengths are in attractive research systems, qualified human resources and intellectual property. Switzerland has the highest ratio of R&D spending per capita worldwide representing 3.2% of Switzerland's GDP, ranking fourth behind Israel, South Korea and the United States[28] . Deep-tech Swiss investment grew to 85% (CHF 1.5 billion) in 2022 vs 2021. Swiss VC ecosystem has created a value of about CHF 70 billion over the last 25 years (Megret, 2021). Investment in robotic sector in 2023 constituted 373 million, in Canton of Zürich 173 million (See Annex, Figure A3 – A5).

Switzerland has high standards of leaving, political and economic stability remaining among the top countries in quality-of-life indices, that helps to attract highly skilled professionals and companies from around the world. It is home of world class education institutions and research centres, generating highly educated workforces. Zürich is one of the world's leading financial centres with attractive business environment, cultural diversity and strong entrepreneurial activity. Survival rate of ETH spin-offs is remaining 93% in comparisons to USA - 68%. Switzerland is an international leader in the field of robotics and drones and is therefore often referred to as the "Silicon Valley of robotics"[29]. In 2017, Switzerland took third place worldwide in terms of robotics patents in relation to the number of inhabitants and has doubled

25 https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-en-main-report-global-innovation-index-2022-15th-edition.pdf

[26] World Intellectual Property Organization, Global Innovation Index, 2021, https://www.globalinnovationindex.org/gii-2022-report

[27] https://ec.europa.eu/assets/rtd/eis/2022/ec_rtd_eis-country-profile-ch.pdf

[28] Federal Statistical Office (FSO), Research and Development (R+D) Expenditure, 2021, https://www.bfs.admin.ch/bfs/de/home/statistiken/ bildungwissenschaft/technologie/indikatorsystem/zugang-indikatoren/w-t-input/f-eaufwendungen.assetdetail.16984295.html

[29] https://www.greaterzuricharea.com/en/robotics

its share of global robotics patents since 2000. According to Startup Genome[30], Zürich is a hot spot and rapidly developing ecosystem. The global ranking was rising 10 places, increasing up to 60% from 2019. Moreover, Switzerland established a robust drone technology foundation and in nearly in all drone niche segments Swiss drone companies show a leading presence.

3.1.3 Ecosystem Innovation metrics

In the previous Chapters, several Innovation Indices were outlined, which rankings are broadly used to determine the success factors and innovativeness of the country with respect to other countries in the world. For instance, the Global Innovation Index (GII)[25] is the most broadly used indicator to show the innovativeness of the country. The index is compiled based on detailed metrics about innovation inputs and outputs, including elements such as infrastructure, business sophistication, research, development, and patent activity. The limitations of this measure is the data availability, subjectivity in survey responses, bias toward quantitative measures, aggregation and weighting issues. Its focus primarily on national level, potentially missing regional nuances.

European Innovation Scoreboard (EIS) and the Regional Innovation Scoreboard (RIS) considered to be the central authoritative sources for the European Commission and national policy making bodies[31]. EIS consists of 27 indicators covering eight dimensions capturing the different aspects of innovation, including human resources, research systems, finance, and support, among others. RIS provides a comparative assessment of innovation performance across regions of European countries. The RIS can help identify regional strengths and weaknesses and inform regional policymaking. The EIS measures quantitative aspects of innovation systems but does not directly measure the quality or impact of the innovations produced (see Appendix, Figures A7, A8). The RIS may not fully capture the diversity and

[30] Startup Genome: https://startupgenome.com/article/global-startup-ecosystem-ranking-2023-top-30-plus-runners-up

[31] https://ec.europa.eu/research-and-innovation/en/statistics/performance-indicators/european-innovation-scoreboard/eis

unique characteristics of each region. Not all indicators used in the RIS may be equally relevant to all regions, and important region-specific factors could be overlooked.

There are several Indices that attempt to measure the Entrepreneurial Ecosystem. The Global Entrepreneurship Ecosystem Index (GEI) [32] was introduced to cover this area and gives rating of an individual country's entrepreneurship ecosystem. The index is used to measure entrepreneurial attitude and ability and aspirations to perform activities in the region. Authors look at the Entrepreneurial Ecosystems as a complex socioeconomic structure with entrepreneurial trial and error dynamic. According to this index Switzerland takes the second (74.3 score) place after USA (80,1). The score board on Figure 11 shows Switzerland vs the USA benchmark.

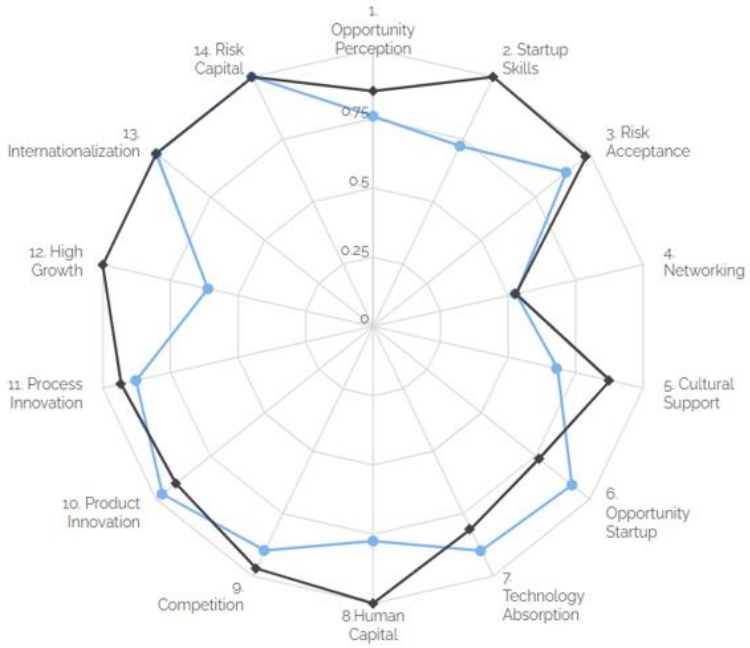


Figure 11. Global Entrepreneurship Development Data: Switzerland ("blue") vs USA ("black")[33]

[32] http://thegedi.org/global-entrepreneurship-and-development-index/

[33] http://thegedi.org/tool/

The biggest divergence between those countries according to this index is in *high-growth* (the percentage of high-growth businesses that intend to employ at least 10 people and plan to grow more than 50 percent in five years), *cultural support* (how a country's inhabitants view entrepreneurs in terms of status and career choice), and *startup skills*. Surprisingly, the *networking metric* (ability to connect to others in a country and the whole world) is relatively low for both countries, where this factor is one of the main strengths of Silicon Valley.

Dealroom.co[34] similarly suggests several indicators to evaluate entrepreneurial ecosystem based on the number of *startups/unicorns, number of funding rounds, total VC funds, amount of exists, an ecosystem total capitalisation value and new acquired funds*.

The main drawback of those measures is that some of the metrics are subjective and can vary depending on interpretation. The wide range of factors could dilute the impact of key entrepreneurial elements and not taking into account significant local or regional differences within the country. Therefore, as a sub-question of this study, I will evaluate the key indicators essential to measure and track the innovation ecosystem performance in the Canton of Zurich.

3.1.4 Stakeholder analysis Canton of Zürich

The stakeholder analysis is based on the adapted Triple Helix and the Technopolis Wheel models. The basis of the TH approach is the relationships between *Government, Industry and Academia*, whereas the Technopolis wheel adds also support groups (communities, financial and emerging companies). Taking into consideration these two models and the reviewed theoretical and case study background, I identify six major groups within the ecosystem: *Government*, *Investor*, *Startup*, *Industry*, *Academia and Users.* Table 1 shows the identified key stakeholders and their roles within the innovation ecosystem of the Canton of Zürich. The evaluation was done in compliance with the ecosystem boundaries and the research question. Source of the data is author's personal professional experience and network, literature background and internet research.

[34] https://app.dealroom.co/

Table 1. Stakeholders analysis, Canton of Zürich

Stakeholder Groups	**Stakeholder**	**Roles**	**Names**
Government (G)	Federal regulatory agencies	Laws, regulations, policy introduction	*FDJP, FDHA, DDPS, FDF, EAER, DETEC, FOT, FOCA, JARUS, FOEN, SPOE, IPI, FEDRO, Armasuisse*
	Cantonal and city regulatory agencies	Urban, road, air traffic planning and control, policy making, licencing, permission, laws realisation	*Cantonal Economic Affairs, Education-, Justice-, Finance-, Security-, Health-, Building Department; VBZ, TAZ, Canton/City Police*
	International agencies	International regulations issue, management	*ESA, EASA, NAA, JARUS, FP*
Investors (Inv)	General Investors	Scale-up, growth, Exits general investment	*LakeStar*
	State funding agencies, KTT Banks (public, commercial, Investment)	Grants, funding, coaching, network Investment, IPO, Exits, M&A, financial transactions	*SNSF, Innosuisse, SECA, SERI, SEF, BRIDGE, Innobooster ZKB-, UBS- Ventures, Pensionfunds*
	VCs	Investment, IPO, Exits, M&A, financial transactions Consulting	*VerveVentures, SICTIC, Wingman Ventures, BackBone Ventures, Swisscom ventures, SwissCanto Invest, RedAlpine*
	Accelerators, Incubators	Financial support, networking, knowledge-resource share, mentoring, coaching	*VentureKick, VentureLab, ESA BIC, Bluelion, IFJ, UP.ch, Talentkick, ImpactHUB, Swissnex, Innobooster, swiTT, Digital-switzerland, , SwissEF, EIC (EU)*
	CVC	Company investment	*ABB Technology Ventures, DiePost, Swisscom Venture*
	Insurance	Insurance activity	*SwissRe, Zürich Insurance, Accenture*
Startups (S)	Manufacturers	Product development, components supplying, services	*See Appendix, Table A1*

	Incubators	Consulting, Coaching, Network, Funding, infrastructure	*Innovation Park Dübendorf, Technopark Zürich, Winterthur*
Industry (Ind)	Private-Public Partnerships (PPP), Associations	Technology integration, collaboration, network	*SUSI, SAAM, Greater Zürich Area, MEM, SWESA, DIAS, Mobility Lab, TCS, TA Swiss*
	Manufacturer, Service provider, Operators	Manufacturing, Operation, Product application	*ABB, SBB, Kyburz, Siemens, Hexagon, IBM, RUAG, Kistler, Google, Microsoft, Amazon*
	Incubators, R&D	Incubate start-ups, co-development innovations, expertise exchange, network	*Disney research, IBM research, Facebook research lab, ABB research lab, Google research, AMAG innovation lab*
Academia (A)	Research Institutions, Associations	Education, training, network, grants, guidance, support	*SSC, EMPA, PSI, (RIPA, HEdA acts), NRP, SATW, Switzerland Innovation*
	University, research laboratories	Education, training, guidance	*ETH, UZH, ZHAW, AI Centre, CSEM, ASL, RSL, LEC, VRL, Robotic and perception group, Dynamic Systems and Control, ZHAW centre of AI*
	KTT, Accelerators	Knowledge, experience transfer, exchange, network	*NCCR, Wyss Zürich, Technopark Zürich, LINA, DIZH, ETH Entrepreneurial Club, Spin-off, ETH Entrepreneurship,*
	Foundations, Associations	Financial and other support	*ETH Foundation, TA-Swiss, Wissenschaftbewegen, W.A. de Vigier Stiftung*
	International	Connecting researches globally	*e.g. ESA, EUREKA, EFI, HORIZON*
Users	Public/Private road, airspace, technology users	Interaction with the technologies	*Citizens of Canton Zürich,*
	Public/Private organisations, technology users	Application for their businesses	*Airports, Schools, Hospitals, Constructure Companies, State Organisations. etc*

Note: the list may be incomplete. Abbreviations definitions are provided in Appendix

3.2 Qualitative research. Interviews

Qualitative research method is an approach to exploring and understanding the meaning that individuals or groups attribute to an investigating problem. The research process involves the development of questions and procedures, the data is analysed inductively, from particulars to general themes followed by researcher interpretation (Creswell, 2014). The goal of the research design is to discover new insights about a phenomenon to formulate a more precise problem or hypothesis. In most exploratory studies, qualitative data is the main element (Given, 2008). The empirical part of the thesis is built on the interviews with various stakeholder groups actively involved in the ecosystem of AS located or closely related to the Canton of Zürich.

The number of selected interviews is chosen with accordance to the study, where authors suggest that grounded theory qualitative studies should include between 20 and 30 interviews, arguing that number of interviews is correlated with cultural factors, implying the subjective nature of sample size (Marshall et al., 2013). The prepared set of generalized interview questions are shown in the Appendix.

To design the interview questions, the theory described by Yin (2003) was applied, where author suggests using the mixed type of questions for the case study interview: How? and What? The interview questions are exploratory and semi-structured, designed to investigate the participants' experiences in the research subject. The semi-structured approach enables to address specific topics and give the interviewees some freedom to form the answers in their own way. With this approach, the interviewer can also ask new questions that may arise in response to the interviewee's answers. This approach is suitable for studies containing both multiple research and multiple case studies (Bell & Bryman, 2007). Considering the semi-structural manner of the interviews and the variety of the expertise of interviewees, the questions were slightly altered and adapted to each stakeholder group emphasising the area of expertise.

The research question consists of three main categories, each part will be investigated separately. The interview questions are organised in the manner to answer each part of the question (See also Appendix for questions examples).

"What are the critical constrains (1) and the success factors (2) of innovation ecosystems when applied to autonomous systems, and what strategies (3) can be employed to foster innovation in the Canton of Zürich?".

In complementing the main research question, an additional problem will be investigated to answer the question raised in Chapter 3.1.3 about appropriate metrics for an innovation ecosystem measure.

The goals of the interviews:

1) *To identify ecosystem challenges and weak linkages between stakeholders*
2) *To identify driving forces and enabling factors*
3) *To collect the ideas, insights for strategies that can be employed to facilitate the ecosystem successful development*
4) *Identify critical indicators important for assessing ecosystem growth*

The interviews took place in a hybrid setup, on-line via video conferencing or in person, face-to-face. The average length was about 45 minutes. The interview transcripts were analyzed and processed manually and with the aid of MAXQDA software[35] that features AI algorithms to facilitate the data processing.

3.2.1 Method selection

For the research design, I am using the induction (developing theory) method from the empirical research design cycle (Groote, 1969). This approach of data analysis is commonly associated with grounded theory methodology (Charmaz, 2001) and thematic analysis (Braun & Clarke, 2006). The qualitative research method, applied in this study, is based on Gioia Methodology (GM) (Corley & Gioia, 2011) developing first order concepts from the words, then second order themes on analytical processes and aggregating dimensions to form the theories. The advantage of this approach is that it can uncover complex processes, relationships, or patterns that might be overlooked in other methods. At the same time, it

[35] MAXQDA: www.maxqda.com

requires a lot of data and cognitive efforts, to be able to deeply engage with the data to generate common patterns and insights. The study starts from the literature, statistical data analysis (observation), followed by data collection (interviews) and analysis that concludes by the theory generation, which will be compared with the statements founded in the literature (see Figure 12). The fundamental idea behind grounded theory is that theories emerge from the data itself, rather than being imposed on the data prior to collection and analysis. In other words, the grounded theory is used to collect and analyse data without existing theory or hypothesis.

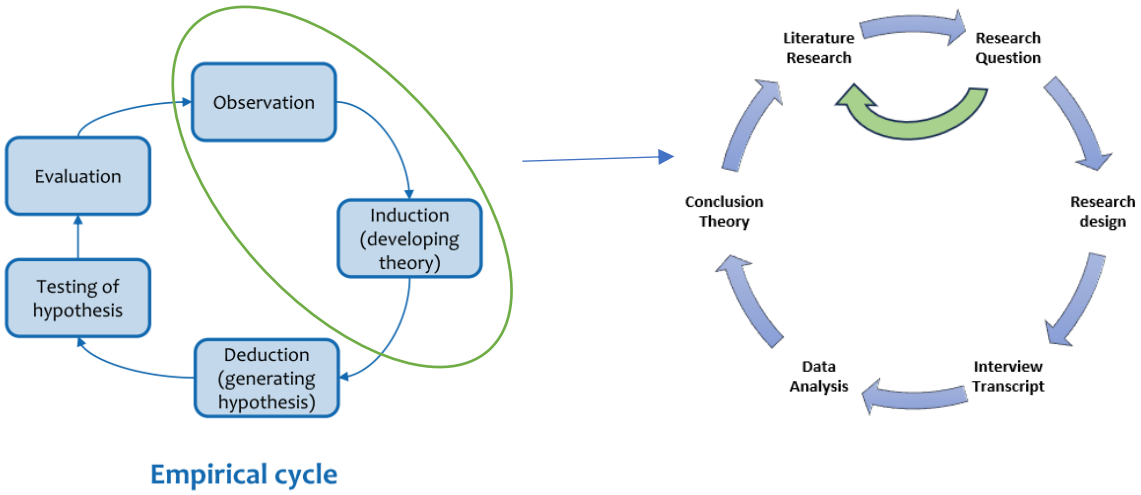


Figure 12. Research method. Induction

3.2.2 Data selection

Data sources are transcripts of 25 interviews collected over a period of approximately one month and participation in one workshop. Boundary conditions were defined around the theory on ecosystem, geography and the selected model for innovation ecosystem analysis.

For the stakeholders evaluation process companies' websites, databases[36] and own network was used to assess the relevance of the participants for the selecting criteria.

[36] CrunchBase: https://www.crunchbase.com/

Selecting criteria for interviewees:

- *Affiliation to one of the stakeholder groups*
- *Having knowledge of autonomous systems*
- *Stakeholders' environment (network, workplace, projects) is connected to the ecosystem of Canton of Zürich*

Optional:

- *Involvement in initiatives, associations other than core activities*
- *Knowledge of other international ecosystems in a similar field*

The number of participants was equally distributed within the stakeholders' groups (see Table 1). A sample of 83 potential participants was selected from which 32 stakeholders were contacted and conducted 25 interviews (see Table 2). The purpose of the broad selection of the stakeholders is to collect the as diverse as possible data to be able to create the generalized theory and avoid the response biases. Most of the selected participants had diverse backgrounds and career paths. For instance, some stakeholders had an experience of working at startup and big corporations or had an experience in investing and at the same time being active in academia.

Table 2. Overview of collected data

	N	Description
Stakeholders selected	83	Stakeholders from various groups: Academia, Government, Investors, Entrepreneurs, Industry
Contacted	32	Contacted (e-mail, LinkedIn)
Interviews conducted	25	Semi-structured, on-line and in person
Observation	1	Workshop[37]

[37] Company Network "Autonomous Ground Vehicles Network" which took place on Tuesday 4th of July at the Innovation Park Zürich in Dübendorf., https://www.switzerland-innovation.com/zurich

The majority of participants were male. Considering the specific of the sector and the statistical data[38] on gender distribution in the technological domain, I consider this fact as self-explanatory. Table 3 shows an overview of Stakeholder's groups participated in the interview. All the real names are not revealed due to privacy reasons.

Table 3. Stakeholder Groups participated in the interview

Stakeholder Group	Founding Year	Company Size	Core Technology Industry	Role in the company
Startup 1	2016	101-250	Ground robot	CTO
Startup 2	2014	101-250	Airspace robot	Founder
Startup 3	2014	10-50	Airspace robot	Founder
Startup 4	2021	1-10	AV	COO
Startup 5	2013	11-50	AV	Head of Dep.
Industry 1	1999	2,000	Aerospace, Engineering	Head of Dep.
Industry 2	1997	24,000	Autonomous solutions	Business Dev.
Industry 3	1902	34,000	Transport, Automation	Head of Dep.
Industry 4	1847	300,000	Automation	Business Dev.
Academia	ETH, UZH, KTT			
Investor	Bank, Private Investor, Corporate Investor, Venture Capital Investor			
Government	City, Cantonal, Federal level legislation, and urban planning officers			

The observation part included participation in a workshop that is part of the quarterly meetings of a network of companies consisting of 22-24 organisations (SMEs and startups) involved in the development of autonomous ground vehicles activities. The aim of the network is to transfer knowledge, both bilaterally and as a group, by facilitating communication between participants. The topic of the workshop was: "Show and Tell": demonstrating experiences,

[38] BFS: https://www.bfs.admin.ch/bfs/de/home/statistiken/kataloge-datenbanken.assetdetail.23747839.html

lessons learned and sharing challenges for open discussion and collaborative problem-solving activities. This session consisted of three parts: presentation of innovation park, presentations and demos of the participants' work, guided tour around innovation park with real case demonstrations and discussions. The workshop was scheduled for four hours followed by open end discussions and products demonstrations. During the workshop, I asked the randomly selected participants research-related questions. The results were incorporated into the analysed data and the section Discussion (see Chapter 5).

3.2.3 Data analysis

The data analysis is based on the content analysis (Kuckartz, 2014), Gioia Methodology (GM) (Corley & Gioia, 2011) and grounded theory procedures described in Corbin and Strauss study (1990, 2015). In the selected methodology, data collection and analysis are often occurred concurrently, and identified patterns are used to build the theories. The data analysis is realised through multiple, repeated steps. The general view of interactive model of data analysis is outlined in Figure 13 (Miles & Huberman,1994), where authors define three concurrent flows: data reduction (coding, selecting, focusing, simplifying), data display (organising information) and conclusion (drawing conclusion, verification).

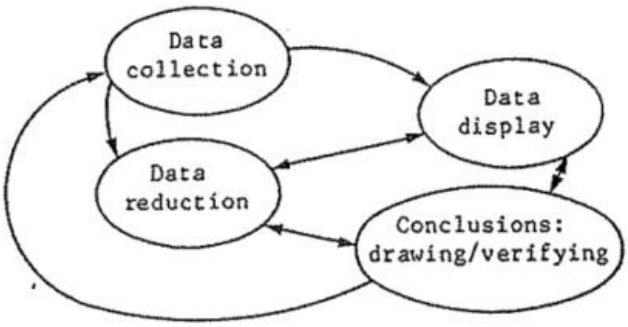


Figure 13. Components of data analysis: Interactive Model (Miles & Huberman, 1994)

Qualitative data analysis is a continuous, iterative enterprise. The iteration process of the grounded theory helps to identify the gaps in the first or second order concepts. When the data supporting the concepts is incomplete, there is a possibility to go back and collect more

qualitative data. This approach enables to collect detailed and in-depth data, collecting and aggregating multiple views on the subject. Thus, findings do not remain on surface level, but allow to form deeper insights and develop unbiased theories (Charmaz, 2014) Furthermore, in spite of the fact that this method is time consuming, it is simple to use and encourage creativity (Glaser & Strauss, 1998, Morse & Niehaus, 2009).

The first coding step (assigning a category) plays the most prominent role (Creswell, 2016). Analysis begins with codes or code labels that condense into themes, which then form dimensions at a higher level. The initial coding sequences include open codes – axial codes – selective codes (Strauss & Corbin, 1990), concepts – categories – core category (Corbin & Strauss, 2015), first order - second order concepts (Corley & Gioia, 2011).

Figure 14 displays the data analysis flow implemented in this study. Steps involve generating categories of raw information (open coding form interview data), identifying relationships between the open codes and group them into larger categories (axial coding, selective coding, concepts).

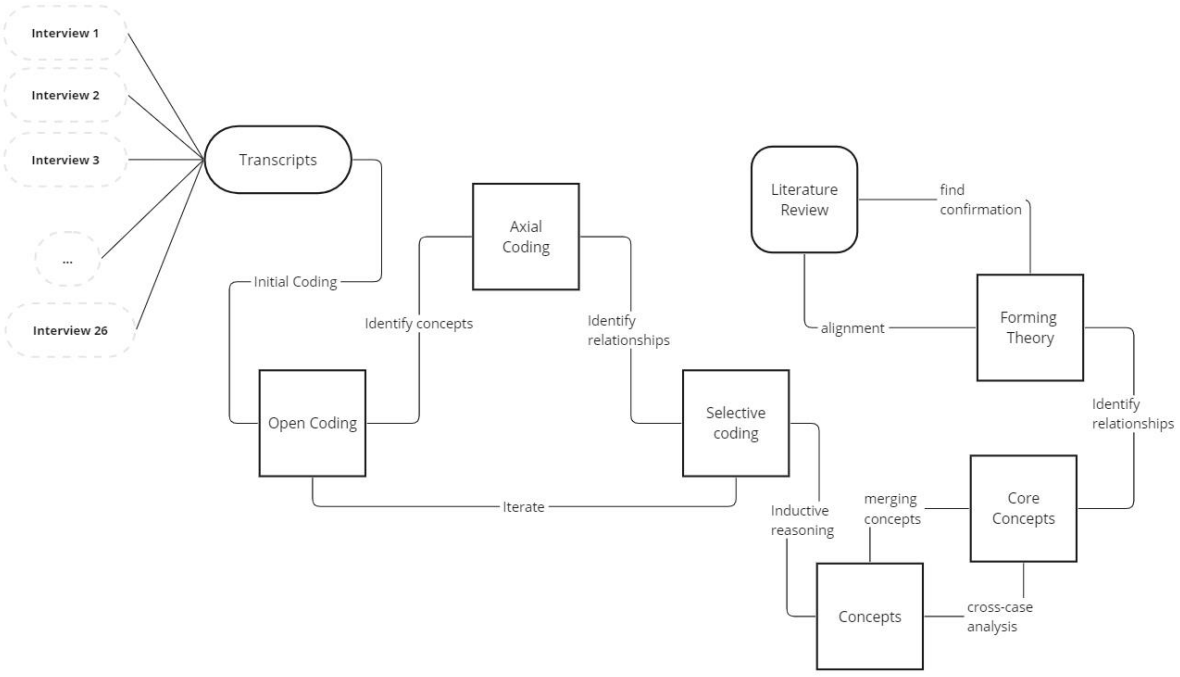


Figure 14. Data analysis flowchart

Once each case individually analysed, it is compared with the concepts that emerged across all the cases leading to insights (Miles and Huberman, 1994). In the final step, concepts are merged through cross-case analysis to form the core concepts (themes). The results then should be aligned with the literature review to bridge the theory gaps and justify the findings.
During the first step of open-coding, 1049 codes were manually generated and assigned to the subcategories in accordance with the research question. All the codes were first grouped into first order concepts then consequently into second-order concepts forming the themes.

4 Results

In this Chapter the key findings will be divided into four main parts, each corresponding to one sub-question of the main research question including the investigation of the ecosystem metrics.

4.1 Ecosystem constraints

In compliance with the method described in the Chapter 3.2.1, I examined the similarities and differences between the categories and merge them into themes keeping in mind the research sub-question: "*…identify ecosystem challenges and weak linkages between stakeholders…"*.
During this phase I looked at how the first order concepts are contributing to the broader, core concepts to form the themes. Combining the findings and meta-analysis of the cases I finalized the broader categories and identified the co-relations between the categories.
Figure 15 shows this process displaying some selected concepts and their core categories: *Entrepreneurial barrier, Technological barrier and Human Factor barrier.*

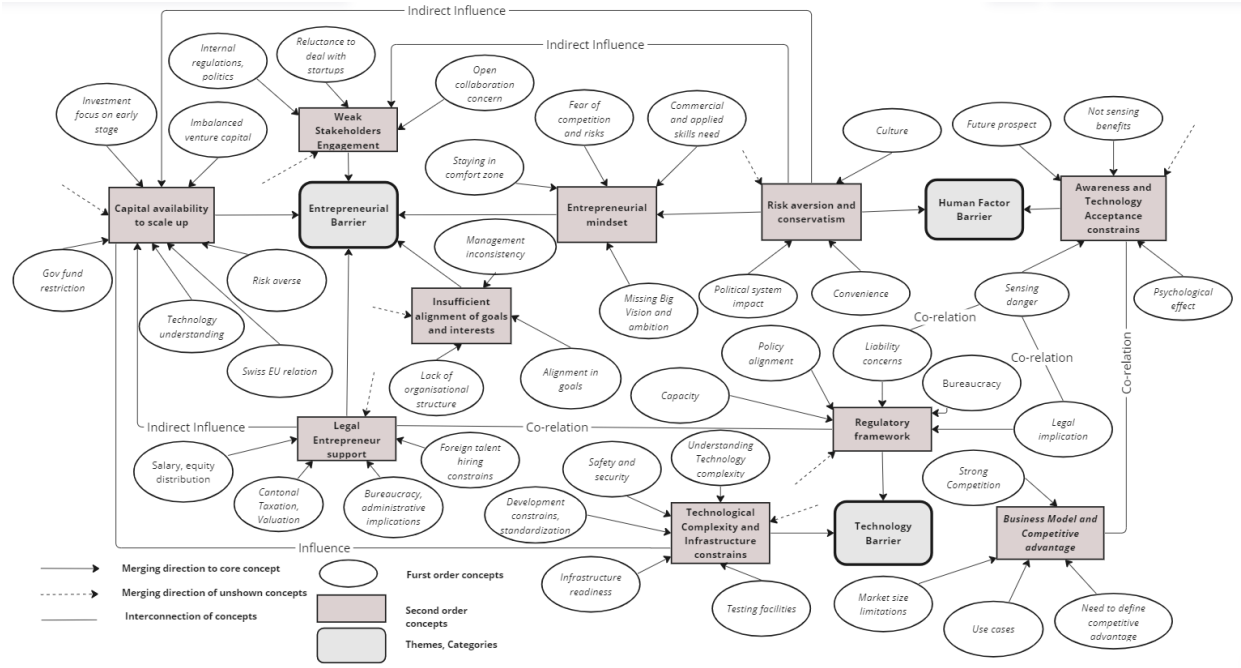


Figure 15. Cross-case analysis of the core categories identification

Following this principle, Table 4 below displays the selected fist- and second-order concepts with the examples of the interview quotes and identified key ecosystem needs.

Table 4. Core categories and related selected stakeholders quats

Category: Entrepreneurial Barrier

Aggregated dimensions

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*	*Identified Needs*
Insufficient alignment of goals and interests	*Lack of organisational structure* *"the problem is more due to absence of clear structure and written works to support your ideas", "there still a gap between just organize being organized", (G)* *"they come with unclear ideas and vision", (Ind)*	*Clear organisational structure, alignment of goals and vision.*

	Management inconsistency to pursue the goals	
	"management gave a little bit up, they let go of the drive and the project stopped", (A) *"there was no clear guidance from the beginning, everybody had their own views on it", "we don't have enough leadership support for innovation", (Ind)*	*Commitment and more guidance from management.*
	Missing alignment in goals	
	"within bigger Cantons there is less alignment in goals with the cities", (G) *"everybody has their own politics, it is culture", (Ind)*	*Goal alignment*
Weak Stakeholders Engagement	*Lack of Industry engagement*	
	"we do everything ourselves", "we don't bring people to work together on site" (Ind), *"companies think that innovation comes from internal sources", (G)* *"they didn't want to collaborate because we were too small", (S)* *"there is an academic level of research, but there is very few support to startups", "corporate involvement is missing", (Inv)*	*Industry engagement in collaborative, co-development processes with entrepreneurs*
	Open collaboration concern	*Legal framework for open innovation*
	"you have to bring value and be careful not giving too much of your IP", "there is no framework how to collaborate and not sharing too much, (Ind)	
	Internal regulations blocking collaborations	*Supportive regulated environment for collaboration*
	"internal regulations make it difficult for the police department to actually support our startups", (S)	
Entrepreneur mindset	*Fear of competition and risks taking*	
	"tend to ignoring competition, not realizing what's going on", "no culture of failure", "people only fund the company if they are certain that it succeeds", (Inv)	*Open culture, competitiveness*
	Lack of entrepreneurial motivation	
	"they want to live comfortably in the society", (Inv), *"young people from university feel safe and secure",* *"you have these cool events and it's fancy to be there,*	*More local successful*

	but that's it", (A) *typically, people are much more for sustainably and just go step by step", (S)* *Missing big vision and ambition* *"startups think only of the market within Switzerland, and they are not scaling their business to international market", "think big is more for Silicon Valley startups", "there are too little exits, because the role model of successful entrepreneur is missing, (Inv)* *"they often look into short term innovation projects", (Ind)* *Missing commercial and applied skills* *"they are good at research, but they never sold a thing in their life", "they are too academic", (Inv)* *"there are too little applying engineering", (A)* *"presentation and marketing skills are missing, but also a language kit, because in the international market everything has to be in English", (Inv)*	*entrepreneurs* *More serial entrepreneurs to mentor, support startups* *Commercial, business education for tech skilled talent* *More applied engineering studies* *Marketing, presentation skills*
Capital availability to scale up	*Imbalanced Venture Capital* *"VC funds are outside Switzerland, …if we are just setting up a small fund for Y fund we have to go to another", "there is an imbalance between local VCs and from abroad, especially for growth stage", (Inv)* *"such technology requires billions of investment", (A)* *Resistance of local Investors* *"very difficult to access capital (both public and private)", " want to have a low rate, low risk investments, (Inv)* *"risk-averse private and governmental investment behaviour in growth stage investments", "lack of risk favourable investors", " level of ambition is quite conservative still", (S)* *"they invest in the good product, not in the idea", (A)* *"not able to match the financial power of what companies need to succeed in bringing complex deep tech products", (Ind)*	*Regulatory framework to facilitate the domestic investments in startups* *More investment capital (billions) to be competitive on the global market* *More risk taking, ambitious investors*

	Dominant investment in research and early stage *"if you need to raise under a million, and you have a great idea, you can do that quickly", (S)* *"there is a very strong collaboration between Industry and Academia", "companies are coming to us with their own projects and willing to invest", (A)* *Common technology understanding* *"this technology requires billions to invest, there is no understanding of this", (A)* *"technology need time and long term investment, not all investors understand this", (S)* *Lack of international funding programs* *"Horizon fund was a great kickstart", "European Commission was supportive us with the initial kick start fund", "EU funds provided friendly investment opportunity, credits. nice loans", (S)* *Government fund restriction* *"we collaborate with startups, we can finance proof of concept, but not the product, it is too expensive", (G)* *"Government lacks resources to adequately support emerging industries", (Inv)*	*Increase awareness of Investors about technology complexity and development stages* *Skilled, specialised investors for each investing round* *Projects, Government support grants to compensate EU funds to prevent the threat of the talent leave* *Risk-taking investors*
Legal Entrepreneur support	*Non beneficial legal conditions* *"investors come up with the ridiculous assessment of value", "taxation on virtual wealth", "investors did recapitalisation, from normal valuation to 1 million and wiped everyone out", "administrative and tax burden in the first years can be crushing", (S)* *"we want to make it attractive for companies to come and use this infrastructure, but at the moment the taxes in Canton are too high, companies go to cantons with lower taxation", (A)* *"people who have no operative role within the company receive more equity…that heavily impacts the valuations and incentivization of employees because there's just less stocks available to actually distribute to people that are trying to build the company on a journey", (Ind)*	*Clear tax strategy to support entrepreneurs and investors* *Transparent, regulated valuation and equity distribution* *Traceability of funding rounds, legal protection of* entrepreneurs

	Foreign talent hiring constrains	
	"you can easily get work permit for EU talent, but for other countries need to pay 70% minimum", "you have to learn German to deal with authorities and the paper work", "foreign entrepreneur outside EU cannot setup the company", (A)	*Attractive taxation for companies who collaborate with startups*
	Salary and equity distribution	
	"for young people, it's easy to decide in favour to big companies, you get nearly twice the salary", (A)	*Compensate salary imbalance*

Category: Technology Barrier

Aggregated dimensions

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*	*Identified Needs*
Business Model uncertainty	*Lack of valid use cases*	*More use cases to increase visibility and awareness*
	"companies will support you, but they need to see a real use case, added value to their product, that would solve the problem of their customers", (Ind)	
	Finding competitive advantage	*Effective Business model*
	"we are good at making watches, pharma and in banking, why not to do what we are good at for a long time", (Ind)	*Cost effective strategy*
	Strong competition on the market	
	"a small Swiss company that is not so long in the market, will lose to a foreign company, which is longer on the market", "big companies spend a lot of money on development…we don't have big car manufactures to be able to compete", "driving assisting technology are very successful on the market", (Ind) *"big tech companies draw talents away", (S)*	*Find competitive advantage, use competences, focus on strengths, country USPs*

	Market size limitations		
	”possible to scale if you go abroad”, (S) *“ecosystem is growing in an isolated way”, (Ind)* *“narrow niche oriented, small market”, “need to find a niche market, what we are good at”, (A)*		*Find a niche to be unique, go abroad to scale*
Regulatory alignment	*Legal implication*		
	“IP rights a showstopper in this innovation ecosystem”, (Ind) *“we stopped the group because one day I had a knock on my door saying, what kind of license you have”, (A)* *“we could test in the lab, no problem, but to go outside is more difficult”, “main barrier for current robotic or autonomous systems are international accepted regulations”, “complex and lengthy certification processes”, (S)*		*Define a legal framework for collaborations and product co-development*
	Liability concerns		
	“liability of the driver versus liability of the city individuals, as well as an insurance company that glues it together in terms of passing one liability to the other was established over a long term for car traffic” *“it is still the responsibility of the person”, “the weight of the drone must be limited, so it can be carried over populated area”, (A)* *“Uncertainty about liability and insurance frameworks for accidents”, (Inv)*		*Internationally accepted legal framework also solving liability issues of technology implementation*
	Policy alignment constrains		
	“we always wait on Europe to decide something before applying”, “we had to pivot while waiting for the low being introduced”, “sometimes the EU laws are not completely applicable to Switzerland because of the differences”, “it was like a Wild West before here”, “it is very difficult to get certification from EASA, local authorities are much more open and responsive”, (S) *“the adopted EU regulation means a lot of extra resource investment in terms of money, manpower and is very tedious for startups”, (G)*		*Regulatory “sandbox”, intermediate solution for pilot testing without red tape* *Permissive policies*

	Bureaucracy, administrative implications	*Less bureaucracy*
	"if you want to fly a drone over a town, you have to hand in 100 Page reports for delegated permission and several 1000 of francs", (A) *"if you want to use the drones to do something with the buildings you need real settings, (Ind)* *"export regulations are not startup-friendly", "approval for complex missions lead to long waiting time, high costs", "EU rules have higher administrative work, costs", (S)*	*More skilled personnel to join authority*
	Limited capacity of authorities	
	"Lack of experience and capacity of authority personnel might initially slow down the application processes", (G) *"Perceived lack of training and capacity of authority personnel for complex mission approval", (S)*	*Increase capacity of manpower*
Technology and infrastructure complexity	*Product complex development*	
	"the standardisation of all the components would be very crucial", (S) *"we couldn't find the suitable components", (A)* *"at some point you need to be on site", (Ind)*	*International standardization of components*
	Safety and security	
	"public safety issue means there has to be some level of governmental security control, not to put physical boundaries", (G), *"government agency should oversight, regulate and manage a whole infrastructure", (A)*	*Involvement of local government to regulate and manage the infrastructure*
	Lack of understanding technology	
	"companies do not understand the product complexity, that is why they fail", "many do not understand what autonomy really mean", (Inv) *"some founders do not understand from the beginning that it is not just a software technology, but much more complex, that needs a production", (A)*	*Understanding the technology complexity, educate*
	Infrastructure non readiness	
	"you have to come up with an entire planning and operation like roadways of airways, corridors, where	*Build and adapt the*

	drones can move", "not the technology itself is the problem, but the infrastructure to realize it", (A) *Lack of testing facilities* *"we have to test outside the Switzerland, because there is no enough facility",* "*if you want to test in real settings it is very difficult, need to ask an owner, police and there is no support from Zurich side",(Ind)* *"technology requires many trials and test to be accepted", "they will not give the okay to those systems if tests were made outside Switzerland", (A)* *"the barrier to entry for anyone who has an innovative idea is sometimes very high, it's really difficult to just try something out", (S)*	*infrastructure to facilitate in technology integration* *Easier access to domestic testing facilities, open public spaces supported by government*

Category: Human Factor Barrier

Aggregated dimensions

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*	*Identified Needs*
Risk aversion and conservatism	*Lack of motivation* ***"****quite a good public transport, very good social system, stable jobs, why to take risks", (S)* *"slow living habits", "not a fighting culture, very regulated environment slowing down innovation because people get also comfortable", (Ind)* *Cultural aspect* *"it's a classical Swiss problem, people work only with the people that they know", (Inv)* *"everyone takes a too narrow look and not a long term perspective", "risk-averse private and governmental behaviour in growth stage investments", (S)* *"we have to have low risk innovations that you don't bet on the next 10 years future", (G)* *"we profiting from other countries mistakes", (Ind)* *"we are almost never first mover", (A)*	*Increase awareness that there is a need for innovation* *Show the added value, benefits to people* *Educate, inform, involve the public, user groups from early stage*

	Political system impact *"political system is very slow", "you need to convince unions that there won't be impact on jobs market", (A)* *"if it comes to implementing those ideas, it takes too long and not enough manpower, resources", (E)* *"in the government there is not enough courage and willingness to push the innovation forward", (G)*	
Awareness and Technology Acceptance constrains	*Not sensing benefits* *"public opinion was very strong against autonomous systems", "the project was cancelled because the community was against it", (A)* *"the largest, negative stakeholder who don't want this kind of innovation is the general public", (Ind)* *"there is a lack of vision, need, and seeing benefits from the technology: why would I need this it's good the way it is right now", (G)* *"people are still not very much aware of the added value and positive impact", (S)*	*Increase awareness, testing and interaction with public*
	Sensing technological danger *"people were afraid to be injured", "drones are perceived as being able to violate one's privacy", (S)* *"authorities are afraid of coming privacy, data protection issues, more accidents on the road", (G)* *"there is fear that autonomous cars bring more traffic on the roads and that this needs more energy", (Ind)*	*Provide security and safety measures*
	Lack of future prospect *"politicians and also citizens think it's a topic of the future it's still far-far away", "if the public does not accept drone operations, there is no business", (S)* *"there is no real examples on the streets that can be seen by majority", (Ind)* *"as long as the public doesn't have an interest, there won't be customers or general acceptance", (G)*	*Participation in drive tests, interaction with technology*
	Psychological effect *"There is more psychological issue than technological for driving cars", "the society don't want to give away control and liability to a machine", "passengers feel more safe when there other human being there", (A)*	*More showcases*

The analysis showed that the key challenges of the ecosystem include inefficiency of goals alignment and conflicts of interests; stakeholders' weak engagement; lack of capital; absence of robust, profitable business model; insufficient regulatory framework; technological complexity and risk averse culture.

Figure 16 shows the AI aided concepts code map grouped in clusters. To define the clusters, codes the distance matrix has been applied. The size of circles is correlated with the frequency of codes assigned for each concept. Connecting lines between the concepts indicate the frequency of overlapping codes. This representation reveals that stakeholder's engagement is strongly co-related with goals alignment; capital availability depends on entrepreneur mindset and regulatory barriers have the closest distances to awareness and technology complexity.

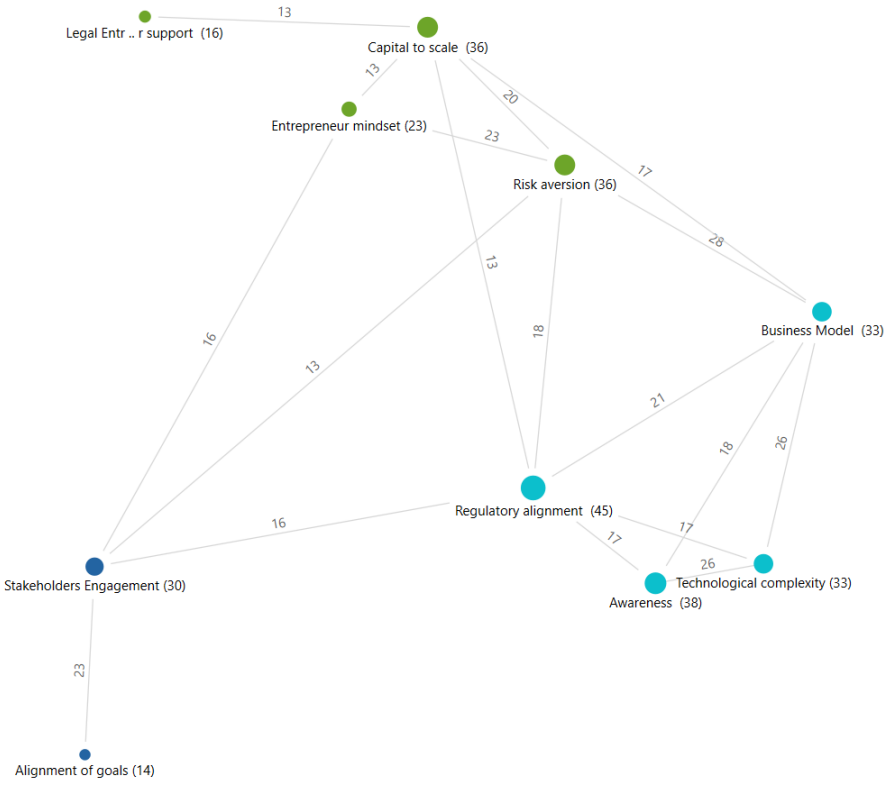
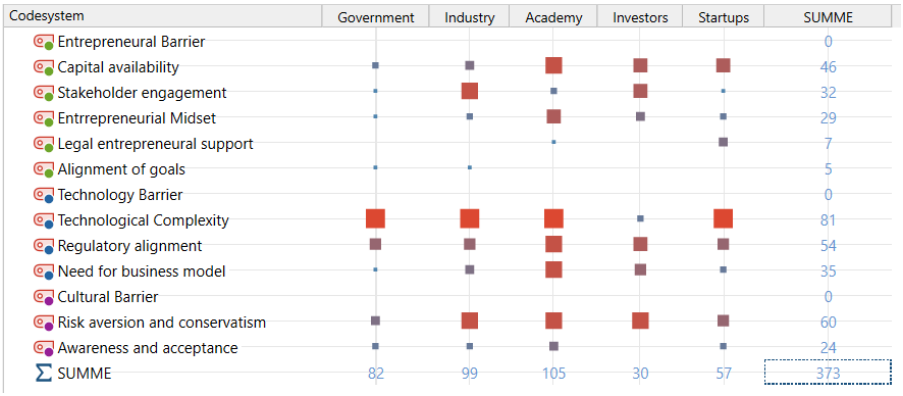


Figure 16. Cluster definition using code map modelling[39]

[39] MAXQDA software

Figure 17 displays the categories in the code corelation matrix form. Most participants agreed that technology complexity, regulatory environment, availability of capital, and risk aversion are the biggest contributors to weakening the ecosystem. Stakeholder groups Academia (105 codes), Industry (99) and Government (82) provided the majority of the inputs.



Codesystem	Government	Industry	Academy	Investors	Startups	SUMME
Entrepreneural Barrier						0
Capital availability						46
Stakeholder engagement						32
Entrrepreneurial Midset						29
Legal entrepreneural support						7
Alignment of goals						5
Technology Barrier						0
Technological Complexity						81
Regulatory alignment						54
Need for business model						35
Cultural Barrier						0
Risk aversion and conservatism						60
Awareness and acceptance						24
SUMME	82	99	105	30	57	373

Figure 17. Corelation matrix of categories related to ecosystem barriers

These results also correlate with the CB study Insights[40], where authors investigated top reasons why startups fail. The main reasons were runout of cash or failed to raise new capital (38%), no market need (35%), flawed business model (19%) and legal challenges (18%).

4.2 Ecosystem success factors

To evaluate the key success factors, I asked the interviewees to provide with the main characteristics of the innovation ecosystem and analysed the positive statements. The procedure to form the concepts for this question is identical as for the barriers identification. The main categories are divided into: *Driving forces, Enablers and Adopters*. By "Driving Forces", I refer to the factors that make the ecosystem innovative, those are the unique sales points; "Enablers" are the factors that facilitate the innovation growth and by "Adopters" I imply the users for whom this technology is developed, including their attitude towards innovation. Table 5 shows the results of the analysis with the selected stakeholders quotes.

[40] CB Insights" The Top 20 Reasons Startups Fail" Aug 3, 2021

Table 5. Key Success Factors of Innovation Ecosystem

Category: *Driving Forces*

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*
Strong pool of highly qualified talent and diversity	*Education system* *"In Zürich we have top universities and great networking programs", "very strong educational system and the facilities", "highest number of people, educated people coming out of the top education in this field", "talent attracting all the big international companies to come here" "Switzerland is the tech powerhouse with ETHZ and EPFL," The university's cutting-edge research in various fields, including robotics, artificial intelligence, and autonomous systems, provides a strong foundation for innovation", (S, Ind, A, Inv)* *Diversity* *"there's a certain talent distribution dynamic in Switzerland", "the diversity here is even more than in Silicon Valley", (S)* *Talent availability* *"Zürich is very attractive for work and living, many talent come and stay here", "companies come to open their R&D labs hear because of the talent", "excellent access to local talents in Swiss universities," open to foreign workers and international business", "high-quality education and research attracts top talent and fosters a culture of innovation", (S, A, Inv)*
Strong Innovative technology expertise and infrastructure	*Expertise in robotics and autonomous systems* *"we excel in autonomous drone, here are 150 drone companies", autonomous systems is much richer in Zurich in Switzerland than in Silicon Valley", "we have a lot of expertise here in autonomous navigation of indoor robots", Switzerland has lots of advantages in terms of safety, but also IT infrastructure", "very nice high tech ecosystems, which can be used even more efficient way if this companies cooperate more closely",(A, S, Ind)*

	Cumulative knowledge *"here has been already, a big ecosystem in AS since the 80s in Switzerland", "we are leaders in high performance measurement equipment and manufacturing", (A, S)* *Fundamental innovative culture* *"we don't get something for granted, like endless resources or oil …we are forced to keep our let's say lifestyle. There is extremely strong cultural fundament that we have to be more innovative than the others, "fundamental research in robotics is in a healthier state", (Ind, S)* *Infrastructure* *"availability of facilities was very important factor for us", "at university we had a lab, where we could test", (S)* *Unique competence as competitive advantage* *"we have competence to put the entire system together, which combine sensing mechanics, system design, and intelligence… it's not only a piece of software", "our strength is in theories, industrialization, manufacturing, making stuff and, we should push for autonomy there. And it's easier to do because it's a controlled environment. So why not focus on our strengths?", (S, Ind, Inv)* *Strong startups ecosystem* *"a very big startup ecosystem, that have a university and also government support", "the startup events and programs were super helpful at the beginning" "our startups have more high quality than maybe in other Countries", "the survival rate of our startups is much higher", "a vibrant start-up ecosystem driven by motivated students, faculty, and various platforms and clubs" (S, A, Ind, Inv)*
Country attractiveness and global image of quality and stability	*Attractive conditions to live and work* *"we have a very good social system", "I can go and swim in the river after the work", "everything is very close", "high wages", "healthy attitude, like some sort of balance, not just work life balance, but also the environment, less wasteful", (S, A)* *High quality and stability* *"political, economic extremely stable conditions, no corruption", "very high quality of products and services", "brand image that can be used as a USP of any startup founded in Switzerland", "maybe we are a little bit slower, but design quality", "economic, financial conditions*

	are pretty good and they attract quite a lot of positive quality of life", (Ind, S, A) *Risk averse, but realistic and forward thinking mindset* *"companies are thinking in the long term and invest in academia", "in one sense conservative, but I do prefer that they are more realistic when they are doing this evaluation", "Swiss are more connected to reality", "truly strong and forward thinking, that probably automatically leads to being risk averse", (A, Ind, Inv)* *Well positioning and proximity advantage* *"very centrally located", "proximity to clients, very convenient", "small country, very good connected", "small and diverse. It is easy to talk with politicians", "we have everything that is needed for early stage and piloting and when it has traction it can be brought to China and US", "you find more or less everything in very close narrow: university, tech company" (S, Ind, Inv)* *Diverse and international* *"Immigrants are more willing to take more risks and lots of Swiss people to work hard for the startups and the ideas and to achieve something. Switzerland is profiting a lot from immigration", "speaking many languages, different cultures", "we have international mindset, so it's, it's very easy to integrate people from abroad", (Ind, S, A)*

Category: *Enablers*

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*
Strong collaborations of Academia with Startups, and Industry	*Academy and Industry collaboration* *"there is a strong link between academia and industry", "strongly driven by this collaboration between industry and academia. "A lot of private investment in research and development and innovation", "quite a lot of interest from big companies in collaboration, because they really see the added value of this open innovation approach, basically, where they get competencies and knowledge and ideas from startups, from academia as well"," Close collaboration between ETH Zurich and local industries enables knowledge transfer, technology commercialization", (Inv, G, S)*

	Academy and startup collaborations *"ETH and UZH are super supportive, also Wyss", "good support from Government and Universities", (S)* *Government startup collaboration* *"Innosuisse helps to transfer more technology into the industry", "the people are very interested, also now we have political support from Zürich. Often they provide the company meetings between academics and companies. They try to promote the startups from here, also around the world", "Increased appreciation that startups are important for the economy", (S, A)*
Strong private investor activity for starting capital	*Availability of Angel Investors* *"we have great Angel Investors here", "if you need to raise under a million, and you have a great idea, I think you can do that pretty quickly", "there is a lot of private investment in research and development and innovation", (S, A)* *Openness and proximity to private investors* *"if people invest their own money, you can really go and talk with them, and there is much more communication than with VCs", (S)*
Public sector proactive support	*Public capital availability* *"Pension funds are allowed to invest into venture capital as part of their alternative investment allocation", "there is a new governmental fund of few 100 millions", "Innosuisse grants will expand our visibility within Switzerland","favorable government policies, grants, and incentives", "easy to raise initial funding", (Inv, S)* *Proactiveness and proximity* *"the proactiveness of the Canton", "Innovation park, Lina projects are initiated by Canton", "country is quite proactive in innovation, trying to really make the matches between companies", "contact to the canton instead of the country when you do something because it's easier and closer from the reality", (A, S)*
Regulated environment, favourable policies	*Progressive regulation system* *"in Switzerland it is easier to get a permit to do testing than in other countries", "they have a good connection with Police Department","Swiss standards are progressive, Switzerland has relatively big international impact", "we were able to influence the EU*

regulatory process so that we can say that now all other EU member states are using this methodology", "if you have an approval in Switzerland, you are able to fly everywhere in Europe, this is a huge advantage for many startups and SMEs in Switzerland", "Switzerland has been a good "sandbox" to test products before exporting", "liberal regulatory framework enabling innovation and commercialization", (G, Ind, A, S)

Strict regulations advantage

"In Switzerland we are quite strict on those laws, which helps us a lot because if you do it in China, it's much more difficult to then come in Europe. If you did it here, it's much easier because the laws are quite strict already," (Inv)

Category: Adopters (Public, End-Users)

Second - order Concepts	*First-order concepts, Examples of Quotes* *Abbr.: S - Startup, Ind -Industry, Inv - Investors, G-Government, A-Academia*
Openness to new technology, safety culture	*"in general, people are open when they see okay, it is good for us, it is good for the society", "they were quite excited during the demonstrations", "the public is very receptive and positive when drones replace heavy equipment or helicopters", (G, S)*

The hierarchical Code-Subcodes Model (see Figure 18) illustrates the hierarchical structure of the identified core concepts with the contributing code frequencies.

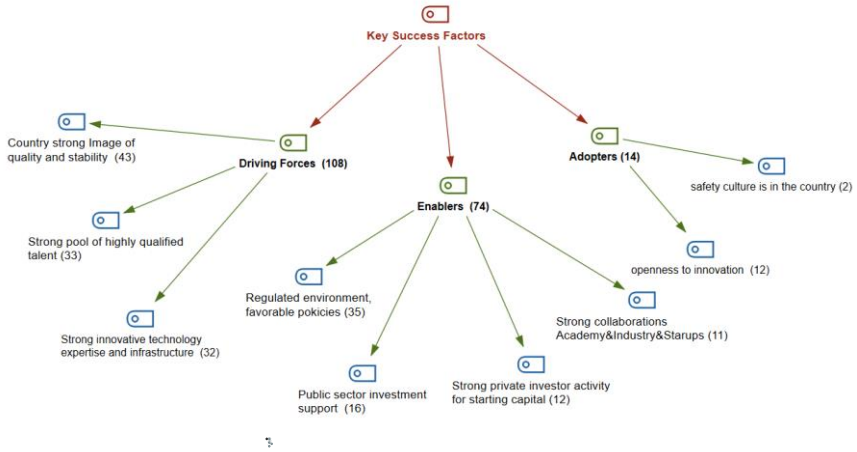


Figure 18. Hierarchical code-subcodes model of the key success factors

To summarise, the major driving forces of the ecosystem are the strong image of the Swiss quality and stability, rich pool of highly qualified talent with competence in sophisticated technology and infrastructure. The ecosystem is supported by strong links between academia and industry, public and private seed funds, and regulations that ensure compliance with international standards and policies. The *adopters* category shows the general positive attitude to the innovative technology, however not sufficient in terms of the number of coded elements.

4.3 Strategies definition

The strategies are formulated in accordance with the identified key ecosystem constrains (barriers) and their relative importance, impact on the ecosystem (see Figure 18). Interviewees were also asked to share their recommendation on what could be done to improve the ecosystem. The result is shown in the Table 6 that summarises *seven core strategies* with corresponding strategic steps ("calls to action") and the selected stakeholders' quotes justifying the reasoning of the chosen strategies. Table 7 provide summary of the steps and the key references.

Table 6. Core strategies and the strategic steps

Core Strategy	Strategic Steps	Contributing Quotes
Increase Innovation Capital	*Attract domestic and foreign investors*	*"to keep investing and build entrepreneur pool, bring more capital to startups", "attract more venture capital firms (incl. from US) to the region by showcasing the ecosystem's strengths, potential for growth, and successful case studies", "VCs or whatever institutions which can help in scaling should invest 20 plus million, up to10 million is typically feasible", "transform Swiss investors in Californian ones", (S)* *"find investor, who is interested in business, and not only about the money", (A)* *"Switzerland needs to take the lead in startups financing using local investors","* promote and support crowdfunding platforms tailored to the ecosystem, allowing entrepreneurs to raise funds

		directly from the public", "introduce incentives such as grants, funding opportunities, and awards specifically targeted at collaborative projects to encourage participation, active engagement", (Inv)
	Network, educate, incentivize collaborations	*"encourage the formation of angel investor networks that pool resources, expertise, and capital to support a larger number of start-ups", "facilitate regular networking events where entrepreneurs and investors can meet, discuss ideas, and build relationships, increasing the likelihood of funding connections", "develop platforms or databases that match entrepreneurs with suitable investors based on industry preferences, stage of growth, and funding requirements", "involve Investors at early stages", "challenge the projects in an early stage, from a scientific perspective, but also from a business from a commercial perspective", (Inv)* *"investors need to understand the technology, startup the business", (A)*
	Create favourable legal environment	*"make sure that there are investors' and companies' friendly laws for startups", "increase government-backed funding initiatives, grants, and tax incentives for start-ups and early-stage companies to attract more investment into the ecosystem",* *"administration must create the environment for startups to develop", (A)* *"regulate equity distribution and valuation processes to be more fair for entrepreneurs", (Ind)* *"loan guarantees from government for strategic high-tech startups", (S)*
	Increase visibility	*"to attract investors, need to do a better marketing advertising", (A)* *"global country image, Swiss startups image", (S)*
Regulatory framework	*Promote collaborations between regulators, developers and public*	*"more transparent management", "regulators should work together with the industry to define testing and validation methods to enable drone industry growth", "stronger involvements in working groups needed (e.g. EASA or standardization bodies)",(S)* *"bring companies interests to the international bodies, and express their needs in order to make sure*

	that the standard regulations also meet their needs", "recognize the responsibility and the power of such organizations", (G) *"create physical or virtual spaces where researchers, entrepreneurs, and policymakers from different fields can interact, share ideas, and collaborate on innovative projects", "engage in close collaboration with industry players, research institutions, and academic experts to develop regulations based on a thorough understanding of the technology and its potential impacts.", "informed public can provide valuable input during the regulatory development process, helping authorities strike a balance between innovation, safety, and societal needs",(Inv)*
Harmonize regulation processes	*"product requirements should be regulated on EU level", "increase efforts in implementing EU 2019/947 and 2019/945 to harmonize international business", "make LUC applicable worldwide", "establishment of a LUC-equivalent certification in order to be competitive in Europe", "regulation and airspace access needs to be proportionate across sectors (small vs. large drones)", (S)* *"enable manned and unmanned aviation in a non-segregated airspace", (Ind)* *"work with regulatory authorities to simplify and expedite the funding process, reducing administrative hurdles for both entrepreneurs and investors", "engage with international regulatory bodies and collaborate with other regions to develop harmonized standards and regulations for autonomous systems", (Inv)*
Create favorable regulatory environment	*"streamline processes to obtain permissions", "reduce the complexity of the U-Space flight approval process", "regulation should make it easier, not harder, to fully test and bring products to market", "availability and easy permission of BVLOS operation and airspace integration", " outdoor flight zones with reduced restrictions for developers", (S)* *"government should have the framework agreements, which should dynamically be adapted to needs", (A)*

Overcome Technology Complexity	*Promote standardization and modular design*	*"fast implementation of standards and regulations to enable the business", (G)* *"standardisation would help a lot companies to push the technology forward", (Ind)* *"FOCA and Swiss companies must more actively pushing for global open standardization", (S)*
	Provide environment for piloting	*"facilitate the opportunity for pilot testing projects on the public roads or on the field", "corporates need an expertise for innovation, as well as space, where this innovation can take place with some degrees of freedom, separated from main activities", (Ind)* *"Introduce regulatory sandboxes or pilot programs that allow companies to test", (Inv)* *"need a freely accessible space to try out for someone with innovative idea", (S)*
	Adapt existing infrastructure for new technology	*"old infrastructure should be ready to adapt the requirements of autonomous system", (A)* *"5G coverage everywhere", "need for physical and communication infrastructure", "supporting the setup of electrical infrastructure – e.g. using the learnings of the electric car industry as a reference", "stronger support hardware and software (computer vision and autonomy) talents", (S)*
	Strengthen competence and organisation	*"support the quick implementation of measures to react on a dynamic market environment (e.g. adaption of education and R&D)", "better organization of drone companies (similar to GA and model aircrafts) in order to act more efficiently both nationally and internationally", (S)* *"engage with universities in the core business for knowledge transfer activities", (Ind)* *"important is the combination of the technology, but also the management expertise", "launch joint research initiatives that address complex, interdisciplinary challenges, encouraging experts from various domains to collaborate on innovative solutions", (Inv)*

Go-to-Market	*Promote strategic partnership*	*"involve corporate with stronger closer interlink between startup and corporate as in US", "facilitate partnerships between academia, industry, government, and non-profit organizations to leverage each sector's strengths and resources for mutual benefit", "foster partnerships between startups and established corporations, enabling access to corporate venture capital and resources for growth", "foster partnerships between the government, private sector, and academia to pool resources, share expertise, and jointly address regulatory challenges", (Inv)* *"talk with different stakeholders and define an agreement to address the need…then during the couple of weeks month define three different solution possibilities and after a couple of months we decide which one we will focus", "technology has to be something that is solving a problem for our customer in a much more efficient way", (Ind)*
	Adaptive, client centric Business Model	*"assess the trends where the world is going and be able to adapt business model accordingly", "need to estimate what impact those trends will have on the company", (Inv)* *"more customer-centric instead of technology-centric entrepreneurial mindset", (S)*
	Focus on adding value	*"show more use cases, where you added value to the customer: saved cost, developed more reliable system", "technology must bring value, we have to find projects that solve real issues", "cost effective technology wise and advancements we can integrate into our company", (Ind)* *"no focus on low-cost products but continue serving complex missions with high-end products/services", "don't build up only on technology, you need a vision what to do with it", "promote the added value of drone technology (time saving, cost savings, 95% less CO2 emissions, replacement of dangerous missions, infrastructure, maintenance"), (S)*
	Go international	*"to be competitive you need to think in EU ecosystem, need to grow international"," foster partnerships with international institutions, research*

		organizations, and industry players to bring in diverse perspectives and global best practices", (Inv) "Swiss drone companies should more aggressively expanding abroad leveraging partnerships with global companies and international customers", (S)
Reinforcement of Stakeholders Engagement	*Define framework for open innovation*	*"define better open innovation collaborative approach to innovation", "the co-development from the beginning, this is the way… influence stakeholders to participate in discussions in parallel with the development, not after", (G) "there is a buttle between institution and that is why it is important to promote communication and cooperation", "establish effective communication channels, both formal and informal, to share progress, challenges, and opportunities among stakeholders", "recognize that building effective collaboration takes time and commitment. Encourage long-term partnerships and provide support even when immediate results may not be apparent", (Inv)*
	Promote networking	*"need a stronger collaboration amongst Swiss drone companies. This strengthens the local industry and create synergies to compete together externally rather than internally", (S) "promote a culture of open data sharing and transparency, enabling stakeholders to access and build upon each other's work, thus accelerating collaborative efforts", "establish regular forums, conferences, and workshops that bring together stakeholders from academia, industry, government, and international partners to facilitate networking and idea exchange", "involve state more in helping startups, (Inv)*
	Incentives to attract, retain stakeholders	*"use collaboration area,s where new companies can work together. Need for bigger ecosystem, where not only startups, but also big companies present", (G) "need the rollout phase to attract many companies so that they start with lower taxes, then we can raise the price, make the taxes as they were." (S) "help strengthen the position of Swiss SMEs in terms of talent access", "provide structural support so that people are willing to quit Google, no need to pay the*

		salary of Google, but has to have the basic safety net so that you try to venture into this", (A) *"clearly define and communicate a shared vision for the ecosystem's development, fostering a sense of purpose that aligns stakeholders towards common goals", (Inv)*
Change Mindset	*Build entrepreneurial mindset*	*"try fast, stop fast, move on, think big", (Inv)* *"keep learning all the time to keep up with all the technologies and invention, educate people", (Ind)* *"find a balance between go crazy and be cautious",* *"have big picture, ask questions: what do we want to achieve? what is the problem we're trying to solve for the society? why can't we solve now?", (A)* *"an open failure culture as a basis for collaborative improvements of the drone industry (learnings)", (G)*
	Network, learn from Heroes	*"bring serial entrepreneurs, supporters who have an experience", "set up training systems around startups, the community building for communication, interaction among startups, peer coaching", "organize pitch events and competitions that showcase promising start-ups to a wide range of potential investors", (Inv)*
	Build the right team	*"tell stories, show light towers, successful projects, go everywhere and talk about these projects, so others could follow", (G)* *"create diversity, invest in people. Success is about attract the people and making sure they have the right environment", (Inv)* *"bring real builders into the spotlight of the Swiss ecosystem", (S)*
Increase Awareness and Acceptance	*Show the value to public and impact on society*	*"show working technology on the streets", "important to explain the benefits for society for the use of drones", "pro-actively educating the public regarding privacy concerns, safety and noise issues", (G)* *"engage the public, show that their tax money were well invested"," public engagement helps individuals understand how to interact with autonomous systems", "transparency builds trust and reduces apprehensions about new and unfamiliar technologies", "engaging the public in discussions*

	about ethical considerations…", "conduct surveys to assess public perception and trust in autonomous technologies over time", (Inv) *"show that what we are doing is relevant, innovative, will have a big impact on the society", (A)* *"do some functioning pilot tests where people will see that it brings value …not just having a gadget on the road", (S)*
Ensure credibility	*"show that the technology is reasonably safe, provide affordable service, convenience and reasonable price", "show that a credible company (state) stand behind the project, as a reassurance of the risks. If there is a trusted name or government behind, the level of trust to technology is increasing", (A)* *"establish clear guidelines for liability and insurance in cases of accidents involving autonomous systems, providing clarity for manufacturers, operators, and users", "educating the public about the safety measures and redundancies in place within autonomous systems can ease concerns and increase acceptance", "Public awareness campaigns can explain how data is collected, used, and protected by autonomous systems", (Inv)* *" more high-level political interest in actually creating a drone industry", "more visionary mindset in politics and large entities", (S)*

Table 7. Strategies and core references

Strategies	**Key references**
Increase Innovation Capital	
• *Attract investors local and international investors* • *Network, educate, learn, incentivize collaborations* • *Create favorable legal environment*	*(Megret, 2021)* *(Wang & Schot, 2022)* *(Faber, 2001)* *(Hwang & Horowitt, 2012).* *(Gbadegeshin et al., 2022)* *(Clrarysse et al., 2014)*
Regulatory framework	
• *Increase international visibility* • *Promote collaborations between regulators and developers* • *Harmonize regulation processes* • *Create favorable regulatory environment*	*(OECD Policy outlook, 2021)* *(Alaassar et al., 2021)* *(Cornelli et al., 2020)*
Overcome Technology Complexity	
• *Promote standardization and modular design* • *Provide environment for piloting* • *Adapt existing infrastructure for new technology* • *Strengthen competence and organization*	*(Zou et al., 2022)* *(Ganco et al., 2020)* *(Landscheidt et al., 2018)* *(Soteropoulos et al., 2020)* *(Manivasakan et al., 2021)*

Go-to-Market

- *Promote strategic partnership* *(Gbadegeshin et al., 2022)*
- *Adaptive, client-centric business model* *(Leppänen et al., 2021)*
- *Focus on adding value* (Kiefer & Clarysse, 2011)
- *Go international* (Tuominen et al., 2022)
  (Najmaei, 2016)
  (Porter, 1985, 1990)
  (Andries et al., 2021)
  (Hannah & Eisenhardt, 2018)

Reinforce of Stakeholders Engagement

- *Define framework for open innovation* *(Grimaldi et al., 2021)*
- *Promote networking* *(Chesbough, 2018)*
- *Incentives to attract, retain stakeholders* *(Adner, 2017)*
  (Alberti & Belfanti, 2019)
  (Valkakokari et al., 2017)
  (Albert and Barabasi, 2002)
  (Ferrary & Granovetter, 2009)
  (Furr & Shipilov, 2018)
  (Phillips & Ritala, 2019)
  (Autio, 2022; Walrave et al., 2018)

Change Mindset

- *Build entrepreneurial mindset* *(Jain et al., 2009)*
- *Learn from Heroes* *(Hayter et al., 2018)*
- *Build the right team* *(Hwang & Horowitt, 2012)*
  (Burgers et al., 2015)

Increase Awareness and Acceptance

- *Show the value to public and impact on society* *(Pushpananthan & Elmquist, 2022)*
  (Zhou et al, 2015)
- *Ensure credibility* *(Koning et al., 2022)*

The results showed that enhancing the innovation ecosystem requires a multifaceted strategic approach that includes: strengthening innovation capital through attracting right investors, creating favourable legal environment, network and increasing ecosystem global visibility; providing an enabling legal and regulatory framework to regulate and protect innovation through harmonisation and simplification of regulatory processes and promoting collaborations between key stakeholders; overcoming the complexity of new technologies through training, skill development, product standardisation, promoting testing environment and adaptation of the existing infrastructure; developing robust go-to-market strategies to effectively launch and scale innovative solutions through focusing on real added values, building strategic partnerships and client centric adaptive business model; reinforcing stakeholder engagement to leverage diverse ideas and build supportive networks; cultivating a mindset towards acceptance of risk and failure as part of the innovation process; and increasing awareness and acceptance of innovation through education, outreach, showing credibility and demonstrable proof of benefits.

4.4 Ecosystem Innovation measure

Due to irrelevance for ecosystem measure and ambiguity of some existing innovation indices, outlined in Chapter 3.1.3, experts were asked to identify metrics that would measure the innovation ecosystem performance. Most experts noted that identifying a set of metrics to evaluate the performance of the ecosystem was a challenge.

After collecting and analysing the interview data, using analytical aggregation method, in total 14 indicators were identified. The highest weights were given to the metrics intended to measure *the number of jobs created in the innovative sector, the innovation that reached the market, venture scale rate, the capital raised by startup for each investment round, company image in terms of attractiveness to employees and on global landscape, the startup impact on economy and sustainability, the number of highly educated people, startups survival rate, the venture capital market growth and the number of patents belonging to the ventures, not older than 3 years and the number of new startups founded*.

A heatmap on Figure 19 and scoreboard on Figure 20 visualises the data considering the frequency of occurrence of each indicator with relation to each stakeholder group. The major consensus was reached for the *job created* index. This metric incorporates the number of domestic jobs generated in the innovative sectors, contributing to the future industry. The domestic startup scale rate: *"how many exits, IPOs", "how many of them are bought by bigger companies*" and the ability of the invention to reach the actual market: *"how much of your market is gained by the new products or service", "how many new ideas did you get from the workshop and new contacts"* were the most important indicators for Investor groups. Startup image is essential to gain the competitiveness and the visibility on the global scale: *"does our startups play a role in the global competition?"*. For academia and investors, it is particularly important for new businesses to demonstrate their value and positive impact on the economy and sustainable development. A startup's potential to raise capital and generate revenue was cited as one of the most relevant indicators of ecosystem growth. Startups s*urvival rate* was characterized as relatively important to see the ecosystem dynamics. Some business ecosystem literature suggests this indicator as main metrics, considering that startups operate in markets which are not clearly developed and that this measure is less sensitive to industry (Santos & Eisenhardt, 2009).

Codesystem	Government	Industry	Academy	Investors	Startups	SUMME
jobs created	2	1	2	4	1	10
number of exits, IPO, M&A		1		2	3	6
startup image and global raiting	2	1			3	6
capital raised			1	3	2	6
innovation that put in the market	1			5		6
economy and sustainability impact			1	3		4
high educated people rate		1	2			3
survival rate		1		1	1	3
VC market growth			2	1		3
number of patents		1			2	3
number of new startups	1			1		2
future skills			2			2
lessons learnt			1	1		2
diversity				1		1
SUMME	6	6	11	22	12	57

Figure 19. Heat map of indices vs stakeholder groups

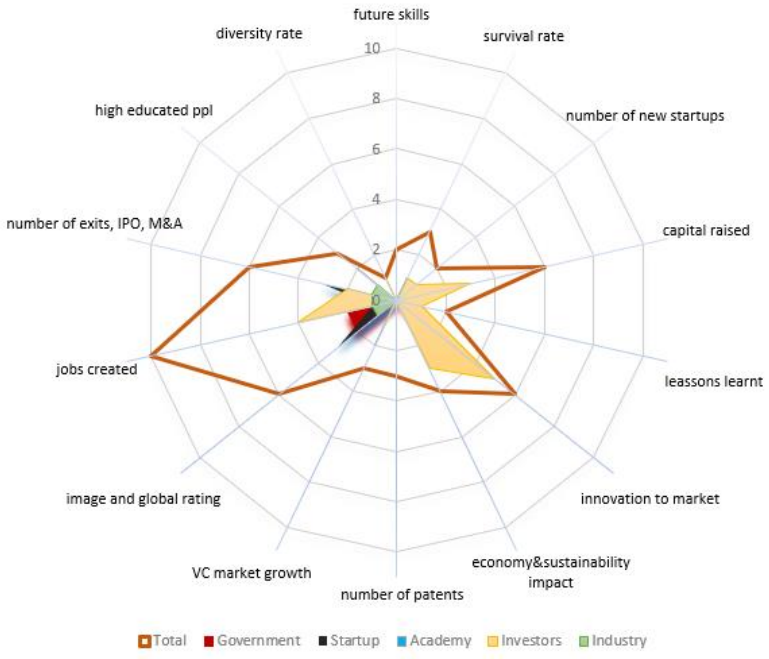


Figure 20. Scoreboard of proposed ecosystem performance indicators

An additional expert idea included indicators such as *lessons learned from failure: "what makes an ecosystem great is the learning that's happening within. The learning happens from both successes and failures… many people just fail and say, okay, I stop…, but what would be a good thing is to say: okay, I failed but let's analyse why, understand and learn"*. This statement correlates with the risk aversion behaviour identified by the most Swiss entrepreneurs.

Furthermore, the importance and the need for continuous learning was indicated by several stakeholders in the course of interviews, also in the context of acquiring new skills to be able to stay competitive in the market. The metrics *future skills* would show how many new skills were brought by the innovation ecosystem to the economy. The interviewees however showed scepticism about the *number of patents* indicators. The concern is that many patents expire before they reach the market as a final product, and this number does not actually reflect the innovative growth of the ecosystem. At the same time, the *diversity rate* indicator was not chosen as an important measure to show the ecosystem performance. It should be however

noted that these findings are the result of limited data collection and further research is needed for more generalized and insightful conclusions.

Considering the available data on the global indices (see Annex, Figures A6-8), we can assess the derived indicators current performance. Figure 21 illustrates the approach, where each indicator is mapped in accordance with its global country performance and the relevance for the analysed ecosystem.

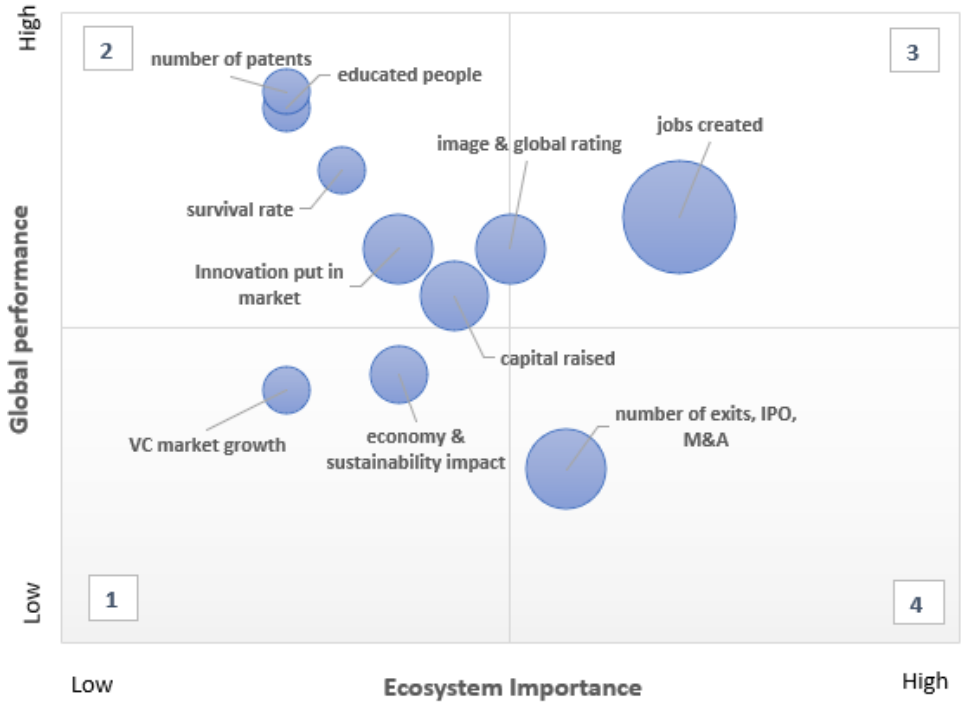


Figure 21. Identified indicator performance map

The complexity of this approach is that the terminology of some European (EIS, RIS) and global innovation indices (GII) may not fully correspond to the terms of the indicators derived from the study. In addition, several indices may correspond to one ecosystem indicator.

Further research and more precise aggregation criteria are needed to classify and visualize the indices on the map. The goal of the overall assessment is to achieve the level, where the most relevant ecosystem indices show the highest performance on the global level (reaching the upper corner of the third quadrant). The current findings show that the "*number of exists, scaleups"* require significant improvements.

5 Discussion

The discussion will be divided into three main parts. The first part will focus on the identified constraints of the ecosystem, followed by success factors contributing to its development, and finally stakeholder relationships, concluding with a SWOT analysis and stakeholder matrix. Please note, that the quots (italic sentences) without reference are taken from the interviews with stakeholders.

5.1 Ecosystem constrains

The analysis showed that the most critical barriers for the ecosystem growth is the technological complexity, regulatory issue and on the capital availability. The challenges associated with the complexity of the technology have already been described in Chapter 2.5. The AS involve the complex processes of the product development and sales, requires the appropriate infrastructure for testing and deployment, the overall understanding of the technology sophistication. Regulatory alignment implies compliance with policies, legal and liability issues. The capital availability refers to the efficient financial capacity of domestic and foreign investors to support the venture growth and scaling.

The main identified challenges to rapid technology adoption are high cost, legal issues, lack of real-world use cases and lack of an appropriate business model that matches customer and technology needs. Unclear or restrictive regulations could hinder the testing and deployment of autonomous systems in public environment. The liability, privacy and security related challenges remain still unresolved for autonomous systems. The question who is responsible for an accident caused by an autonomous car has not been answered yet. There is a lack of industry standards and interfaces, companies generally work on their own technologies and the coordination of interfaces to the infrastructure (traffic control system, building technology, etc...) is missing. An incompatibility with international policies or inefficiency of the standardisation may stop the development or postpone it jeopardising company's competitiveness on the market: *"we stopped the group because one day I had a knock on my door saying, what kind of license you have".* At the same time, the technology acceptance by the public and government needs more showcases and positive results to develop the trust

(Sifakis & Harel, 2023). Interviewees observed that entrepreneurs often underestimate their understanding of the complexity of the technology and unable to meet all the related challenges: *"companies do not understand the product complexity, that is why they fail"*. The integration of the technology into the existing infrastructure is the next level of the complexity that needs to be properly managed. A collaborative effort between government, industry and entrepreneurs is necessary to create appropriate transition conditions, compatible interfaces, and security measures to deploy new technology.

The most important part of the AS development is piloting that involves *"many trials and tests"*, *"space to be able to accelerate", "outdoor testing infrastructure".* The main barriers for entrepreneurs at this stage is the administrative hurdles, high expenses, lack of testing environment and regulations: "*if you want to fly a drone over a town, you have to hand in hundred-page reports for delegated permission and thousands of francs",* "*if you want to test in real settings it's very difficult, need to ask an owner of a big building, inform the police and there is no support from Zurich side*", *"we could test in the lab, no problem, but to go outside is more difficult"*. Furthermore, more tests within the country should be conducted to show the technology credibility and to gain more trust: "*they will not give the okay to those systems if they are not made some tests within Switzerland itself*." The lack of required space for piloting outside the lab and complex regulatory procedure forces some entrepreneurs to test their products outside the country: *"we have to test outside Switzerland, because there is not enough of the testing facility"*. Legislation and approval procedures for pilot tests require refinement, standardization, and simplification to enhance efficiency for all stakeholders. A viable solution should be devised to enable technology testing in suitable environments, under favourable regulatory conditions, while minimizing administrative burdens for entrepreneurs and R&Ds. Public safety requires more government control and legal assurance, especially in the early stages of the technology development.

A significant amount of autonomous technology is being made for export that requires compliance with international policies and standards. Tensions in bi-lateral trade agreement between EU and Switzerland[41] might result in losing leading position and influence on

[41] Source: https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-83705.html

European policy makers. The alignment between EU and Swiss laws is still in its development stage causing additional hurdles to entrepreneurs and need to be harmonized: *"we wait on Europe to decide… we have to wait more years", "sometimes the law is not completely applicable to Switzerland", "export is very difficult from Switzerland, regulations are not startup-friendly", "approval for complex missions lead to long waiting time, high costs", "we had to pivot while waiting for the low being introduced".* The recent changes in Swiss drone regulations gave access to EU market, but also meant additional administrative work: *"the adopted EU regulation means a lot of extra resource investment in terms of money and manpower"*. According to entrepreneurs Swiss authorities are responsive and proactive: *"it is very difficult to get certification from EASA, local authorities are much more open and responsive*", however, there is a capacity issue: *"lacking authority personnel capacity for complex mission approval"*. The new regulations require constant collaboration with developers, and it implies the active participation of several stakeholders (local and international) that adds additional managerial and organisational complexities.

New technologies mean large investments into development, resources and know-how. The venture capital shortage, especially at the late financing stages was justified by statistical data and analysis in Chapter 3.1.1. The concentration of VC firms and venture capital investing in startups in Silicon Valley is USD 15,2 billion, compared to CHF 3.9 billion in Switzerland (CHF 2.1 billion in Canton Zürich). There are many accelerators, incubators, and state funding opportunities for startups at the early and seed stages*: "if you need to raise under a million, and you have a great idea, you can do that quickly"*, however, there is a shortage of funding to scaleup phase: *"they are not able to match the financial power of what some companies need to really succeed in bringing complex deep tech products"*. VCs in SV ecosystem are regarded to be willing to accept high risks in their investments, which also facilitates the entrepreneurial mindset. This phenomenon was confirmed by the interview results. Some interviewees "blame" the risk averse attitude of the local investors: *"we don't have the big VCs, because it's a little bit different culture"*, *"a lack of risk favourable investors"*. There is also a *"wait for other failures then act*", *"first regulate then experiment"* behaviour observed, which can be a disadvantageous for the fast-changing deep tech market. At the same time, an investment in

autonomous systems involves relatively high risks and long waiting times for returns, requiring patience, commitment, and sufficient liquidity[42].

Several participants stated that Swiss entrepreneurs are more risk averse than those in Silicon Valley and this is often a barrier to successful products commercialization and massive exits. The reasons were namely related to the cultural factor: *"safety culture", "slow living habits", "not a fighting culture", "no failure culture", "very regulated environment", "people are too comfortable", "lack of language skills".* There is also a certain common communication barrier was indicated that prevents from the socialisation and networking: *"Swiss people work only with the people that they know", "it's a classical Swiss problem, people work only with the people that they know"*. Some interviewees had an opinion that entrepreneurs sometimes are lacking a big vision "*think big*" and ambitions: *"startups think only of the market within Switzerland, and they are not scaling their business to international market*", and that this often a main stoppage on the way to the big breakthroughs. Furthermore, the sales and the marketing skills to promote themselves and the products are missing. Swiss entrepreneurs are often following the rule: *"if you're good, people will learn about you"*, which is rarely a good strategy in a highly competitive environment. Several interviewees are noted that there is a lack of presentation and language kit skills. However, this trend is changing, particularly in Canton Zurich, where cultural diversity and the presence of international talent are having a positive impact on the dynamic of entrepreneurial behaviour. Statistically, Canton of Zürich is more risk taking than the other cantons (55% vs 32%[43]). Often the attitude correlates with the external environmental factors. For instance, the availability of financial support can result in risk averse behaviour: *"startups are afraid of competition due to this lack of financing, the lack of big money", "they sell companies because they afraid not to be able to raise the money".* To resolve the capital availability issue may change the behaviour of entrepreneurs and improve the overall ecosystem dynamic. When compared to Silicon Valley, Swiss entrepreneurs lack some basic characteristics that are claimed to be the key to creating a successful and dynamic innovation ecosystem. For instance, Lee (2000, p.103) observed that

[42] BCG: https://www.bcg.com/publications/2021/overcoming-challenges-investing-in-digital-technology

[43] Source: Global Entrepreneurship Monitor 2022/2023, gem-switzerland_2022-2023

the Silicon Valley entrepreneurs *"…take enormous risk in order to create new technologies*". The risk-taking behaviour is often rewarded by the large amounts of "risk-free" capital from venture firms, encouraging this type of behaviour. Moreover, venture capitalists accept that approximately half of their portfolio companies are likely to fail and this is a quite common practice. Saxenian (1996, p.29) states that *"…unlike elsewhere, there is little embarrassment or shame associated with business failure"*. The studies also showed that entrepreneurs *"appeared to be very ambitious and possessed of a strong desire to make a difference in people's lives or to make an impact through their business*" (Gold, 2018, p. 119). Author argues that a successful ecosystem has been facilitated by a dynamic social network that develops through trust and an open culture. Cohen and Fields (1999) refer to this phenomenon as "performance-generated trust", a building block of social capital shared by all participants in the ecosystem.

Although the startup ecosystem is very strong in the Canton, securing adequate funding for expansion and commercialization remains a challenge. Furthermore, demand for qualified professionals in AS worldwide can lead to a talent drain affecting the competitiveness of the local ecosystem. Moreover, there is a danger that companies can leave to the countries of their investors: *"if the VC from Silicon Valley will become dominant, and they come up with totally different ideas, they may close the office in Zurich and go in Silicon Valley"*.

Some experts pointed out on an existing taxation issue, emphasising the need for tax incentives and regulatory framework that would protect both entrepreneurs and investors. For instance, according to participants, entrepreneurs are taxed on the wealth, which is often a "virtual" value resulting in the liquidity shortage: *"founders have on paper 30 - 40% of the equity in common shares…they have to pay a wealth and income tax, but they can't sell their shares for that amount*", "a*dministrative and tax burden in the first years can be crushing"*. The insufficient liquidity to pay those taxes can be very critical for entrepreneurs and may impact the investors willingness to invest: *"VCs are not going to be attracted to invest in companies, knowing that founders going to pay ridiculous taxes and probably leave".*

Swiss market is relatively small, and there are many strong global competitors, including big car manufacturers in the neighbour countries. The size of the domestic market forces entrepreneurs to go in the foreign countries to seek for the demand and global visibility. To

overcome the threat of losing these innovative companies, local government and corporates could facilitate entrepreneurs in entering those markets and/or open up domestic opportunities by establishing partnerships or becoming their first customers. This would give startups credibility, stable customer, expertise, new customers and result in steady ecosystem growth (Kiefer & Clarysse, 2011).

Due to Swiss liberal democratic system, public opinion is very powerful and can influence the governmental decisions. The study showed that one of the reasons why the projects were not realised is the negative public influence and no government support: *"public opinion was very strong against autonomous systems", "the largest, negative stakeholder who don't want this kind of innovation is the general public", "*i*n government there is not enough courage and willingness to push the innovation forward"*. One of the main reasons for this negative view is not sensing the benefit of the technology: *"there is a lack of vision, need, and seeing benefits from the technology: why would I need this, it's good the way it is right now".* Public and Government do not see the use of the technology and see more inconveniences caused by noise, accidents, data privacy, etc: *"people were afraid to be injured"*, "*there is a fear that AS bring more traffic on the roads and that this needs more energy*". These results show that more effort should be made to convince the state and people that the technology have a future potential and can bring a real value to the society.

In summary, the successful integration of autonomous systems relies not only on the current hardware and software capabilities but also on the availability of capital, effective regulations, and the willingness and active involvement of end users. Without public acceptance and efficient collaboration, the potential growth of the autonomous industry could be significantly hindered: *"hardware basically is there, the software is also there. To close the link and to make the autonomous systems really autonomous requires a help from the other side, from the end users", "the lack of public acceptance might stop the industry from flourishing".* A correlation is found between the risk-taking behaviour, the culture of failure acceptance and the capital availability. Lack of openness, trust and limited communication can negatively affect the creation of essential interactions and network among stakeholders and thus inhibit the development of the ecosystem. The findings demonstrated the high importance and influence of stakeholder groups such as Government (policy makers), Investor and Public on the

effectiveness of the innovation ecosystem, which justified the inclusion of these stakeholders in the TH model extending it to Six Helix (see Figure 22). Innovators, R&Ds are the catalysts and drivers of the ecosystem. They generate new ideas and create innovations, but they need an enablers, supportive environment to develop, produce and commercialize technologies. The streamlining of design and product standardization, the harmonization of regulatory activities, sufficient capital, proactive engagement of all stakeholders, and the technology broad acceptance are crucial factors for the rapid deployment of innovative technologies and the ecosystem growth.

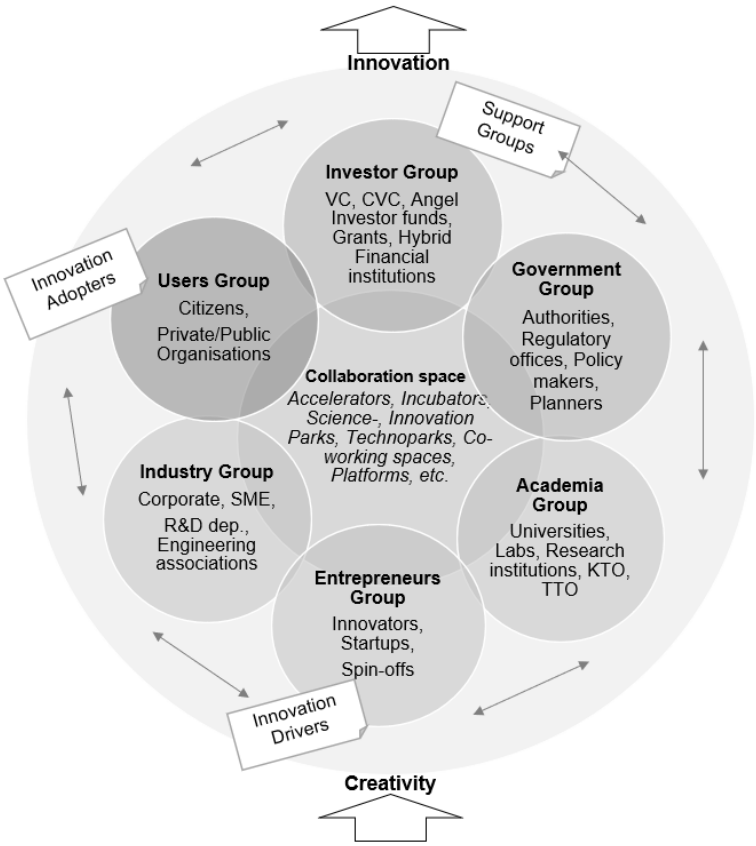


Figure 22. Proposed Six Helix Model

5.2 Ecosystem success factors

According to interviewees, Canton of Zürich has a very robust education system and strong talent pool that fosters an atmosphere of innovation: *"in Zürich we have top universities and great networking programs", "very strong educational system and the facilities", "highest number of educated people coming out with the top education in this field"*. This creates a powerful dynamic of talent distribution and diversity. The quality of the talent pool is a significant attraction for both local and international companies setting up R&D departments in Zurich: *"talent attracting all the big international companies to come here",* "*companies come to open their R&D labs hear because of the talent".* In the opinion of experts, Switzerland's unique competence and competitive advantage lies in its historical ability to deliver high-quality products, to provide high-precision and high-performance industrialization, and to combine sensor mechanics, system design and intelligence in entire systems: *"we have competence to put the entire system together…", "our strength is in theories, industrialization, manufacturing, making stuff", "we excel in autonomous drones industry", "autonomous systems is much richer in Zurich in Switzerland than in Silicon Valley", "we are leaders in high performance measurement equipment and manufacturing".* Participants emphasized the strong startup ecosystem with high survival rates, which is supported by universities and the government, as well as the close relationship with industry. Availability of angel investors and public capital is a boost for startups. Furthermore, Switzerland's political and economic stability, social system and the proximity to European market, customers and suppliers are strong advantages contributing to the key success factors: *"political, economic extremely stable, no corruption", "brand image that can be used as a USP of any startup founded in Switzerland".* The risk aversion behaviour is rather positively perceived as a quality of being pragmatic, *"realistic but forward thinking", "more connected to reality*", that is highly appreciated in a business environment. The international diversity, its openness to immigration, and a multilingual society contribute to a vibrant and multicultural innovation hub. Furthermore, participants underscored the importance of work-life balance and the exceptional quality of life, factors that continue to attract talent and foster new business opportunities within the country. The consensus among the interviewees is that Switzerland

boasts a robust and progressive regulatory system that creates a conducive environment for entrepreneurs, with a notable international influence: "*if you have an approval in Switzerland, you are able to fly everywhere in Europe, this is a huge advantage for many startups and SMEs in Switzerland".*

To conclude, the interview results showed that the innovation ecosystem of Canton of Zurich is driven by a strong talent pool from top universities, exhibits diversity and an international mindset. Its culture of innovation, expertise in autonomous systems, and robust startup environment contribute to its unique competence as a competitive advantage. Furthermore, the quality of life, political stability, central location, forward-thinking mindset and high-quality standards attract international businesses and talents, making Zurich an attractive hub for innovation. Table 7 provides a visual summary comparing the key characteristics of Silicon Valley (Stensson & Wessman, 2015; Gold, 2018) with those of the Canton of Zürich IE.

Table 7. Comparison characteristics of success factors: SV vs Canton of Zürich

Silicon Valley	***Match***	***Canton Zürich Ecosystem***
High presence of scaling capital, large VCs	Yes/No	Positive tendency in the past 2 years, high presence of seed capital, angels, state funds
Culture of risk – taking	No	Pragmatic, realistic, forward thinking
Open culture	Yes/No	Canton Zürich has open culture, but not as SV
Dense Industry Landscape	Yes	Presence of big corporates, industry
Dense Social Network	Yes/No	Well-connected network with some stakeholders
Vast Pool of Talent	Yes	Highly skilled workforce
Influential University	Yes	Presence of highly ranked universities
Advanced in AS (AV)	Yes/No	Advanced in AS (control, robots, drones)
Appealing Climate	Yes/No	Centric location, great infrastructure
Role models of successful startups	Yes/No	There are unicorns/exits, but not many

When we analyse these characteristics in comparison to those of Silicon Valley (Gold, 2018, Chapter 2.4.1), numerous similarities emerge. Both ecosystems feature robust education systems, prestigious universities, and cutting-edge technology sectors with a dense concentration of industry leaders. The Canton of Zürich ecosystem particularly excels in autonomous system technology like robotics and drones, whereas Silicon Valley stands out in the realm of autonomous driving. Any areas where the Zürich ecosystem may not match Silicon Valley's strengths can be offset by the complementary success factors outlined in Table 7.

5.3 Stakeholders relation

The importance of collaboration within the ecosystem was discussed by several authors. Adner and Kapoor stated that the presence of strong and stable relationships supports the creation of synergies that enrich the pool of available resources (2010). Kolloch and Dellermann (2018) argue that efficient and effective collaborations improve resilience of the ecosystem. Studies and analysis of the most successful innovation ecosystem (e.g., Silicon Valley, Boston, Cambridge) showed the advantage of collaborative synergies between various stakeholders. Resilience of the ecosystem depends on the robustness of its network (Newman, 2003), while robustness implies a complete set of heterogeneous and complementary agents and a dense network (Hartman et al., 2001). The absence of one important player (or weak relationship) can weaken the entire network and ecosystem.

To get visibility, access to market and operational experience young companies collaborate with industry. At the same time, big companies benefit from the novelty and creativity of the ideas while interacting with startups. Established corporations often recognize that they must engage with cutting edge technology to survive in the highly competitive market and use corporate incubator and accelerator programs to offer opportunities for mutual learning. Such collaborations give companies access to ideas and new strategies and provide startups with the necessary capital, resources, knowledge and established international distribution channels (Kupp et al., 2017). Government plays many critical roles in fostering innovation[44], in

[44] Source: PWC, https://www.pwc.com/gx/en/technology/pdf/how-governments-foster-innovation.pdf

particular by creating a supportive policy and regulatory environment in which startups can thrive through a variety of knowledge-sharing resources and collaborative incentives that enable the development of scientific research and communities of public and private sector contributors. Government and Academia can also play an 'entrepreneurial' role themselves (Etzkowitz & Zhou, 2021), by envisioning and funding the creation of whole innovation sectors and then acting as a partner in bringing successful innovations to scale. The collaboration with corporate investors, venture capital firms is very crucial for startups to launch their business and steady growth. It is one of the key enables to make the innovation happen (Kiefer & Clarysse, 2011, Gold, 2018). Furthermore, nascent technology adoption requires constant feedback from the users to identify the actual needs and to be able to pivot early when the technology is not a good fit (Kapoor & Klueter, 2020).

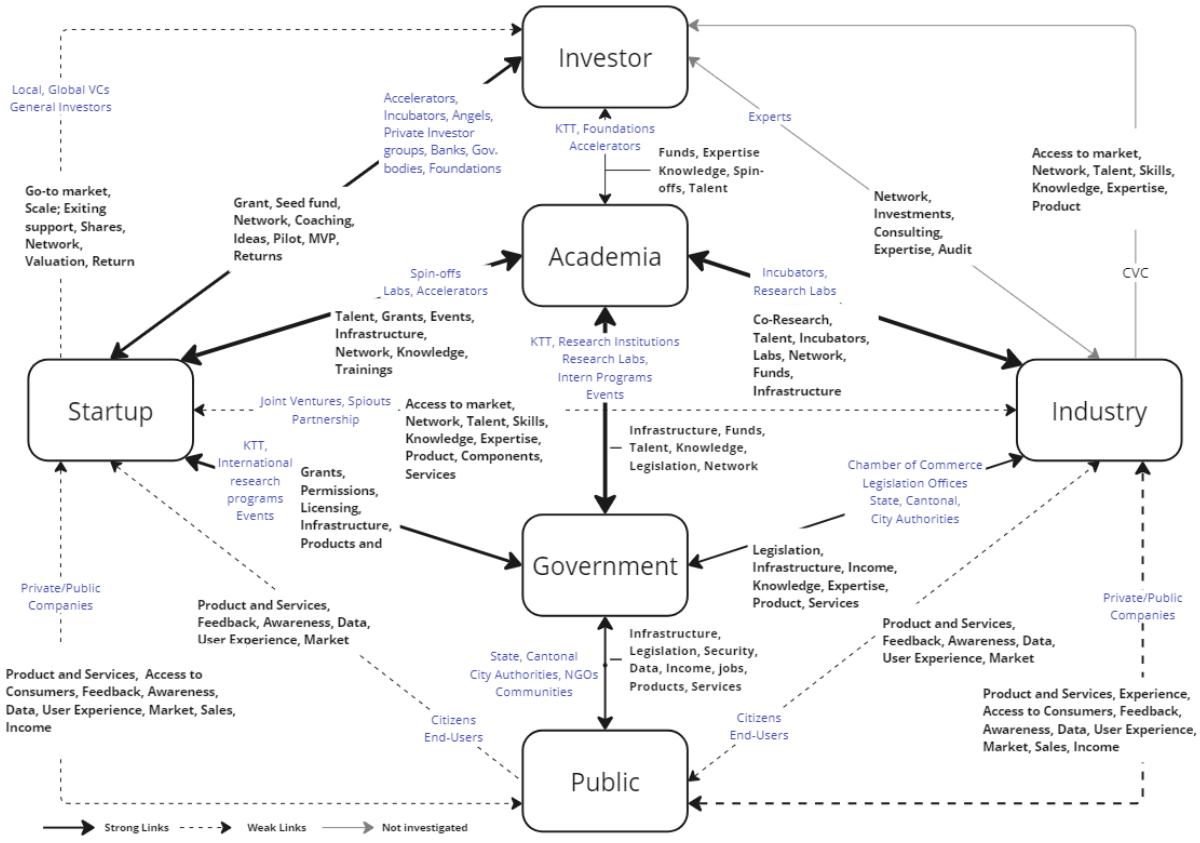


Figure 23. Ecosystem stakeholders' engagement diagram based on Six Helix Model

In the course of data analysis several weak linkages in the ecosystem stakeholders' engagement were identified. Figure 23 displays the relationships between the different ecosystem stakeholder groups. The dotted lines show the identified weak linkages. There were various reasons identified why those collaborations would not work properly in the investigating ecosystem. The most common reason is the "*not sensing the benefit*" and the lack of resources (manpower, capital). For the established company it is important to see the product fit to their core business before the engagement with the external parties (e.g. startups). Investors share similar perspective, as they typically expect returns on their investments within a 5 to 10-year timeframe. Moreover, users may not always perceive the immediate benefits because emerging technologies often give rise to new markets, which require time to establish demand. Additionally, the Canton of Zürich benefits from a well-developed conventional infrastructure, particularly in its transportation network, which effectively meets most of the requirements. The weakest engagements were identified between Industry - Startups, Investor - Startups at their scaling phase, and Public – Startup/Industry. The Triple Helix relational model Academia-Government-Industry is in a good state, there is a strong entrepreneurial support from universities, knowledge transfer offices, accelerators and federal government funds, providing with infrastructural and financial resources: *"a very big startup ecosystem, that have a university and also government support", "there is a strong link between academia and industry", "strongly driven by this collaboration between industry and academia", "a lot of private investment in research and development and innovation"*. However, these relationships must be reinforced by the effective organization structure, efficient strategy, and management commitment: *"management gave up, they let go of the drive and the project stopped", "there was no clear guidance from the beginning, everybody had their own views on it"*.

Investors' weak engagement is partly correlated with the risk averse culture. The major funding is placed into low-risk industries as real estate to diversify the portfolio. A slight lack of trust between Startup and Investor groups was observed. Several stakeholders from Investor group stated that entrepreneurs do not possess with the necessary commercial knowledge and business understanding, being too academic focusing mainly on the scientific problems: *"in here everybody wants to get the Nobel Prize and at Stanford everybody wants to be a billionaire", "they are good at research, but they do not sell", "presentation and marketing*

skills are missing". Entrepreneurs in turn have a concern that valuations and funding processes, as well as equity distribution is lacking traceability, transparency and fairness: *"investors come up with the ridiculous assessment of value", "people with no operative role within the company receive more equity", "investors did recapitalisation from normal valuation … and wiped everyone out"*. A clear regulatory framework as well appropriation of missing skills and understanding of each other needs could compensate the mistrust and create more stronger relationships stimulating bigger investments.

Industry engagement is limited mainly due to not sensing the added value to their core businesses: *"they didn't want to collaborate because we were too small for them", "companies will support, but they need to see a real use case, added value to their product, that would solve the problem of their customers".* It was also observed that companies have insufficient manpower and leadership willingness to organize and manage innovation teams with startups. Moreover, internal company rules, business priorities can impede these cooperations. Industrial corporations collaborate more with academia than directly with startups: *"companies are coming to us (academia) with their own projects and willing to invest in professorships"*. State participation is further constrained by budget limitations, frequently preventing them from providing support to innovative companies beyond the initial seed stage: *"we can finance proof of concept, but not the product, it is too expensive"*. One of the main concerns within the interaction between industrial enterprises and startups remains the fear of sharing internal resources and intellectual property. The legal framework is often missing, and it prevents open innovation and product co-creation: *"you have to bring value and be careful not giving too much of your IP", "there is no framework how to collaborate and not sharing too much*". To address these concerns, it is necessary to establish clear legal frameworks and contracts, leverage IP licensing and technology transfer agreements, foster trust through smaller collaborations and open communication. Support from government and engagement of third-party mediators could facilitate safe and productive collaborations (Grimaldi et al., 2021).

Public engagement is still missing in both sides Startups and Industry groups, however companies recognize the importance and benefit of this collaboration: *"as long as the public doesn't have an interest, there wont be customers or general acceptance of the technology".* This is a responsibility of the companies to involve the users, but also government could

consider supporting in this engagement by providing the secure environment and organising more collaborative spaces. The engagement of customers in the development processes is important from the company's visibility and faster product adoption point of view, it could bring more use cases and instant user feedback. For instance, it was suggested that there are organisations on the customer side who has an interest to drive the innovation forward and push the technology. Those companies establish small R&D groups that buy the products and collaborate with the manufacturers on the customised applications: *"this is probably the most important part besides the regulations, to have not just manufacturers that work on these robotic systems, but also the counterpart with customers, …, to work together to create new use cases".* In addition, this collaboration would create a realistic testing environment and infrastructure at customer sites, where compliance with stringent regulations is not required. Furthermore, state, or private organisations could collaborate with companies by using the products for educational or entertainment purposes.

This relationship analysis revealed that there is a strong bond in the fundamental Triple Helix model, between Academia, Industry and Government groups. However, there are significant gaps in stakeholders' engagement of the extended Six Helix model. Those weak linkages were observed between Startups and Industry, Startups and Investors, as well as between Public and Startups/Industry groups.

The results are supporting the findings of the study provided by researchers investigating the "chasm" between pre-commercialization and commercialization phases, where the weakness of financial support and the substantial gap was identified between knowledge and business activities (Clrarysse et al., 2014). This also supports the statement of the Table 7, where SV success factor: "dense social network" is not fully matching in the investigated ecosystem.

An effective strategy to strengthening these loose ties would increase the efficiency of the innovation ecosystem, improve overall performance, and accelerate innovation adoption.

5.4 Stakeholder matrix

As a part of the analysis, a Stakeholder matrix for the selected stakeholders was created. Figure 24 displays the assessed attitude and power of the key players toward autonomous systems.

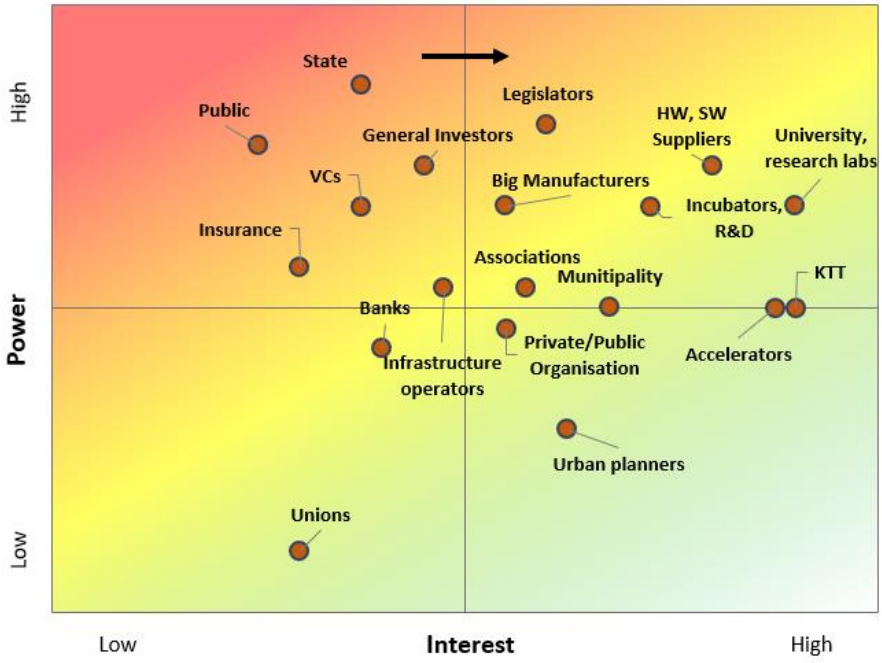


Figure 24. Ecosystem Stakeholder Matrix

The most powerful actors are the most influential and have the greatest impact on the ecosystem. The higher their interest in autonomous systems technology and innovation, the better the ecosystem performs and the faster it develops.

For a more successful and dynamic ecosystem, players in the “red” zone should be willing to move to the “yellow” zone. Stakeholders such as the federal government, public and large venture capital funds have a big impact on the ecosystem, therefore, it is important that these players are convinced of the technology's immense potential.

Please note that the estimates provided in this study are founded on existing literature and interview data. However, it is important to acknowledge that a more precise analysis would require the collection of additional data.

5.5 SWOT analysis

The SWOT analysis summarizes the key findings of the study. Success factors correspond to the strengths of the ecosystem and facilitate the realization of opportunities, while constraints are related to weaknesses and may contribute to the ecosystem threats. The source of the statements is the interviews data and survey[45].

Strengths	**Weaknesses**
Strong technological development,	*Limited market size,*
Dense ecosystem network of established companies and corporations,	*Slow decision system,*
Strong research and education system,	*Lack of capital for scaling,*
Strong startup ecosystem,	*Risk averse mindset,*
Political, economy stability,	*Conservatism,*
Diversity,	*"Too academic",*
Highly skilled talent,	*Startups visibility on global scale,*
Proximity to suppliers, location	*Business little agility,*
Good social system,	*Lack in IT integration,*
Infrastructure,	*No big car manufacturers,*
Loyalty and tolerance,	*Lack of tax incentives for companies,*
Openness to technology,	*Slow regulatory processes,*
Forward – thinking realistic attitude,	*Too little startup exits, upscales,*
Image of product quality and excellence,	*R&D government business support,*
Strong collaborations between Academia and Startups, Academia and Industry,	*Weak startup collaboration with SME,*
Patent and scientific performance,	*Lack of commercial, self-presentation skills*
R&D expenditures in public sector,	*Other non - EU countries have more permissive regulations, e.g. BVLOS,*
High productivity,	*Lack of approved bodies and standards for compliance for high-risk drone operation,*

[45] Survey and interviews with Swiss companies conducted in May 2021, Source: Drone Industry Insights UG https://www.s-ge.com/sites/default/files/article/downloads/dias_-_the_swiss_drone_industry_report_2021.pdf

Rather permissive regulatory framework,
Strong private investors support,
One of the first movers in drone industry.

Lack of test environment for passenger drones.

Opportunities

Swiss policy authorities have strong impact on national and international rulemaking,
Capital availability in the country,
Global reputation, neutrality is an advantage to conquer new markets,
Label "Swiss made" is perceived as highly valuable across the globe,
Proactive Government initiatives towards innovation,
Long, historically proven experience in high precision technology development,
Not much effect from geopolitical pressure,
Standards/Certification for operation can help to leverage operation,
More skilled talent will be required for complex technology,
Social acceptance possible via marketing, showing AS capabilities and benefits,
Open exchange and communication between Swiss companies and related industries can leverage synergies,
The loss of trust in closed systems increased the interest in open-source solutions.

Threat

Public influencing high power, lack of public acceptance might stop the industry,
Foreign vs Swiss funds imbalance might lead to human, capital drain,
Conflicting interests with EU government,
Big internationals hiring best talent,
Startups moving abroad due to lack of capital and testing environment,
High global competition,
Highly dynamic and depending on many stakeholders ecosystem requires alignment,
Fear to fail, culture of safety,
Slowing down R&D at companies,
Relatively low ratios VC/ R&D, VC/GDP,
Highly competitive market, new rivals,
High administrative work to comply with EU rules for manufacturers and operator,
Switzerland might lose leading position in committee work to influence EU policies,
If the regulation lacks permissiveness, talents may move to other countries,
Conservative and risk-averse investor attitudes are holding back the rapid growth needed to compete in international market.

5.6 Ecosystem strategies

The results of analysis (see Table 6) showed that successful innovation ecosystem strategies require significant investment, favourable legal and regulatory environment, active and dedicated engagement of all stakeholders, extensive, easily accessible infrastructure for pilot testing and adoption, ambitious entrepreneurs, and public engagement to ensure the acceptance and credibility of technological innovation.

As it was justified earlier the Triple Helix in its originated form of Government – Academia – Industry is not sufficient to describe and analyse the ecosystem in AS technology. The innovation ecosystem is built around a highly dynamic industry that is associated with risks and uncertainties and involves more complex interactions, requiring active participation and support from multiple stakeholders (Ferasso, 2019.; Gomes et al., 2018) .

This Chapter further elaborates on each of the identified core strategies in conjunction with the strategic steps and corresponding selected stakeholders' inputs, along with the proposed action plan.

5.6.1 Innovation capital increase strategy

Responsible groups: Investor – Government – Startup

5.6.1.1 Attract investors

Sufficient innovation capital is the key factor for the development and commercialisation of autonomous system technology. It allows to attract the best talent, finance infrastructure, production and close the gap between developing and scaling, exiting phase. The higher the investments the greater the probability of success and economy growth. For these reasons, Investors should be more active in investing larger amounts in the growth, scaling up stage of Startups. Dominique Megret in his book "DeepTech Nation" (2021) suggested that to be competitive in the high-tech world Switzerland should invest CHF 5 to 10 billion annually in entrepreneurial ecosystem, balanced between Swiss (50%) and foreign (50%) investors.

Considering that the autonomous vehicle cost in its validation phase for levels 4 and 5 in urban areas is 3.5 billion dollars (McKinsey survey[46]) this amount is very reasonable.

New financing mechanisms are needed to bridge the gap between seed funding and scale capital. Because it takes long time to go through this step, many startups leave the country without reaching the market due to lack of financing. Swiss companies need to become more active providers of venture capital to fill this gap. Government, banks and other institutions could consider supporting angel investors by creating additional investment funds and incentives: "*increase government-backed funding initiatives, grants, and tax incentives for start-ups and early-stage companies to attract more investment into the ecosystem*", *"encourage the formation of angel investor networks that pool resources, expertise, and capital to support a larger number of start-ups", "work with regulatory authorities to simplify and expedite the funding process, reducing administrative hurdles for both entrepreneurs and investors."* Additionally, the government could engage in initiatives aimed at matching private investments up to a specified threshold to mitigate risks and, consequently, stimulate increased investment. For instance, a program similar to the Small Business Administration (SBA) [47] fund-matching program in Silicon Valley could be implemented to incentivize VC capital investment. These funds could have an additional social, sustainable goals mission on state, cantonal or city level. More local investors should be involved in financing Swiss entrepreneurs to avoid the threat of startups and know-how migrating to the foreign investors home countries when they decide to do so. To achieve this, one approach could involve reducing investor risks. Investors might specialize in distinct funding phases of ventures where they possess greater expertise and confidence, thereby facilitating more effective and efficient investment practices (Megret, 2021). Another approach could be to stimulate investors' interest by actively promoting startup success stories that highlight the added value and technological benefits they bring. This can be complemented by showcasing the potential for high returns through technology-driven ventures, thereby inspiring greater participation and investment in the ecosystem.

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[46] https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/whats-next-for-autonomous-vehicles

[47] https://www.sba.gov/

5.6.1.2 Network, learn, incentivize collaborations

Establishing venture capital networks, innovation funds, and public-private partnerships can facilitate in providing funds at various stages of startup growth. Investors are more likely to invest in a business when they have personal connection with entrepreneur and can see the potential. To address the gap between Investors and Startups and to gain trust from both sides, Investors and entrepreneurs should better understand each other businesses and objectives (Wang & Schot, 2022), "*investors need to understand the technology, startup - their business"*. Startups could learn about the needs and expectation from investor side by studying their business and network, and vice versa, investors could enhance their understanding of the technology complexity and learn more about benefits that this technology could bring by attending entrepreneurial, industrial fairs and interacting directly with startups at all stages of product development. There are some additional suggestions from the participants: *"challenge the projects in an early stage, from a scientific perspective, but also from a business from a commercial perspective", "recognize that building effective collaboration takes time and commitment", "encourage long-term partnerships and provide support even when immediate results may not be apparent", "develop platforms matching entrepreneurs with suitable investors based on industry preferences, stage of growth, and funding requirements"*.

Government or other involved institutions could consider initiating direct networking campaigns, where investors, entrepreneurs and industry leaders would meet and exchange their experiences, concerns. This would promote knowledge exchange, collaborations, partnerships, long-term relationships and increase investment opportunities[48]. Furthermore, establishing and maintaining networks between stakeholders can increase trust, openness and chances of technological success by joint problem solving (Faber, 2001) and thus, attract more new players. Moreover, promoting crowdfunding platforms would allow entrepreneurs to raise funds directly from the public.

[48] "Why investor network important for startups?" Source :
https://fastercapital.com/content/Why-Investor-Networks-are-Important-for-Startups.html

5.6.1.3 Create favourable legal environment

The structure of the financial system and its ability to maintain the availability of capital are vital aspects of ecosystem stability (Hwang & Horowitt, 2012).

Canton of Zürich contributes with competitive Corporate Income Tax (19.65%). It is still much higher than in the Canton Zug (11.89%). The absence of taxation on profits earned abroad is one of the main tax advantages of a Switzerland.

The government plays one of the most important roles in the investment market as a regulator and facilitator. Authorities could consider improving cantonal tax policies to remain attractive to the companies and avoid a threat that rapidly growing companies would relocate to other countries to be able to test or scale. To motivate and support Swiss investors to be more "risk-taking" and encourage business angels and corporates to be more active on the venture market, governmet could potentially introduce favourable tax schemes, e.g., tax breaks, deductions or grants for those who invests in innovative startups as it is done, for instance, in Germany (INVEST)[49] or England (Seed Enterprise Investment Scheme, SEIS[50]). Policies and initiatives could be implemented aiming to balance local and foreign venture capital flows, particularly in the growth stage of businesses, addressing the investing capital imbalance. Furthermore, to secure the interactions between startups and investors responsible authorities could consider introducing measures to regulate the equity distribution among stakeholders for each funding round. The valuation processes should be regulated to become more transparent and traceable to protect both entrepreneurs and investors. Studies showed that clear shareholders' agreements that contains ownership, defined roles and their responsibilities, and exit strategy can help young companies to cross the "valley of death" (Gbadegeshin et al., 2022). Reducing the bureaucracy and regulatory hurdles associated with sponsoring an emergent technology, coupled with "*friendly laws for investing in startups*", as well as tax incentives can make the investing process smoother and more attractive for all stakeholders.

[49] https://www.bafa.de
[50] https://www.gov.uk/

5.6.1.4 Increase international visibility

To increase international visibility, government and industrial companies could consider initiating the promotion campaigns and incentivize the participation of young entrepreneurs in international research programs, industrial innovation fairs, workshops, etc. This would give an access to additional international, EU funds and worldwide networks. To compensate non-participation in international projects (e.g. HORIZON) more domestic programs should be offered (similar to SNCF, Innosuisse trade fair, BRIDGE) to strengthen the venture capital industry as is done in Sweden (AP6[51]) or Israel (Yozma[52]) in synergy with pension funds, private and public investors engagement. Furthermore, Swiss government could initiate a global program to attract more international companies, entrepreneurs and various businesses who are willing to relocate and invest in Switzerland (e.g., Global Investor Programme in Singapore[53]). To increase visibility and incentivize international investors' willingness to invest in Swiss ecosystem, more use cases of successful Swiss startups should be promoted outside the country. This would boost attractiveness, confidence and inspire foreign companies to explore similar opportunities. Swiss government could also consider introducing international incentives such as global grants and awards to stimulate the collaborative projects and encourage domestic entrepreneurs actively engage increasing visibility.

5.6.2 Policy framework strategy

Responsible groups: Government – Industry – Startups

5.6.2.1 Promote collaborations between regulators and developers

Collaborations with authorities to establish clear and adaptable regulations can encourage innovation and ensure applicability of the new laws. In the regulatory processes of nascent technologies government plays one of the crucial roles. Decisions that the responsible authorities are taking influence activities of all ecosystem stakeholders. In the McKinsey

[51] https://www.ap6.se/
[52] https://www.yozma.com/
[53] https://www.edb.gov.sg/

survey on the main barriers of Autonomous Vehicles adoption, regulations were viewed as the main bottleneck[54].

The active engagement of companies is important for all stages of policy development. Companies can help improve policies if they are better informed about upcoming assessments. The laws would be more effective and better aligned with stakeholders' needs and perspectives if there is more systematic and cohesive approach involving them in the development process. Engaging stakeholders at this early stage can help in understanding and defining the actual problems that the law or regulation aims to address. It also opens the door for potential solutions that might not have been considered if only policymakers were involved (*OECD Policy outlook, Key findings*)[55]. This interaction could be occurring in parallel with the product development processes. Inputs from the developers (both R&D department and entrepreneurs) would strengthen the policy makers competences and capabilities and at the same time would foster the ecosystem rapid growth: *"regulators working together with the industry to define testing and validation methods to enable drone industry growth."*

For instance, to build technical knowledge and better understand stakeholders needs through the close exchange with the drone industry, the private-public partnership «SUSI» (Swiss U-Space Implementation[56]) between Federal Office of Civil Aviation (FOCA) and Swiss Skyguide air traffic control was established. This partnership consists of around 30 national and international companies and facilitates in understanding the current and future needs of companies and developing new regulatory frameworks accordingly.

Creating physical and virtual spaces can catalyse collaboration between researchers, entrepreneurs, and policy makers from different sectors. Cooperation with international bodies in policy development would have a positive influence on the quality and applicability of laws and have a beneficial impact on the country's image and economy. Internationally recognized policies will stimulate exports and increase the country's weight in the world market. To

[54] https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/our-insights/whats-next-for-autonomous-vehicles

[55] https://gslegal.gov.gr/wp-content/uploads/2021/10/OECD-REGULATORY-POLICY-OUTLOOK-2021.pdf

[56] https://susi.swiss/

encourage these collaborations a dedicated, specialised group of diverse experts could be established, where practitioners and policy makers on national and international level would gather for sessions with the goal to increase insight into a problem, create alignment and develop a robust strategy for regulations creation and implementation.

5.6.2.2 Harmonize regulation processes

To stimulate the Swiss market, the harmonization with international policies and standards is a crucial factor. In the highly dynamic and competitive field, a compatibility with international laws would be very beneficial to entrepreneurs while increasing the speed to market, exporting capabilities and Swiss product worldwide applicability, thus, international visibility. This should also reduce the administrative work and additional financial implications. Proactive participation of Swiss authorities in EU policy would contribute to faster harmonisation and adoption of the regulations discussions (also see section 5.6.2.1). The collaborations between international bodies and local organizations could be facilitated through regular meetings, forums or conventions, where ideas and interests can be openly expressed. To ensure capacity of all the involved stakeholders, members should include this initiative in their operational agenda.

Switzerland can have a decisive influence on international policy developments or even take on a lead. For instance, due to its pioneering role and expertise in drone industry, as well as bilateral air transport agreement with EU, Switzerland was able to play a key role in shaping development of new regulatory frameworks in the drone Industry at European level (EASA, EU 2019/945, EU 2019/947). FOCA plays an active role in international standardization at European and global level and maintains the bilateral exchanges with other civil aviation organizations abroad.

5.6.2.3 Create favourable regulatory environment (sandbox) for entrepreneurs

Startups in highly regulated industries are confronted with high compliance costs and often do not have sufficient regulatory knowledge (Alaassar et al., 2021).

To reduce the complexity of the approval processes for pilot tests and avoid the threat that the companies leave to the countries with more permissive regulations, a more simplified, adaptive

regulatory framework for innovators should be introduced. So called “sandboxes” are developed as an instrument for reducing regulatory barriers to promoting innovation. Similar to FinTech (Cornelli et al., 2020) and AI[57](*Artificial Intelligence Act and Regulatory Sandboxes*, n.d.), a regulatory "sandbox" could be introduced for autonomous systems to ensure that entrepreneurs and R&Ds would test their products for a certain period of time under more favourable legal conditions, “*streamline processes to obtain permissions”* and with less administrative, financial efforts. The initiative was already launched by Swiss State Secretariat for Economic Affairs (SECO) and described in “Prüfauftrag zu Regulatory Sandboxes”[58]. Its further elaboration and adoption would significantly benefit to AS technology and ecosystem growth. The regulatory framework should be “*flexible, adaptive, and responsive to technological advancements and update regulations to keep pace with the evolving landscape”*. This framework could be taken as a form of dynamically adapted agreement and be valid in the whole country allowing to test the technology in an open space environment.

5.6.3 Overcome technology complexity strategy

Responsible groups: Government – Industry – Startup

5.6.3.1 Promote standardisation and modular design

To overcome the technology complexity, all the components and designs should be standardized. The system should be built with modular and open standards, allowing for easy integration with other platforms and systems (Zou et al., 2022). This enhances the value proposition as it can fit seamlessly into various ecosystems. AS could also benefit when companies producing sensor technology focus on improving their core businesses while system manufactures experiment with different combinations of upstream components to innovate the designs (Ganco et al., 2020). Entrepreneurs should stay updated with regional and international regulations related to autonomous systems, ensuring full compliance and avoiding potential legal setbacks. It is important that companies aware about the latest international

[57] Source : https://www.europarl.europa.eu

[58] Source: www.seco.admin.ch

standardization and make the adjustments (approvals) at the early stages to not to lose the access to the international markets. To increase awareness about the standardization processes, companies could consider participation in focused groups, associations, where all the technological developments are discussed on the regular basis on national (e.g. DIAS[59], SAAM[60], Autonomous Ground Vehicle network), and international levels (e.g. IAS, ATOS, Robotics and Autonomous Systems). Additionally, it is crucial that the *"effective communication channels, both formal and informal are established, to share progress, challenges, and opportunities among stakeholders"*. These networks would enable companies to share experiences and raise awareness of common issues at national and global scale.

5.6.3.2 Provide favourable environment for testing

The autonomous system technology requires space and infrastructure to be tested on. Together with the simplified regulatory framework (see section 5.6.2.3), government bodies and big companies should allow entrepreneurs to test their technology in the close to real conditions environment to insure the credibility and validation of the results: *"facilitate the opportunity for pilot testing projects on the public roads or on the field", "introduce regulatory sandboxes or pilot programs that allow companies to test and develop autonomous systems under controlled conditions, providing insights for refining regulations"*. Simulations could be very helpful at development stages, but at some point, not sufficient. For these purposes, Swiss government could consider providing a secured, protected environment, where the technology could be freely tested on the public roads, constructing sites or other environment suitable for the technology application domain. For instance new initiatives as LINA[61] (consortium of academia and industry partners founded with the help of the Canton Zurich) and Innovation Park Dübendorf[62] provide spaces to test autonomous systems. However, these projects are very new and still need time to be fully developed to be able to accommodate all kinds of advanced technologies and companies. Closer collaborations with customers-organizations, public

[59] https://droneindustry.ch/

[60] https://www.saam.swiss/

[61] https://www.lina-switzerland.ch/

[62]https://www.switzerland-innovation.com/zurich/de

institutions would enable easier access to test environment, premises and end-users. Moreover, early sales could determine the demand and provide with testing facilities (Gbadegeshin et al., 2022).

5.6.3.3 Adapt existing infrastructure for new technology

The existing infrastructure might be not suitable for the new technology adoption. Government (policy makers, urban planners) and Industry should work together on redesigning physical and communication spaces to be more adapted to autonomous systems deployment. This also involves the restructuring of the traffic management and additional education of the road (air) operators to deal with the highly complex environment: "*stronger support hardware and software", "5G coverage everywhere".* Furthermore, additional safety and security measures should be introduced to comply with the liability and legal frameworks. Infrastructure will evolve as AS technology matures, and requirements will also vary depending on the specifics of urban environments (Soteropoulos et al., 2020). Moreover, an integrated policy framework could be developed to prioritise safety, efficiency and accessibility when integrating autonomous systems alongside conventional technology (cars), public transport commuters and pedestrians (Manivasakan et al., 2021).

5.6.3.4 Strengthen competence and organisation

Technology complexity requires multidimensional academical and applied skills. It is important that companies constantly learn new skills to stay competitive. It is essential that innovators continue to experiment and learn to develop and introduce more efficient, robust and safer products (Landscheidt et al., 2018). The technical skills could be combined with the organisational skills for more effective collaboration between startups and other multiple stakeholder groups: *"important is the combination of the technology, but also the management expertise*", "*launch joint research initiatives that address complex, interdisciplinary challenges, encouraging experts from various domains to collaborate on innovative solutions."* The technical competence can be strengthened through the collaborations between

corporates and startups[63], participation in joint projects (incubators, accelerators). Additionally, universities and research institutions could consider adapting the education system to the new market demands. Universities and companies could also consider promoting additional educational programs, scholarships, and partnerships to attract and retain qualified professionals.

5.6.4 Go -to -market strategy

Responsible groups: Startup – Industry – Government

5.6.4.1 Promote strategic partnerships

Public-private partnerships contribute to the success of entrepreneurial business models and can be beneficial to the ecosystem. Corporates have an important responsibility, as have an influence on both demand and high-tech supply, create economic value and have the power to solve the foreign technology dependency problem (Megret, 2021). Established companies have significant resources but might lack of innovators, whereas startups have many great innovative ideas, but lack the access to growth capital. Strategic partnerships could be beneficial for both parties. Startups and industrial companies could consider a hybrid value proposition strategy based on niche focus, establishment of commercial partnerships and/or acquiring partners in downstream value chain (Kiefer & Clarysse, 2011). To gain trust and possibilities to collaborate with big leaders, startups could concentrate on adding values to the core businesses of these companies and to be able to solve their customers needs.

Partnerships with venture firms (CVCs) and big corporates could contribute to entrepreneurs in terms of technical validation on full-scale infrastructure, product purchasing, joint solution development, access to marketing channels, providing brand awareness, and most importantly, assure credibility and trust among stakeholders: "*by building partnerships with more mature, well-known companies, would increase their credibility".* This would also foster a collaborative ecosystem, where companies and startups leverage each other's strengths through

[63] https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/collaborations-between-corporates-and-start-ups

mutual incentives, shared resources, and open communication. Established companies as well as the public sector could help startups in technical tests and tenders to enter the global market (Megtet, 2021). A commercial contract with those companies, and technological validation can be more valuable than funding for entrepreneurs.

Establishing other partnerships could be also beneficial for the ecosystem development allowing resources, knowledge exchange, strengthening the stakeholders' capabilities and awareness: *"facilitate partnerships between academia, industry, government, and non-profit organizations to leverage each sector's strengths and resources for mutual benefit*", "*foster partnerships between the government, private sector, and academia to pool resources, share expertise, and jointly address regulatory challenges*." For instance, involvement in commercialization project with a public organization can lead to big purchases (Gbadegeshin et al., 2022).

5.6.4.2 Adaptive, client-centric business model

The main value propositions of the startups are usually new added value and/or cost savings. A successful business model combines technical potential with the realization of economic value. The business model should meet the challenges of the ecosystem, be adaptable to the constantly changing environment and have an appropriate customer-centric strategy (Tuominen et al., 2022). However, a good business model cannot guarantee high company performance due to dependence on a tight competitive market. The company's efficient business model can be combined with a value-enhancing strategy (differentiation, lower costs) to increase the chances of survival (Leppänen et al., 2021).

What customers expect might not align completely with the current technology and products. It is important that the business model is able to adapt to ecosystem changes without big losses. That is why, entrepreneurs should continuously assess market trends to align the business model accordingly (Najmaei, 2016). This could involve pivoting the product, target market, or the whole business strategy. Autonomous systems could benefit when companies producing sensing components focus on improving their core businesses, while hardware manufactures experiment with different upstream components to innovate the design (Ganco et al., 2020).

Customers are the most important stakeholders in the value proposition chain and ecosystem. It is crucial that companies stay always agile and client-oriented: *"technology has to be something that is solving a problem for customer in an efficient way"*. Close collaborations with industries would help in a sense that entrepreneurs receive the access to the markets and the customer pool. The critical success factor would be acquiring and retaining credibility with customers and partners. Implementing a continuous feedback loop with clients and stakeholders would facilitate understanding the evolving needs (Kanban workflow, Agile methodology). Incorporation of advanced analytics and AI would help to personalize experiences, prioritize flexible organizational structures; agile methodologies can foster a culture of adaptability and learning, ensuring that services and products evolve in alignment with client expectations and market dynamics.

5.6.4.3 Focus on adding value

In the context of autonomous systems, a value-adding strategy involves integrating advanced technologies and methodologies to enhance system capabilities, reliability, and efficiency, while ensuring user-centric design, continuous learning from operational data, and robust safety, positioning the system as a reliable technology for its intended applications. To be more competitive, companies need to demonstrate more use cases that would bring benefits to customers and have a positive impact on society (see also section 5.6.4.2). Startups may focus on a niche market, a unique product offering, choosing either product differentiation to meet specific needs, or a cost leadership strategy by offering the lowest price (Porter, 1985), continuously interacting with customers through interactive collaborations to understand their daily challenges and needs (Andries et al., 2021). Periodically feedback should be gathered from users and stakeholders, ensuring that the system continues to meet and exceed expectations, and making necessary adjustments. Learning the needs help to shape the product for particular industry niche and offers guidance on monitor changes in the market and evaluate the product-market-fit (Hannah & Eisenhardt, 2018). The timing of market entry is very important for an emerging industry. Companies could compete by creating a dominant design and/or dominant category (products that meet similar needs and can compete in the same market niche) (Suarez et al., 2015). At the country level, entrepreneurs could promote the

unique Swiss historical image of quality and precision and focus on niche products in which they excel (e.g., drone industry, autonomous robotics, control systems).
Political neutrality gives Switzerland more advantages, especially in times of geopolitical instability (US vs China trade band), when Switzerland can still trade more freely with different countries. Thanks to Swiss unique historical geopolitical reputation, high competence in various fields and the availability of highly qualified personnel, Switzerland can be turned into an international hub of AS technology.

5.6.4.4 Go international

Fostering partnerships with international institutions, research organizations, and industry can bring diverse perspectives to startups, global best practices and visibility. Global presence and competitiveness can stimulate the domestic ecosystem's growth.
Government could support Swiss Industry by increasing the country footprint on a global market, actively participating in international, EU trading forums, establishing partnerships, jointly developing policies and introducing incentives that would encourage entrepreneurs to expand their operations globally. This could include trade agreements, subsidies, or international trade missions. Businesses and government agencies can be first and critical customers and references for Startups (e. g. NASA in Silicon Valley), especially in the early stages to bridge with international markets and provide credibility.

5.6.5 Stakeholders engagement strategy

Responsible groups: Industry – Startups – Academia – Government

5.6.5.1 Define framework for open innovation

Sorensen and Stuart (2000) argued that as firms grow old and establish long-standing routines, they become gradually insulated from external technological developments and concentrated more on optimisation of internal processes. From the other hand, companies that continue to invest in their innovative capabilities also in crisis continue to grow in returns (Chesbrough, 2002). Open innovation allows intellectual property, ideas and people to flow freely within and

across organizations (Chesbough, 2018). Enabling open data sharing and transparency provides stakeholders with important tools, resources that they could use to build on their products accelerating collaborative efforts and innovation. However, intellectual properties protection often prevents collaboration and forces companies to conduct their development in isolation, which can lead to *"reinventing the wheel"* and being late to market. To overcome this barrier, companies could develop codes of conduct, introduce a clear and effective collaborative framework to regulate product co-development, including the resolution of intellectual property issues and liability concerns. Management could also provide explicit guidance and maintain momentum to keep the team motivated and focused: "*clearly define and communicate a shared vision for the ecosystem's development, fostering a sense of purpose that aligns stakeholders towards common goals."* Alignment of goals is crucial across different stakeholders (Adner, 2017). Regular reviews and feedback as well as orchestration of stakeholders' goals with shared value activities (Valkakokari et al., 2017) can ensure alignment and progress towards the mutual ecosystem goals (Autio, 2022; Walrave et al., 2018, Jacobides et al., 2018). Adaptive ecosystem strategy framework could facilitate in open innovation development within the ecosystem (Furr & Shipilov, 2018). Although the ecosystem is a complex system, it always has a mechanism of self-organizing based on interactions between the actors and their interconnected activities (Phillips & Ritala, 2019).

5.6.5.2 Promote networking

Complex networks can generate innovative solutions, determine the creation of new knowledge, while dense social ties, regular face-to-face contact make economic exchanges possible (Thompson, 2004). One of the identified key success factors of Silicon Valley ecosystem is a dense and dynamic network of stakeholders. What sets this ecosystem apart is *"its complete and robust complex system of innovation supported by social networks of independent economic agents in which the venture capital firms have a specific function"* (Ferrary & Granovetter, 2009, p. 326). For some companies, the social network in Silicon Valley has been recognized as the most important factor contributing to a company's success and the primary reason for relocating to the region. For instance, by participating in networks companies could recruit the team members, secure R&D agreements with customers, raise fund

and gain access to the valuable data. Strogatz and Watts (1998) noted that the structure of a network affects its dynamics, where the probability of interaction between agents is higher if their interdependence is high (complex network theory (CNT)). Albert and Barabasi (2002) suggest considering the economy as a complex network with firms as nodes and various economic and financial ties as links connecting them. For instance, entrepreneurship and innovation is understood as the result of the interaction of numerous economic agents. Players who are linked by friendship (social tie) can become business partners to create a company - economic ties (e.g. Google, PayPal, Apple) (Gold, 2018).

Promoting a vivid collaboration between entrepreneurs, as well as between public and private entities can support in ecosystem growth, accelerate the development and deployment of autonomous systems: *"establish regular forums, conferences, and workshops that brings together stakeholders from academia, industry, government, and international partners to facilitate networking and idea exchange."* Industry connects with startups and universities to leverage their innovativeness, while entrepreneurs gain expertise and market share. Moreover, networking can build strong, trust-based relationships between startups and enterprises.

5.6.5.3 Introduce incentives to attract and retain stakeholders

To create a supportive environment for open collaboration and co-development processes between corporates and startups, government could consider establishing legal frameworks that facilitate innovation and protect intellectual property rights (also see section 5.6.5.1). The frameworks should clearly define how startups and industrial enterprises collaborate while protecting their intellectual property. Swiss government should consider the impact of taxation and adjust accordingly to make it more attractive for new ecosystem members to enter. For instance, Canton could reduce the taxes at the initiate stages of collaboration between companies and startups and come back to normal taxation when the project reached its maturity: *"need the rollout phase lower the taxes to attract many companies so that they start, then we can raise the price make the taxes as they were"*. Other incentives could aiming the mutual goals alignment; demonstrating the social or environmental impact; providing certain privileges or exclusive access to products, services, or information; involving influencers, that

would lead to higher visibility and credibility; offering equity or ownership stakes; showing high potential for innovation or growth.

To retain entrepreneurs and avoid the threat of their leave to work for big corporates or other countries, responsible authorities could consider introducing a comprehensive tax strategy for entrepreneurs that would provide a tax relief in the early stages of the business, e.g. incrementally increasing taxes once, the companies become profitable. Government could also consider providing secure loans for those who start the venture.

Moreover, in the open innovation culture, the free movement of talent (Silicon Valley) is very important for ecosystem dynamics. The country could derive significant benefits from highly skilled foreign workforces. Streamlining the work permit process, including for non-EU talent, would facilitate the internationalization and diversification of the ecosystem, further enhancing its potential.

5.6.6 Change mindset strategy

Responsible groups: Academia – Government – Startups – Industry

5.6.6.1 Build entrepreneurial mindset

The ecosystem needs a critical mass of people that are seeking competition, challenge, new opportunities, rather than normal monetary motivation.

Encouraging entrepreneurship can lead to the creation of more high-quality startups, which in turn can attract more investors and industrial leaders. Swiss high-tech startups are often founded by younger entrepreneurs with average age 27[64]. The ventures are made up of highly qualified and experienced teams, however, the interview results showed that there is a lack of business, sales and marketing skills. To promote a culture of entrepreneurship universities and government could provide with more mentorship programs, collaborative spaces, where entrepreneurs would get the support from more experienced professionals. Universities and research institutions could develop specialized training programs for entrepreneurs to leverage

[64] https://www.startupticker.ch/en/news/swiss-entrepreneurs-secure-a-spot-in-the-forbes-30-under-30-europe-list

their presentation, commercial and managerial skills (e.g., MAS MTEC, MTEC Mentoring programme[65], ETH Entrepreneur Club[66]). Several studies (e.g., Jain et al., 2009; Hayter et al., 2018) have highlighted the need for academics to develop an entrepreneurial role identity, a need to start seeing themselves not only as a scientist, but also as an entrepreneur. Government could be also involved in those programmes. For instance, Singapore government recently launched SGInnovate[67] focusing on deeptech space, where entrepreneurs are brought together with private sector partners, educational institutions, and research organizations, so they can provide mentorship, assist with business plans, securing funding, and help get products to market.

Additionally, the ecosystem must be willing to accept visionaries with ambitious dreams that can be easily shared. Experimentation and iteration between different players could be also encouraged. It is essential that there is a social acceptance of trying and failing, and that people in the ecosystem demonstrate a willingness to help others (Hwang & Horowitt, 2012, *Silicon Valley success factors*).

5.6.6.2 Learn from heroes

MIT study[68] showed that entrepreneurs in US start their business in average at 45 years and the success rate increases with the age and professional experience. Considering that Swiss entrepreneurs are much younger (see section 5.6.6.1) and there are not too many success stories yet, it would be beneficial for them to participate in international networks, where more experienced entrepreneurs share their success/failure stories and where they could learn. To motivate entrepreneurs to "*think big*", they should interact more with the serial and successful entrepreneurs, to be able to learn from their stories and get inspired.

Companies and universities could facilitate by inviting the "heroes", unicorns, successful entrepreneurs to participate in interactive workshops and seminars with Q&A sessions.

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[65] https://mas-mtec.ethz.ch/education/special-programmes/mentoring-programme-mas.html

[66] https://www.entrepreneur-club.org/

[67] https://www.sginnovate.com/

[68] https://hbr.org/2018/07/research-the-average-age-of-a-successful-startup-founder-is-45

5.6.6.3 Build the right team

One of the key success factors for the company is to find the right team, to be able to *"bring real builders into the spotlight*". The more diverse the pool of the expertise within the startup, the more powerful and competitive the venture in the market: *"create diversity, invest in people. Success is about attract the people and making sure they have the right environment"*. A high extent of diversity in the ecosystem and possibilities for these diverse people to meet up is regarded as vital (Hwang & Horowitt, 2012, *Silicon Valley success factors*). The core of this is diversity of knowledge, rather than the gender, age, or culture. Integrating diverse expertise from different disciplines can be challenging, but very critical for a company success engaging with AS.

Startups could consider hiring members with various backgrounds, experience and of different nationalities who would share same values and goals. It would be beneficial to be able to assess current team's skills and identify where the gaps are. This would give a better understanding of what additional talent needed to bring on board. A strong leadership can set the direction, inspire the team, and foster success. Moreover, regular constructive feedback and recognition can keep the team motivated and engaged (Burgers et al., 2015).

5.6.7 Increase awareness strategy

Responsible groups: Public – Government – Industry – Startup -Academia

5.6.7.1 Show the value to public and impact on society

Positive public perception and acceptance of AS motivates entrepreneurs, companies and investors to participate in the development and deployment processes that is strengthening the innovation ecosystem. Moreover, *"public engagement allows for the correction of misconceptions and misinformation about autonomous systems, enabling more accurate discussions and decisions."*

Startups should be prepared to bring their technologies to the public: *"show working technology on the streets"*. At the same time, technology must bring positive impact to environment and sustainability to gain the credibility among public: *"show that what we are doing is relevant, innovative, will have a big impact on the society"*. Various campaigns could

be launched to emphasize the importance of innovation and the role that it can play in their lives (Koning et al., 2022; Zhou et al, 2015). *"Public awareness campaigns help demystify autonomous systems, clarifying their capabilities, benefits, and limitations. This transparency builds trust and reduces apprehensions about new and unfamiliar technologies*." Public could be engaged in participation in demonstrations, co-creation, testing trials. For instance, company Volvo initiated a project "Drive Me", where autonomous vehicle could be tested by 100 families for their daily commute. This campaign increased technology awareness and helped to collect feed-back from the public (Pushpananthan & Elmquist, 2022)

Government and Academia could increase awareness and acceptance by launching publicly accessible educational initiatives (seminars, workshops) to improve general understanding and acceptance of autonomous system technologies: *"pro-actively educating the public regarding privacy concerns, safety and noise issues".* Programs can educate public about safety measures and technology capabilities to mitigate the concerns and fears. *"Informed citizens are more likely to view these technologies as safe and reliable".* To achieve trust, there must be open communication about the goals and the purposes of the technology, moreover, *"engaging the public in discussions about ethical considerations, such as decision-making algorithms and potential societal impacts, ensures that autonomous systems are developed with a sense of responsibility and aligned with societal values".* Transparency about risks, challenges, and how companies addressing them could increase technology acceptance.

5.6.7.2 Ensure credibility

To increase public acceptance of autonomous technologies, concerns about safety, privacy, and ethics must be addressed. Organizing workshops, seminars, and public awareness campaigns can address safety and ethical concerns and build trust in autonomous systems.

Academia and government could endorse and support credible projects to enhance public trust: *"show that the technology is reasonably safe, provide affordable service, convenience and reasonable price", "show that a credible company (state) stand behind the project, as a reassurance of the risks. If there is a trusted name or government behind, the level of trust to technology is increasing".* This could include providing entrepreneurs with funding, offering policy support, or partnering with projects on public-facing initiatives. Swiss government could

also support in providing facilities and space, where startups could showcase new technologies. Collaboration with users essential for developing autonomous systems that meets real-world needs. Engaging with public, policy makers, and other stakeholders can help ensure that autonomous systems are designed with safety, reliability, and ethical considerations in mind. In addition, *"by fostering a culture of engagement, regions can establish a foundation for long-term acceptance of autonomous systems, paving the way for their integration into daily life"*.

5.7 Strategies roadmap

As a concluding step, I recommend mapping out strategies based on their complexity and the time needed for implementation (see Figure 25). The third quadrant represents the most complex and time/resource-intensive strategies. The challenges associated with these strategies are of the highest importance (see Figure 17). This quadrant requires more attention from strategists and should have the highest priorities in terms of implementation.

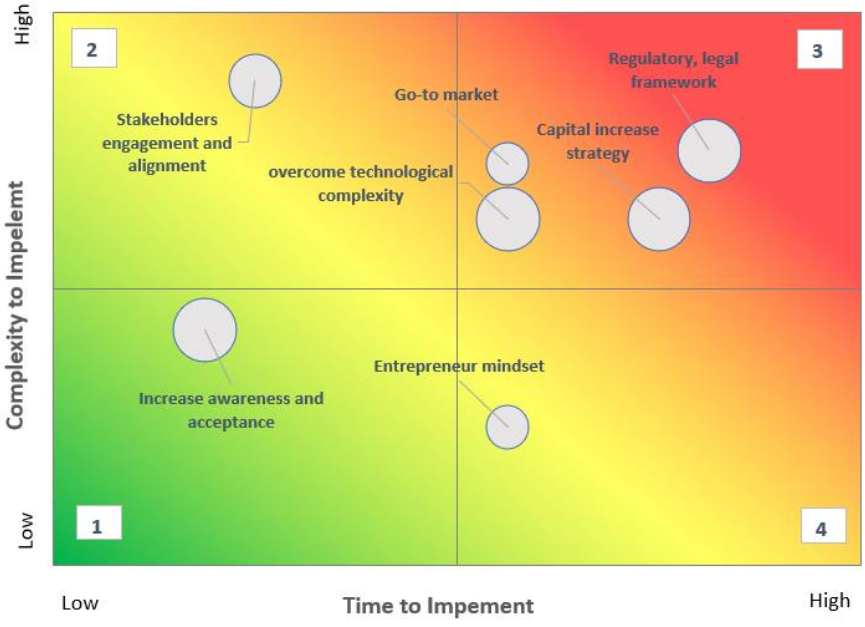

Figure 25. Strategies Implementation complexity and time demand

Regulatory framework, capital raise, and market entry strategies are the most time and effort consuming. However, when the all necessary steps are taken to engage stakeholders, improve technology complexity, and change mindsets, the overall ecosystem dynamics will evolve. Technology adoption and awareness will increase gradually, depending on the overall development of the innovation ecosystem.

In the course of implementation of the strategies, it is essential to understand and take into considerations the objectives and the values of each stakeholder. The harmonization of those needs at each step would significantly increase the positive dynamics of the ecosystem. Conversely, unresolved conflicts of interests would drop the performance and motivation. Alberti and Belfanti (2019) demonstrated through real-case applications that shared value is created in clusters if there is a common agenda, a backbone structure, mutually reinforcing activities, a shared measurement system and a constant communication among stakeholders.

6 Conclusion

Autonomous systems are a key future technology that will change the economy and transform society in the coming years and decades (Goddard et al., 2021). This market will scale already within 5-10 years[69] and there is a great potential for Switzerland to take a leading role in this industry. The future of autonomous navigation systems market is expected to grow from $6 billion to $12.9 billion by 2028)[70] , the global drone market demand will grow to CHF 37.6 billion in 2026. This growth is driven by various factors such as technological advancements, increasing focus on sustainability and environmental responsibility.

In order to remain competitive, Switzerland needs to strengthen its historical advantages based on passion to high precision, high quality technology, excellent skilled personnel, diverse culture, stable and liberal political system and attractive quality of life. Government should actively promote research and development (R & D) activities, establishing so-called

[69] https://www.dhl.com/global-en/delivered/sustainability/top-trends-in-sustainable-logistics.html

[70] researchandmarkets.com

“Sandboxes”, allowing innovative companies to test their products and services, and business models in a live environment, and Investors should be willing to take risks investing in promising Startups.

Canton of Zürich has rich innovation ecosystem in autonomous systems, largely due to the efforts of top universities, research Institutions, financial support from private-public sector and culture of excellence. Government entities serve in roles that stimulate and facilitate these efforts. Recognizing the significance of innovation ecosystems and its challenges is crucial foundation for strengthening the innovation Canton and the Country. The growth of Innovation fund, supportive regulatory framework and entrepreneurial mindset has the potential to significantly enhance the ecosystem prosperity.

Successful integration and adoption of autonomous systems in Canton of Zürich relies on multifaceted alignment between technological advancements, effective and equitable business structures, comprehensive standardization, supportive government policies, robust financing models, and strategic utilization of the country's industrial and manufacturing strengths. The transformation of this complex landscape necessitates active collaboration among tech developers, academia, industry, local authorities, and government bodies. Furthermore, demonstration of the technology's practical value through real-world projects can enhance social acceptance and market viability.

6.1 Contributions

Research contribution has been made towards understanding of the innovation ecosystem functioning, particularly in relation to emerging technologies as autonomous systems. An extended Triple Helix and Technopolis Wheel model was proposed consisting of Six Helices – micro ecosystem offering a tool for assessing the state of the art and dynamics of innovation ecosystems built around emerging technology. Figure 26 shows the proposed model, that was applied to describe the Innovation Ecosystem of the Canton of Zürich, revealing the key players and their relations within the ecosystem.

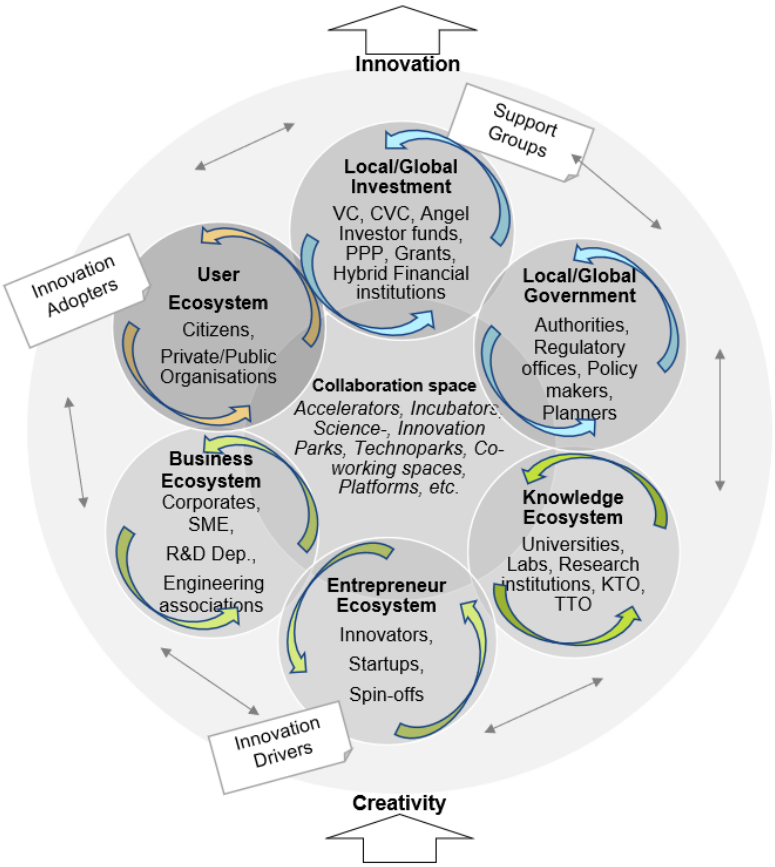

Figure 26. Six Helix Model of Innovation Ecosystem

Each ecosystem's helix represents the micro ecosystem that corresponds to the core activities of each stakeholder group, i.e. Academia – Knowledge creation Ecosystem (KE), Startups – Entrepreneurial Ecosystem (EE), Industry – Business Ecosystem (BE). Business Ecosystem is organised as complex network of companies developing product and focusing on addressing the needs of customers (Clarysse et al., 2014). BE provides Entrepreneurial Ecosystem with resources, client pool and expertise to navigate in constantly changing and highly competitive environment. The Knowledge Ecosystem is a hotspot built around universities and research institutions playing a central role in advancing technological innovation together with innovators, facilitation tacit knowledge flow as well as attractiveness of new talent (Saxenian, 2006). Government and Investor groups are the facilitators (fuel) of the innovation ecosystem who has the power to influence its development and growth. User Ecosystem is the society for whom the whole ecosystem was created, they create the need and demand for new technology.

In compliance with the definition given by Klimas & Czakon (2022, p.6) this model of Innovation Ecosystem represents a *collaborative environment involving the innovation activities of the co-evolving actors-micro ecosystems of entrepreneurs, government, investors, industries, academia and users, organized across co-innovation processes of autonomous systems, and resulting in co-creation of new value delivered through innovation*.

This approach can serve as a blueprint for other regions aspiring to create, assess and improve their innovation ecosystems. The study provides insights into the driving forces and challenges influencing the development and success of the innovation ecosystem. The results showed the impact and importance of various barriers for diverse stakeholder groups, as well as weak links within the ecosystem. A set of key indicators was proposed along with a model to measure the performance of the innovation ecosystem. The approach, when further developed, allows monitoring progress and guiding future development efforts of the entities involved in the ecosystem.

Lastly, an action plan of strategic framework of seven strategies responding to the ecosystem challenges was suggested, designed based on ecosystem Stakeholders' insights and the extensive literature review and benchmark aiming to nurture the growth of the innovation ecosystem.

In overall, findings have revealed the current state of the ecosystem development in the Canton of Zürich. Knowing the challenges and success factors of the ecosystem can support Stakeholders and strategists to take effective actions towards the ecosystem improvement contributing to economy and market competitiveness growth. The proposed guidance and strategy framework can facilitate in this endeavour.

This research can complement or extend the recent study (Gbadegeshin et al., 2022) proposing strategies framework to overcome the Valley of Death for technology-based companies.

6.2 Limitations and future work

The subject of innovation ecosystem development is very broad and requires more in-depth research and analysis. The results of this study are based on the data obtained from a sample of 25 interviews and 1 workshop observation. This may not be representative for all aspects

of the ecosystem evaluation. The derived findings might not depict the full diversity of stakeholders' views towards the ecosystem. Furthermore, stakeholder group - Public was only indirectly participating in the analysis. Also, the analysis of the relation between Industry and Investor groups was out of the scope of this study.
In the course of the data analysis, one more key stakeholder was identified, who did not participate in the interview sessions – Insurance (re insurance) companies. The importance of this actor role might gradually increase when the Autonomous Systems are widely adopted.

In the future work, in order to overcome the limitations of this study, more comprehensive and extensive research needs to be undertaken. A future work could be devoted to a large-scale qualitative study to test the hypotheses, model generated by this research. For example, surveying, interviewing a larger number of stakeholders across different regions could provide more insights into the dynamics of innovation ecosystems. For more generalized results, a sample of stakeholders should be extended including Society group (End-users/Citizens, Customer/Organisations), as well as Insurance company group. A broader scope and examination of a diverse range of stakeholders may provide further complementary insights.
For future research, it would be beneficial to investigate the Innovation Ecosystem functionality at the country level to assess Switzerland's competitiveness on a global scale, applying extended evaluation model and complex network theory (Barabasi, 2002). This would involve a deeper examination of the roles and contributions of each entity into ecosystem and the dynamics of their interactions with each other. The future work could also investigate the specific ways how governments, entrepreneurs, universities, and corporations could foster an environment that is more conducive to innovation. This could include studying best practices from different regions, ecosystems, and exploring the effects of different policies and initiatives. It would be also important to focus on understanding the specifics of the risk averse behaviours in certain stakeholders and work on strategies to change this mindset. This study could provide valuable insights for innovative entrepreneurs and companies seeking to operate in a more dynamic environment. Furthermore, each proposed strategy can be elaborated independently as a separate research question with more detailed evidence and extensive case studies.

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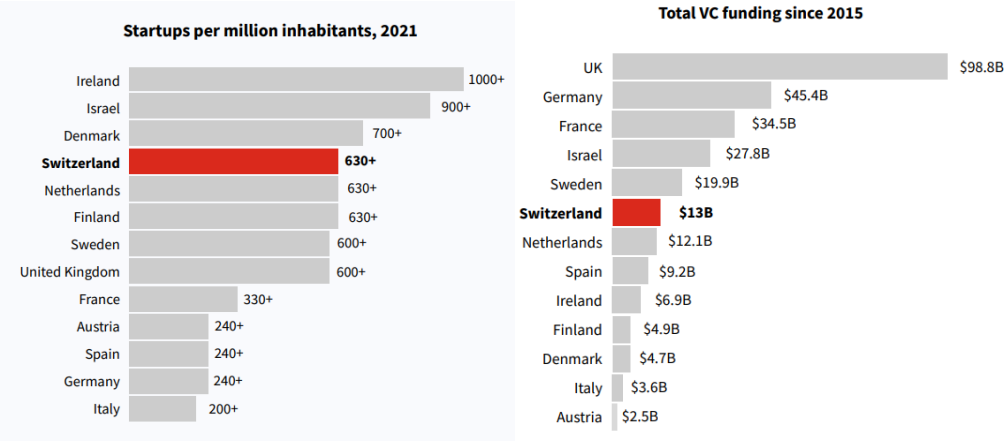
Appendix



a b

Figure A1. Density of Swiss startups (a), Total VC funding since 2015 per country(b)

Source: dealroom.co, The Swiss startup ecosystem in numbers (2021)[71]

R & D intensity indicators

	Key indicators (2019)				Ratios			
	Inhabitants millions	GDP billions $	R & D billions $	VC billions $	R & D ($) / capita	R & D / GDP	VC / GDP	VC / R & D
Switzerland	9	708	24	2.6	2,799	3.4%	0.4%	11%
Israel	9	387	18	8.3	1 956	4.6%	2.1%	47%
USA	331	21,428	579	136.5	1 748	2.7%	0.6%	24%
South Korea	52	1,642	76	3.7	1 453	4.6%	0.2%	5%
Japan	126	5,082	163	2.6	1 291	3.2%	0.1%	2%
Germany	83	3,846	119	5.7	1 436	3.1%	0.1%	5%
Singapore	6	372	7.1	8.1	1 220	1.9%	2.2%	114%
Netherlands	17	909	20	0.9	1 176	2.2%	0.1%	4%
Sweden	10	556	18	1.7	1 835	3.3%	0.3%	9%
France	67	2,716	60	5.5	892	2.2%	0.2%	9%
UK	66	2,827	48	13.2	728	1.7%	0.5%	27%
Italy	60	2,001	26	0.6	434	1.3%	0.0%	2%
China	1,400	14,343	316	40	225	2.2%	0.3%	13%

Figure A2. R&D intensity indicator. Source: (Megret, 2021)

[71] https://dealroom.co/blog/the-swiss-startup-ecosystem-in-numbers

Table A1. Startups Ecosystem Canton Zürich (Source: Crunchbase[72])

Company Name	Total raised M, CHF	Product Type	Year found	N of rounds	Serie	Lead Investors
Verity	81	drone	2014	5	B	*Fontinalis Partners (US), A.P. Moller Holding(DK), Kitty Hawk (US)*
Wingtra	43,9	drone	2016	9	B	*Wingman Ventures(CH), European Innovation Council(BE), VentureOut (US)*
ANYbotics	70	robots	2016	3	B	*NGP Capital (US), Walden Catalyst(US), Innosuisse (CH), Swisscom Ventures(CH)*
Daedalean	72,5	drone	2016	7	B	*Carthona Capital(AU), SICTIC(CH), EASME - EU Executive Agency for SMEs (BE), Innosuisse (CH)*
Fotokite	25,6	drone	2014	12	B	*MSA Safety(US), Credit Suisse (UBS) (CH), GENIUS NY(US)*
Sunflower Labs	21,1	drone	2016	4	B	*General Catalyst(US), Stanley Ventures(US), Social Discovey Group(US), Drone Fund(JP)*
Scewo	15,3	robot	2017	6	B	*Verve Ventures(CH), Venture Kick(CH), ZKB(CH), Wingman Ventures (CH)*
Embotech	15	AV	2013	7	B	*Zürcher Kantonal Bank(CH), Conzzeta(CH), VentureOut(US), ZF Group(GE), European Innovation Council(BE), Innosuisse(CH)*
Nanoflex Robotics	15	robot	2021	2	B	*Innosuisse(CH), Mountain Labs(CH), Ascend Capital Partners(Hong Kong), Kinled Holding(US)*
Auterion	10	drone	2017	2	Seed	*Lakestar(CH), Tectonic Ventures(US), Costanoa Ventures(US), Mosaic Ventures(UK)*
Fixposition	8,8	AV	2017	8	Seed	*Venture Kick(CH), True Ventures(US), Segway-Ninebot(US)*
Seervision	8,8	robot	2016	8	M&A	*Verve Ventures(CH), Venture Kick(CH), European Innovation Council (BE)*
Sevensense	7,7	robot	2018	3	A	*ABB Technology Ventures (CH), Venture Kick(CH*
Voliro	2	drone	2019	3	Seed	Venture Kick(CH), Alpana Ventures(CH), BackBone Ventures(CH)

[72] https://www.crunchbase.com/

AMOUNT INVESTED Industries	2019	2020	2021	2022	2023
health	$868m	$1.3b	$1.7b	$802m	$620m
robotics	$43.4m	$55.3m	$57.7m	$199m	$373m
fintech	$346m	$274m	$684m	$788m	$178m
energy	$158m	$136m	$190m	$1.1b	$80.8m
semiconductors	$65.9m	$51.6m	$80.5m	$118m	$29.7m

Figure A3. Investment by Industry Switzerland

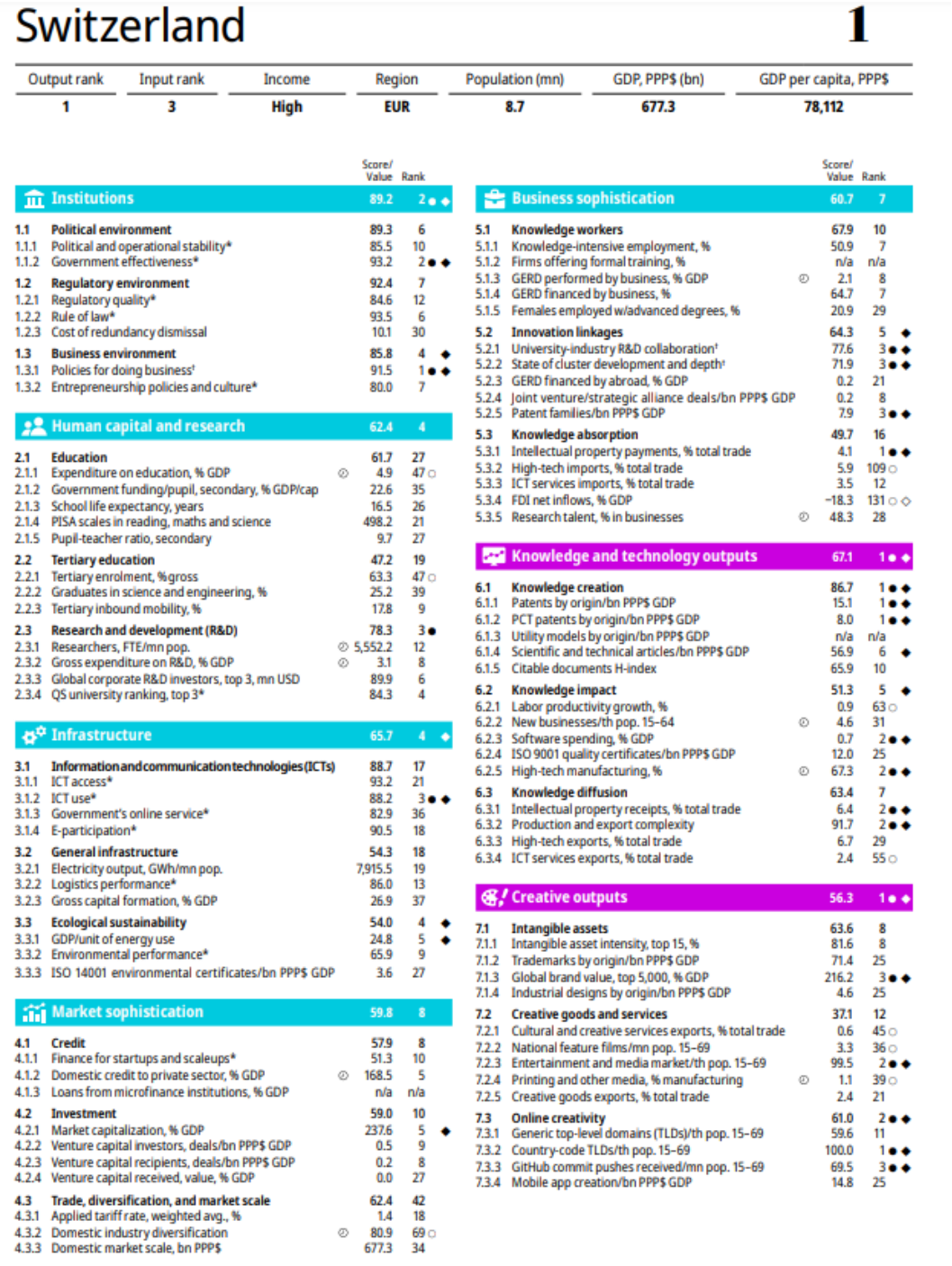
AMOUNT INVESTED Industries	2019	2020	2021	2022	2023
health	$87.5m	$284m	$306m	$195m	$174m
robotics	$31.2m	$42.6m	$33.3m	$94.9m	$173m
fintech	$159m	$123m	$117m	$51.1m	$99.7m
energy	$2.5m	$7.0m	$12.4m	$25.6m	$29.5m

Figure A4. Investment by Industry Canton Zürich

AMOUNT EXITED Locations	2018	2019	2020	2021	2022	2023
United Kingdom	$105.0b	$95.3b	$90.5b	$143.8b	$58.9b	$28.8b
Ireland	$8.4b	$752m	$2.4b	$12.2b	$38.2b	$2.0b
Germany	$22.2b	$23.7b	$66.6b	$57.3b	$29.1b	$19.3b
Netherlands	$17.7b	$14.9b	$9.2b	$23.4b	$19.9b	$3.8b
Sweden	$17.2b	$6.3b	$11.0b	$23.7b	$19.5b	$846m
France	$14.6b	$10.1b	$15.8b	$28.9b	$18.7b	$10.6b
Switzerland	$9.1b	$12.0b	$14.0b	$23.8b	$3.2b	$5.5b

Figure A5. Exits value per country

Source: Dealroom.com



Switzerland 1

Output rank	Input rank	Income	Region	Population (mn)	GDP, PPP$ (bn)	GDP per capita, PPP$
1	3	High	EUR	8.7	677.3	78,112

		Score/ Value	Rank
Institutions		**89.2**	**2**
1.1	**Political environment**	**89.3**	**6**
1.1.1	Political and operational stability*	85.5	10
1.1.2	Government effectiveness*	93.2	2
1.2	**Regulatory environment**	**92.4**	**7**
1.2.1	Regulatory quality*	84.6	12
1.2.2	Rule of law*	93.5	6
1.2.3	Cost of redundancy dismissal	10.1	30
1.3	**Business environment**	**85.8**	**4**
1.3.1	Policies for doing business[1]	91.5	1
1.3.2	Entrepreneurship policies and culture*	80.0	7
Human capital and research		**62.4**	**4**
2.1	**Education**	**61.7**	**27**
2.1.1	Expenditure on education, % GDP	4.9	47
2.1.2	Government funding/pupil, secondary, % GDP/cap	22.6	35
2.1.3	School life expectancy, years	16.5	26
2.1.4	PISA scales in reading, maths and science	498.2	21
2.1.5	Pupil-teacher ratio, secondary	9.7	27
2.2	**Tertiary education**	**47.2**	**19**
2.2.1	Tertiary enrolment, % gross	63.3	47
2.2.2	Graduates in science and engineering, %	25.2	39
2.2.3	Tertiary inbound mobility, %	17.8	9
2.3	**Research and development (R&D)**	**78.3**	**3**
2.3.1	Researchers, FTE/mn pop.	5,552.2	12
2.3.2	Gross expenditure on R&D, % GDP	3.1	8
2.3.3	Global corporate R&D investors, top 3, mn USD	89.9	6
2.3.4	QS university ranking, top 3*	84.3	4
Infrastructure		**65.7**	**4**
3.1	**Information and communication technologies (ICTs)**	**88.7**	**17**
3.1.1	ICT access*	93.2	21
3.1.2	ICT use*	88.2	3
3.1.3	Government's online service*	82.9	36
3.1.4	E-participation*	90.5	18
3.2	**General infrastructure**	**54.3**	**18**
3.2.1	Electricity output, GWh/mn pop.	7,915.5	19
3.2.2	Logistics performance*	86.0	13
3.2.3	Gross capital formation, % GDP	26.9	37
3.3	**Ecological sustainability**	**54.0**	**4**
3.3.1	GDP/unit of energy use	24.8	5
3.3.2	Environmental performance*	65.9	9
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	3.6	27
Market sophistication		**59.8**	**8**
4.1	**Credit**	**57.9**	**8**
4.1.1	Finance for startups and scaleups*	51.3	10
4.1.2	Domestic credit to private sector, % GDP	168.5	5
4.1.3	Loans from microfinance institutions, % GDP	n/a	n/a
4.2	**Investment**	**59.0**	**10**
4.2.1	Market capitalization, % GDP	237.6	5
4.2.2	Venture capital investors, deals/bn PPP$ GDP	0.5	9
4.2.3	Venture capital recipients, deals/bn PPP$ GDP	0.2	8
4.2.4	Venture capital received, value, % GDP	0.0	27
4.3	**Trade, diversification, and market scale**	**62.4**	**42**
4.3.1	Applied tariff rate, weighted avg., %	1.4	18
4.3.2	Domestic industry diversification	80.9	69
4.3.3	Domestic market scale, bn PPP$	677.3	34

		Score/ Value	Rank
Business sophistication		**60.7**	**7**
5.1	**Knowledge workers**	**67.9**	**10**
5.1.1	Knowledge-intensive employment, %	50.9	7
5.1.2	Firms offering formal training, %	n/a	n/a
5.1.3	GERD performed by business, % GDP	2.1	8
5.1.4	GERD financed by business, %	64.7	7
5.1.5	Females employed w/advanced degrees, %	20.9	29
5.2	**Innovation linkages**	**64.3**	**5**
5.2.1	University-industry R&D collaboration[1]	77.6	3
5.2.2	State of cluster development and depth[1]	71.9	3
5.2.3	GERD financed by abroad, % GDP	0.2	21
5.2.4	Joint venture/strategic alliance deals/bn PPP$ GDP	0.2	8
5.2.5	Patent families/bn PPP$ GDP	7.9	3
5.3	**Knowledge absorption**	**49.7**	**16**
5.3.1	Intellectual property payments, % total trade	4.1	1
5.3.2	High-tech imports, % total trade	5.9	109
5.3.3	ICT services imports, % total trade	3.5	12
5.3.4	FDI net inflows, % GDP	−18.3	131
5.3.5	Research talent, % in businesses	48.3	28
Knowledge and technology outputs		**67.1**	**1**
6.1	**Knowledge creation**	**86.7**	**1**
6.1.1	Patents by origin/bn PPP$ GDP	15.1	1
6.1.2	PCT patents by origin/bn PPP$ GDP	8.0	1
6.1.3	Utility models by origin/bn PPP$ GDP	n/a	n/a
6.1.4	Scientific and technical articles/bn PPP$ GDP	56.9	6
6.1.5	Citable documents H-index	65.9	10
6.2	**Knowledge impact**	**51.3**	**5**
6.2.1	Labor productivity growth, %	0.9	63
6.2.2	New businesses/th pop. 15–64	4.6	31
6.2.3	Software spending, % GDP	0.7	2
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	12.0	25
6.2.5	High-tech manufacturing, %	67.3	2
6.3	**Knowledge diffusion**	**63.4**	**7**
6.3.1	Intellectual property receipts, % total trade	6.4	2
6.3.2	Production and export complexity	91.7	2
6.3.3	High-tech exports, % total trade	6.7	29
6.3.4	ICT services exports, % total trade	2.4	55
Creative outputs		**56.3**	**1**
7.1	**Intangible assets**	**63.6**	**8**
7.1.1	Intangible asset intensity, top 15, %	81.6	8
7.1.2	Trademarks by origin/bn PPP$ GDP	71.4	25
7.1.3	Global brand value, top 5,000, % GDP	216.2	3
7.1.4	Industrial designs by origin/bn PPP$ GDP	4.6	25
7.2	**Creative goods and services**	**37.1**	**12**
7.2.1	Cultural and creative services exports, % total trade	0.6	45
7.2.2	National feature films/mn pop. 15–69	3.3	36
7.2.3	Entertainment and media market/th pop. 15–69	99.5	2
7.2.4	Printing and other media, % manufacturing	1.1	39
7.2.5	Creative goods exports, % total trade	2.4	21
7.3	**Online creativity**	**61.0**	**2**
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	59.6	11
7.3.2	Country-code TLDs/th pop. 15–69	100.0	1
7.3.3	GitHub commit pushes received/mn pop. 15–69	69.5	3
7.3.4	Mobile app creation/bn PPP$ GDP	14.8	25

Figure A6. Global Innovation Index Source: Report 2022[73]

[73] https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-en-main-report-global-innovation-index-2022-15th-edition.pdf

Switzerland	Performance relative to EU in 2023	Performance change 2016-2023	Performance change 2022-2023
SUMMARY INNOVATION INDEX	**139.6**	**-0.6**	**-1.8**
Human resources	**190.1**	**0.8**	**-4.1**
Doctorate graduates	218.7	11.4	0.0
Population with tertiary education	153.8	-6.0	-6.0
Lifelong learning	199.0	-8.8	-8.8
Attractive research systems	**224.5**	**-3.0**	**-5.5**
International scientific co-publications	274.9	2.5	0.0
Most cited publications	140.4	-17.6	-10.1
Foreign doctorate students	330.5	25.4	0.0
Digitalisation	**136.2**	**0.0**	**0.0**
Broadband penetration	N/A	N/A	N/A
People with above basic overall digital skills	161.5	0.0	0.0
Finance and support	**84.7**	**24.4**	**-0.1**
R&D expenditures in the public sector	128.1	11.3	0.0
Venture capital expenditures	96.2	53.9	-0.3
Government support for business R&D	18.3	11.3	0.0
Firm investments	**150.4**	**4.7**	**0.0**
R&D expenditure in the business sector	144.4	4.6	0.0
Non-R&D Innovation expenditures	N/A	N/A	N/A
Innovation expenditures per employee	N/A	N/A	N/A
Use of information technologies	**134.7**	**7.0**	**7.0**
Enterprises providing ICT training	N/A	N/A	N/A
Employed ICT specialists	136.7	6.9	6.9
Innovators	**131.3**	**-13.7**	**0.0**
Product innovators (SMEs)	128.9	-40.6	0.0
Business process innovators (SMEs)	133.4	14.9	0.0
Linkages	**194.3**	**15.5**	**2.5**
Innovative SMEs collaborating with others	80.4	11.5	0.0
Public-private co-publications	468.0	0.0	0.0
Job-to-job mobility of HRST	170.8	26.5	5.9
Intellectual assets	**133.2**	**-14.2**	**-11.7**
PCT patent applications	147.4	-3.0	-3.0
Trademark applications	124.4	-4.1	-2.5
Design applications	122.0	-36.5	-29.7
Employment impacts	**165.8**	**-5.2**	**0.0**
Employment in knowledge-intensive activities	169.9	0.0	0.0
Employment in innovative enterprises	162.4	-10.1	0.0
Sales impacts	**98.7**	**-9.9**	**0.6**
Medium and high-tech goods exports	74.9	-2.7	0.9
Knowledge-intensive services exports	120.1	10.5	0.8
Sales of innovative products	109.6	-46.4	0.0
Environmental sustainability	**125.0**	**-1.6**	**0.5**
Resource productivity	192.0	11.5	0.0
Air emissions by fine particulate matter	132.6	4.2	0.0
Environment-related technologies	47.6	-17.3	1.4

The second column shows performance relative to that of the EU in 2023. Colours next to

Figure A7. European Innovation Scoreboard (EIS), Source: Report 2022, Regional profiles[74]

[74] https://ec.europa.eu/assets/rtd/eis/2023/ec_rtd_eis-country-profile-ch.pdf

Zürich (CH04)

	Data	Normalised score	Relative to	
			CH	EU
Tertiary education	64.8	1.000	130	190
Lifelong learning	26.1	0.951	115	256
International scientific co-publications	8405	1.000	100	326
Most-cited scientific publications	1573.5	0.939	119	172
Above average digital skills	40.9	0.799	102	170
R&D expenditures public sector	0.94	0.635	100	112
R&D expenditures business sector	1.17	0.594	74	88
Non-R&D innovation expenditures	±	n/a	n/a	n/a
Innovation expenditures per person employed	±	n/a	n/a	n/a
Employed ICT specialists	10.0	1.000	152	190
Product innovators	±	0.774	110	139
Business process innovators	±	0.875	109	135
Innovative SMEs collaborating	±	0.416	110	85
Public-private co-publications	1627.8	1.000	104	255
PCT patent applications	6.09	0.845	97	137
Trademark applications	6.94	0.470	67	94
Design applications	1.03	0.295	42	51
Employment knowledge-intensive activities	21.8	0.834	132	147
Employment innovative enterprises	±	0.849	100	148
Sales of innovative products	±	0.556	99	116
Air emissions by fine particulates	8.5	0.734	98	122

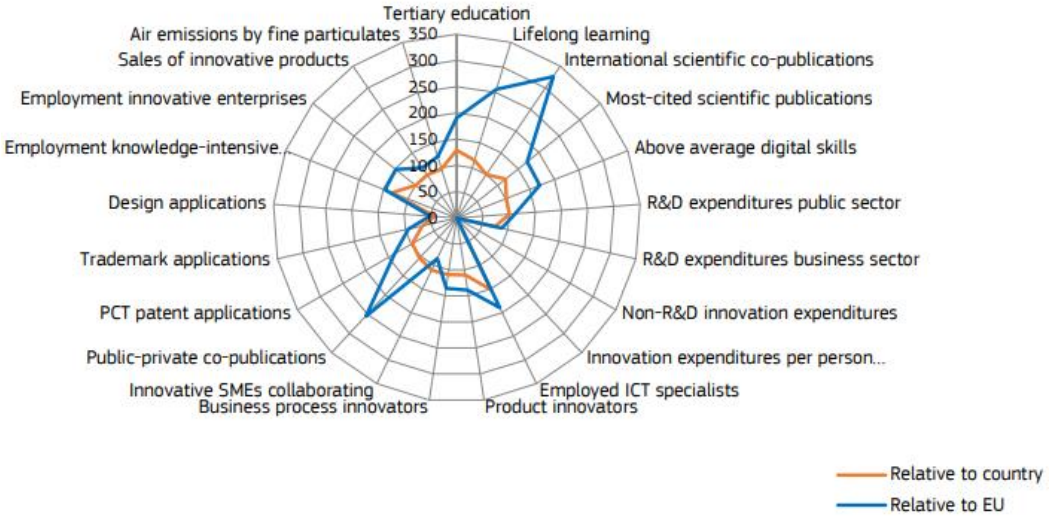


Figure A8. Regional Innovation Scoreboard (RIS),Zürich area

Source: Regional Innovation Scoreboard 2023[75]

[75] https://ec.europa.eu/assets/rtd/ris/2023/ec_rtd_ris-regional-profiles-switzerland.pdf

Sample of Interview Questions

Success factors and gaps

- How would you describe the innovation ecosystem in autonomous systems in Canton? Please name 6-7 key characteristics
- What do you think are the key strengths of the ecosystem in Switzerland/Canton, opportunities that you believe could be leveraged to foster the ecosystem growth?
- What do you see as the key weaknesses and challenges in the development, adoption, and commercialization of the autonomous systems in Canton?

Collaborations

- How would you assess the effectiveness of the collaboration between ecosystem stakeholders and the network activity on national and international level?

Capital availability

- How do you assess the availability and access to funding and investment opportunities within the ecosystem for entrepreneurs, big companies?

Regulations

- How would you assess the existing regulatory framework for autonomous systems in Canton? Are you aware of supporting initiatives promoting by the Government?

Talent

- How would you describe the availability of skilled talent in the field of autonomous systems in Canton? What do you think the motivation to start a new business?

Societal

- What role do you think public awareness and engagement play in the development and adoption of autonomous systems in the region?

Infrastructure

- How would you assess the current state of infrastructure, both physical and digital, to support the development and deployment of autonomous systems in Canton?

Strategies

- What strategies, initiatives should be implemented to overcome the identified challenges to strengthen the innovation ecosystem in the Canton?
- How would you measure the innovation ecosystem?

Abbreviations

AS – Autonomous Systems

ASL – Autonomous Systems Lab

BVLOS – Beyond Visual Line of Spot

DDPS - Federal Department of Defence, Civil Protection and Sport

DETEC - Federal Department of the Environment, Transport, Energy and Communications

DIAS - Drone Industry Association Switzerland

DIZH - Digitalization Initiative of the Zurich Higher Education Institutions

EAER - Federal Department of Economic Affairs, Education and Research

EASA - European Union Aviation Safety Agency

EFI - European Financial Service

EMPA - Swiss Federal Laboratories for Materials Science and Technology

ESA BIC - European Space Agency Business Incubation Centre Switzerland

FDF - Federal Department of Finance

FDHA - Federal Department of Home Affairs

FDJP - Federal Department of Justice and Police

FEDRO - Federal Roads Office

FOCA - Federal Office of Civil Aviation

FOEN - Federal Office for the Environment

FOT - Federal Office of Transport

FP - Innovation Framework Programmes

HedA - Higher Education Act

IE -Innovation Ecosystem

IPI - Swiss Federal Institute of Intellectual Property

JARUS - Joint Authorities for Rulemaking of Unmanned Systems

LEC – Laboratory for energy and conversion

NCCR – National Centres of Competence and Research

NRP – National Research Program

MEM - Swiss mechanical, electrical and metal industry

PSI - Paul Scherrer Institute

RIPA - Promotion of Research and Innovation

RSL – Robotic System Lab

SAAM - Swiss Association for Autonomous Mobility

SATW - Schweizerische Akademie der Technischen Wissenschaften

SECA - Swiss Private Equity & Corporate Finance Association

SEF - Swiss Economic Forum

SERI - State Secretariat for Education, Research and Innovation

SNSF - Swiss National Science Foundation

SORA - Specific Operations Risk Assessment

SSC – Swiss Science Council

SUSI - Swiss U-Space Implementation

SWESA - Swiss Entrepreneurs & Startup Association

TA Swiss – Technology Assessment foundation

TAZ - Civil Engineering Department (Tiefbauamt der Stadt Zürich)

TCS – Swiss Touring Club

TH – Triple Helix

VBZ - Zurich Public Transport

VRL -Vision for Robotics Lab