

Digitalization and the Evolution of Innovation Ecosystems: A Longitudinal Case Study of GTI IT Solutions

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Abstract – The study explores the impact of digitalization on innovation ecosystems, on the basis of the case of the GTI IT Solutions at lower and greater levels of digitalization. This study uses a longitudinal single-case study design and analyzes the data through pattern matching, data exposure, SNA (Social Network Analysis) and comparison across the stages. The results indicate that more digitisation was associated with more R&D activity, development of the MovPrime application, and more generalised information exchange, knowledge exchange, networking, training, consulting, technology transfer, expertise, investment and funding exchanges with industry peers, JVs, innovation centres, customers and suppliers, and government bodies and associations. The study points at ecosystem connections as a potential “add-on” source to fuel continuous digital innovation and effective organizational growth.

Keywords – Innovation Ecosystem, Digitalization, Digital Innovation, GTI IT Solutions, Social Network Analysis, R&D, Interorganizational Relationships.

I. INTRODUCTION

The term ‘ecosystem’ was first used in the early 20th century to describe the complex interrelationships between living creatures and their environment, but the notion of an innovation ecosystem has gained popularity in recent years. The notion was extended in the late 20th and early 21st century to the field of innovation to gain a better understanding of the wider context of invention and the different elements that impact the innovation process. The notion of the innovation ecosystem is coined to underline the importance of networks, collaboration and the interdependence of diverse actors in the innovation process. This is referred to as ‘a confluence of humans, actions, things, organizations and connections that fosters innovative performance’ [1].

The digital advancements such as blockchain, artificial intelligence, machine learning, cloud computing, the Internet of Things, augmented reality and data analytics are transforming practically every aspect of human life. They have contributed significantly to the birth, evolution, and dissemination of innovation and have become an integral part of the innovation ecosystem. Marion and Fixson [2] have shown that digital technology can improve the invention process in several ways. These are conceptualization, model creation, evaluation and market introduction. For instance, the companies can use data analytics and machine learning techniques to get useful information from massive amounts of data that helps in making informed decisions and predictions. Technological progress has enabled the quick spread of ideas regardless of geographical location, thereby increasing market access.

The enterprises and society are not able to catch up with the tremendous speed of technological, economic and social revolutions. The fast development of ICT has resulted in the exponential growth of the Internet and numerous kinds of digital data. Globalization has influenced the innovation landscape and economic and social activities have grown thanks to the

materialization of some variables that are relevant in the formulation of competitive advantage. Governments, academic institutions, corporations, professions and the wider community have been the principal bearers of the burden of responsibility for innovation [3]. It is considered to be an indispensable tool for building a vibrant society, adeptly resolving various issues at the social, economic and environmental level, by its proponents.

There are numerous good reasons for people to pay more attention to innovation. It encompasses concerns such as resource depletion, climate change, young unemployment and the promotion of social inclusion and the need to improve economic growth and harness technical advancement; enhance product innovation and production efficiency; cope with severe global market rivalry [4]. Innovation is indeed the key determinant in deciding whether a country can attain continuous economic growth. This view advocates the idea of the policy of economic recovery and the development of activities to create an innovative environment. This is owing to the greater development potential of high-tech firms and the fact that the most reliable strategy to boost employment and stimulate the economy is the implementation of academic advances.

The number of publications on innovation ecosystems has been rapidly growing in recent years. The concept of the innovation ecosystem has been widely studied and has been borrowed from a wide range of academic disciplines. The larger definition of the phrase covers a range of phenomena including commercial, technological, platform, entrepreneurial and knowledge ecosystems. Academics have used the word in a variety of ways, leading to questions over its meaning. Because of lacking detail, the idea may not be useful in the future for further understanding. Increased attention of authorities to innovation ecosystems now occurs in many areas including sustainability, economics, innovation and commerce [5]. By focusing creativeness in strategic locations, and accelerating growth in strategic sectors or regions, systemic change can be achieved.

The development of an innovation ecosystem which is increasingly adopting digital technologies is of interest. The data was collected by observing the participants, the relationships between the various entities and the assets and innovations that were passed from the initial phase to the subsequent phase of the digital transformation of GTI IT Solutions. The focus was on the use of digital technology and strengthening of research and development.

The remainder of the study is organized as follows: Section II presents the theoretical background and important literature on innovation ecosystems, digitalization, R&D networks and innovation diffusion. The research approach, data collecting and data analysis procedures that were used in the research are described in Section III. The context of the case and the analytical framework of the investigation of changes in different levels of digitalization are presented in Section IV. In Section V, the empirical data are presented and discussed paying particular attention to changes in ecosystem players, interactions, transferred assets and network structures. Lastly, the key results of the study are summarized and discussed in Section VI in relation to the development of innovation ecosystems.

II. THEORETICAL BACKGROUND AND RELATED LITERATURE

Innovation Ecosystems and Digital Value Creation

Value creation is a dynamic and collaborative process that is especially relevant in fast changing sectors within the framework of innovation ecosystems [6]. Innovation ecosystems are significantly distinct from business ecosystems which are about the role of a particular business and its first circle of partners. This is because within an innovation ecosystem, several entities involved in innovation activities (e.g. corporations, research institutes and government organizations) share a shared process of innovation. These types of ecosystems enable enterprises to mediate knowledge, and to facilitate the knowledge and connections exchanges with the incumbent companies [7].

Digital technology is also an important enabler in boosting the collaborative processes as it provides the infrastructure that may aid to communicate and exchange data and co-creation processes in a quick pace. Digital technologies are not just tools, they are also significant enablers for the establishment, operation and evolution of innovation ecosystems. They are the bedrock of the intricate web of links of innovation ecosystem that allows to mix different skills and resources. Recent empirical study reveals the diversity of consequences that new digital technologies, such as artificial intelligence, large-scale data analysis or digital twins, can have on the ecosystem and innovation dynamics as well as on the management or customer value creation decision-making processes. These properties (generativity, convergence and combinatoriality) are found in digital technologies and are crucial to the creation of ecosystems.

R&D Networks in The Digital Marketplace

With the change of digital marketplace, supported by high-tech like IoT (internet of things), smart factories, integrated communication, machine learning, big data and artificial intelligence, the significant need of improving the efficient collaboration of R&D systems is obvious. And for these systems to keep their value they need be dedicated to the latest high-tech breakthroughs. One of the main shifts in R&D systems in the digitally-enabled economy may be toward more decentralized systems. This tendency is aided by technologies such as blockchain and DLT. It is also considered that the digital economy has an impact not just on the downstream processes of R&D networks, but also on production and distribution operations [8].

In this context, Xing et al. [9] propose the institutional theory to characterize the capability of R&D networks to cope with the complexity of the digital economy. Institutional theory helps to understand the impact of informal and formal protocols, cultures and conventions on the behavior of organizations. This is important to comprehend the networking processes in R&D systems in the face of issues of the digitally-enabled economy. The study sample is a short review of

numerous businesses that operate in the R&D area of the digitally enabled economy. The organizations are from different industry to get different ways and experiences. This heterogeneous approach lends itself to a comprehensive investigation of the significance of these notions in practice and provides understanding into the intentional creation and reorganization of R&D systems in response to the requirements of the digitally-enabled economy.

Interorganizational Networks and Innovation Diffusion

From the literature analysis, it appears that organizations that do not collaborate and do not participate in formal or informal information sharing limit their knowledge reservoir over time thus decreasing their ability to build exchange relationships. It is necessary to point out that networks are crucial in promoting the development of innovation within and between firms and in the diffusion of innovations across industries. National innovation systems have a strong impact on the diffusion of ideas at the institutional level, via influencing networking activities [10].

Uyarra, Shapira, and Harding [11] has shown that the UK innovation system encourages diffusion of more radical discoveries that need the engagement of entrepreneurs in industries instead of technology within industries. The implications for networking are obvious. At the firm level, the participation of executives and subordinate workers in professional, sector-specific and cross-sector networks has been identified as a factor that can help in the diffusion of innovations. The more people participate in these forums, the more likely their employing firms are to take up new ideas [12].

Networks are important, not just for acquiring knowledge to stimulate internal innovations or to spread technological advances, but also for obtaining knowledge about innovative ways of working which have been developed or adopted by other organizations. This is achieved through various means. First, through the enhancement of information accessing, enhancing awareness and adoption of innovation; and second, social engagement, establishing trust and reciprocity that allow for knowledge exchange.

Pittaway et al. [13] report that the majority of the literature emphasizes the importance of persons, especially the usefulness of information and interpersonal networking in innovation adoption. In a wider sense, it is commonly agreed that networks positively influence the diffusion and development of innovation. However, it seems necessary to further investigate the influence of network systems on the generation and distribution of various types of innovation, such as organizational, process, and product innovation.

III. METHODOLOGY

Research Design and Selection of Cases

The study used a longitudinal single-case study design to assess the development of an innovation ecosystem across two different stages of digitalization. The unit of analysis was GTI IT Solutions' innovation ecosystem. The focus was on the actors, interorganizational linkages, assets exchanged, and innovation activities linked to the firm's development. This study is appropriate for a single-case method because it aimed to explore inside the same organizational and industrial setting rather than to compare other firms. This allowed us to distinguish changes in the structure and functioning of ecosystem links when GTI IT Solutions progressed from a lower-digitalization stage to a higher-digitalization stage.

GTI IT Solutions was not chosen randomly. It has a development history, which can be split into two analytically separate phases. In the first stage, the digital transformation was mainly marked by the market adoption of existing IT products and advisory services, while the second stage, higher-digitalization, was marked by an increase in research and development and the release of the MovPrime application. The inclusion of these two stages allows the comparison of the ecosystem structure and relationship properties in one case. Thus, the fundamental dimension of comparison was operationalized through the digitalization stage, and the main analytical dimensions were represented by the actors, relationships and exchanged assets of the ecosystem.

The comparative structure of the study might be formulated as:

$$\mathcal{C}_s = (E_s, R_s, A_s, O_s), s \in \{L, H\} \quad (1)$$

in which $\mathcal{C}_s$ is the configuration of the ecosystem at stage s ; E_s ecosystem actors, R_s relationships between actors, A_s assets that flow through the relationships, and O_s the innovation outcomes. In the current study, $s \in \{L, H\}$. L stands for the lower-digitalization stage and H is for the higher-digitalization stage. This concept gives a systematic way to consider if changes in the digitalization relate to changes in the structure and functionality of the innovation ecosystem. The entire research approach and the process of choosing the cases and analyzing them in comparison is presented in **Fig. 1**. The graphic illustrates the methodological procedures used in the inquiry and the case evidences were systematically transformed to analytical products. This sequence ensured that the comparison of the two development stages was using a common analytical process, and was not based on independent reports of the company's success.

Gathering and Analyzing Data

The research was conducted with primary and secondary data in an effort to understand GTI IT Solutions, its journey and its connection to the players of the innovation ecosystem. The unit of analysis was the evidence which was analyzed for information on players in the ecosystem, properties of the relationships, assets transferred, and attributes of the

developmental stage. The gathered material was not treated as a mass of qualitative information, but was thoroughly sorted and classified based on characteristics that were taken from the pertinent literature and the analysis pattern of the study.

Pattern-matching was the first analytical method used. Empirical evidence was compared to features found in the literature to see if the instance exhibited ecological traits theoretically relevant. This pattern matching link can be written down as:

$$M(e_i, k_j) = \begin{cases} 1, & \text{if evidence item } e_i \text{ supports characteristic } k_j, \\ 0, & \text{otherwise.} \end{cases} \quad (2)$$

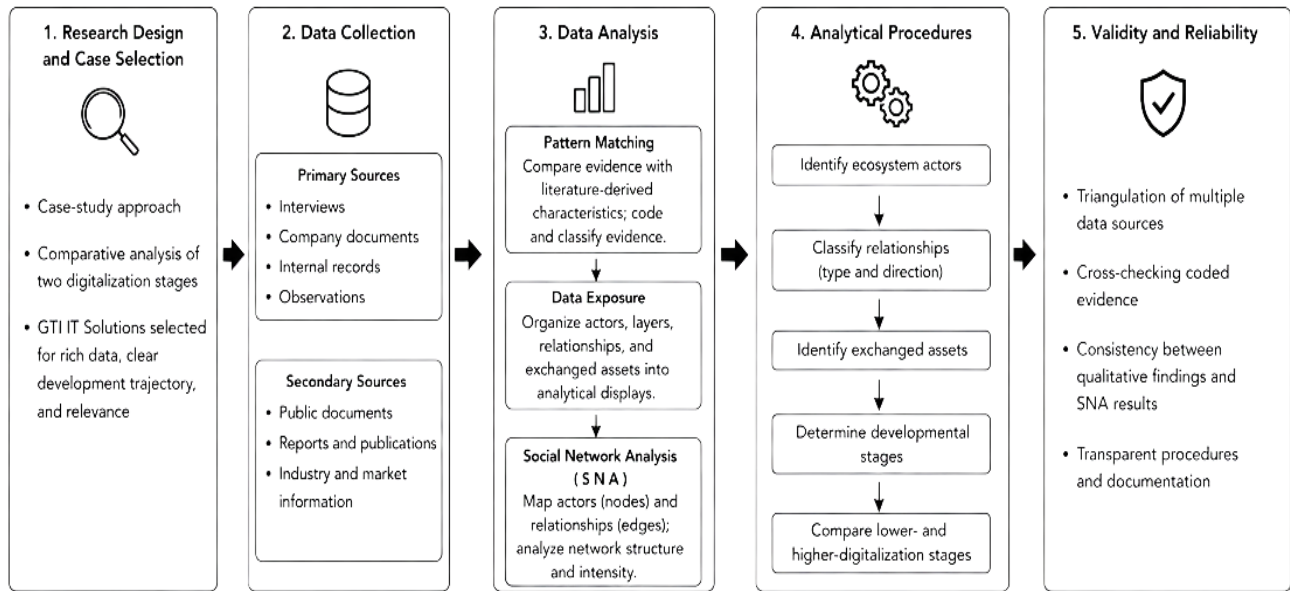


Fig 1. Research Methodology and Analytical Procedure

where e_i is the empirical pattern obtained from the evidence of the case and k_j is the theoretically generated pattern. Evidence was recorded when it corroborated an already known trait, but also when there was discrepancy between the empirical and theoretical patterns, which was then carried over for further interpretation. This resulted in 349 items of evidence being produced and these were classified based on over 160 features. The emerged classifications provided the empirical data to identify actors, interactions, ecosystem levels and exchanged assets.

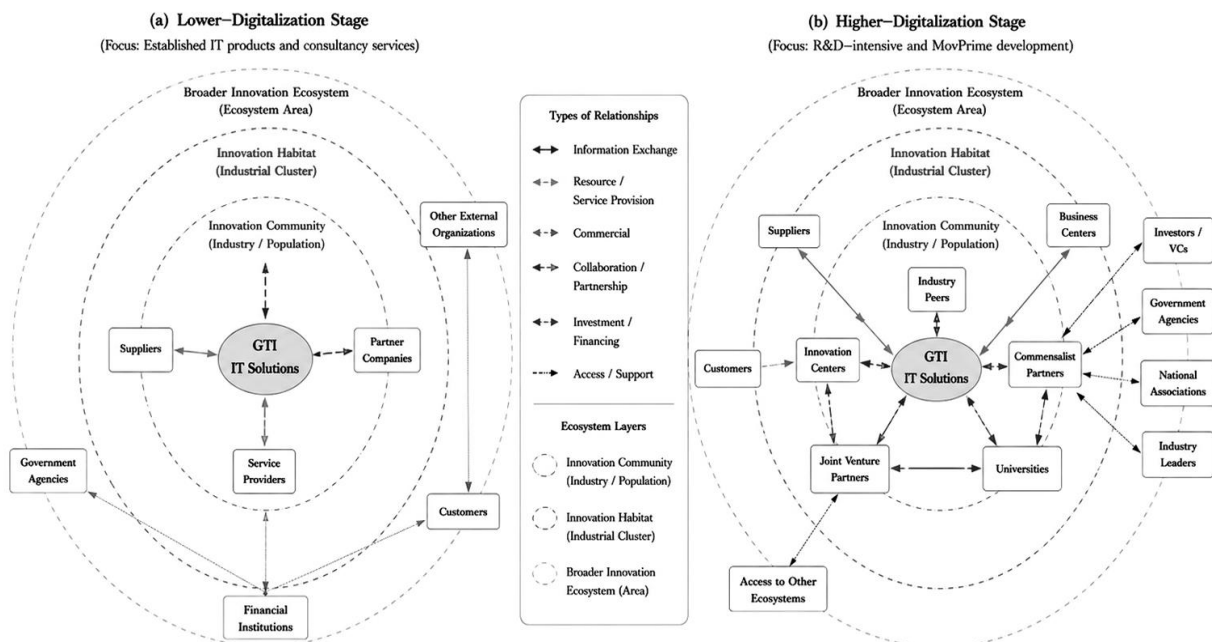


Fig 2. Analytical Illustration of The Innovation Environment of GTI IT Solutions at The Two Development Phases

The second phase involved the exposure of the data, which involved converting coded evidence into a picture of the innovation ecosystem. The actors were identified and categorized based on the innovation community, innovation habitat and wider innovation ecosystem. Then the relationships were illustrated based on their primary role, such as commercialization, information sharing, collaboration, provisioning of resources and investment access to other ecosystems and habitats. The outcome of such an approach is showed analytically in **Fig. 2**, where a comparison between the configuration of the ecosystem in the situation of lower and higher digitalization can be provided.

Our third approach was based on Social Network research (SNA) to analyze the relational structure revealed by the previous qualitative research. We portrayed the ecosystem as:

$$G_s = (V_s, E_s), s \in \{L, H\} \quad (3)$$

where G_s is the network for developmental stage s , V_s is the set of ecosystem actors as nodes, and E_s is the set of relationships as edges. Each actor identified from the case evidence was represented as a node, and an edge was created where evidence suggested that there was a relevant relationship between actors. Relationship types were distinguished according to their function, such as customer/supplier ties, information sharing, collaboration, financial/investment relationships and access to other habitats or ecosystems.

Degree centrality was used to investigate the relative importance of actors within each network, which is the number of direct linkages connected to each actor:

$$C_D^{(s)}(i) = \sum_{j \neq i} a_{ij}^{(s)} \quad (4)$$

where $C_D^{(s)}(i)$ denotes the degree centrality of actor i , $a_{ij}^{(s)} = 1$ when there is a relation between actor i and j and $a_{ij}^{(s)} = 0$ otherwise. This allows for the identification of actors having structurally important positions in the ecosystem. The resulting networks for the two developmental stages are shown in **Fig. 3**.

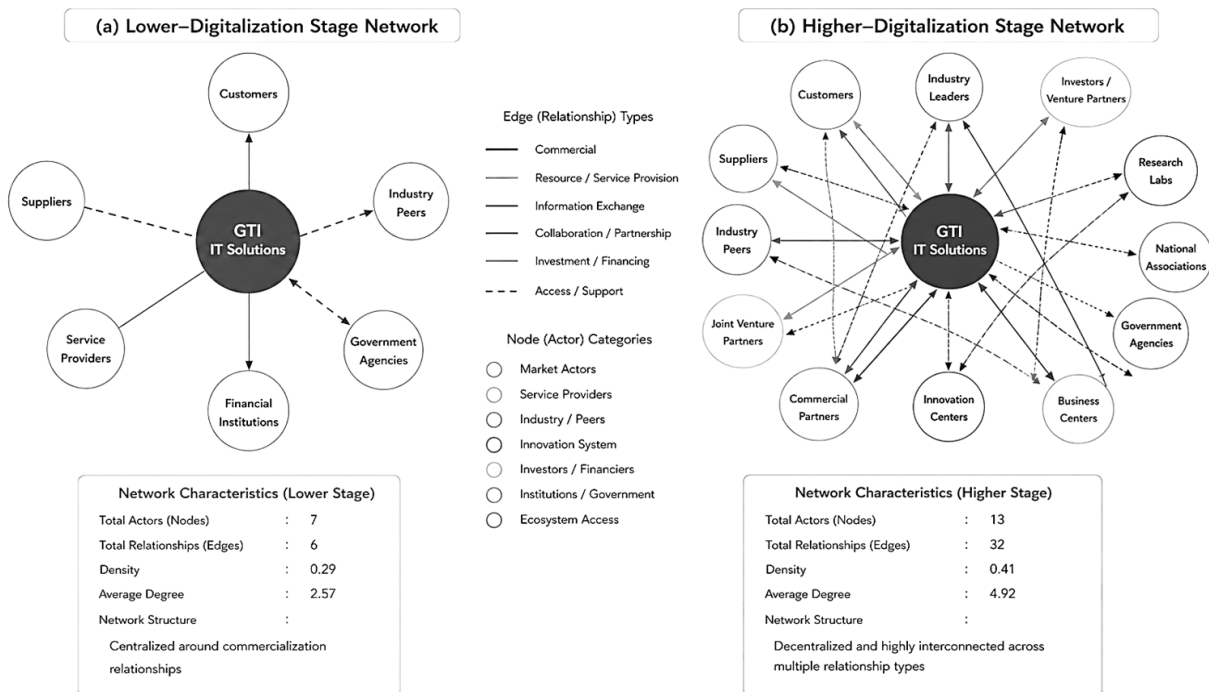


Fig 3. SNA of The Innovation Ecosystem of IT Solutions of GTI

The last step of the analysis was the comparison of the composition, relationship structure and transferred assets of the ecosystems in the different stages. The diversity of participants, the purposes of interactions, and the resources exchanged via interactions were considered in each level of the analysis. The ratio can be written as:

$$\Delta C = C_H - C_L = (\Delta, E, \Delta, R, \Delta A, \Delta O) \quad (5)$$

where C_H and C_L are the ecosystem setups at higher and lower digitalization levels, R_H and R_L the associated relationship structures and A_H and A_L the assets that are exchanged. Because of the comparison, the study was able to identify changes

associated with the transition from commercialization-oriented interactions to the more diversified and knowledge intensive interactions.

Analytical validity was provided by the triangulation of the available evidence, the methodical coding and the consistency of the classification in the two developmental stages as well as by comparing the qualitative results with the SNA results. The relationships revealed in pattern matching were cross-checked before being included in the analytical display and network structure. Similarly, actors from the SNA had to match those of the evidence from the previous analysis.

IV. CASE CONTEXT AND ANALYTICAL FRAMEWORK

Innovation Ecosystem of GTI IT Solutions

The transformation of GTI IT Solutions serves as a suitable stage to explore the digitalization's impact on interorganizational innovation relationships. The company can be seen as having a lower and higher digitalization phase. The firm's activities in the lower-digitalization stage were mostly focused on traditional IT goods and consultation services such as the ERP system and other IT services. So, its ecosystem connections were mainly to customers and suppliers, and commercialization and profit making were the main activities of these relationships. The outcome was a rather limited R&D intensity, diversity of actors and knowledge-oriented engagement.

The digitalization stage is a qualitative step in the development of the company. GTI IT Solutions increased its investments in R&D and started the MovPrime app, which required capabilities and resources that were not necessary for its previous products and services. Consequently, the firm made ties with a broader spectrum of actors: industry peers, joint-venture partners, commensalist partners, innovation centers, business centers, investors, government agencies, national associations, industry leaders and others. The shift between the two phases is presented in **Fig. 4**, which shows the shift from a commercialisation network that is somewhat concentrated to a more heterogeneous innovation environment.

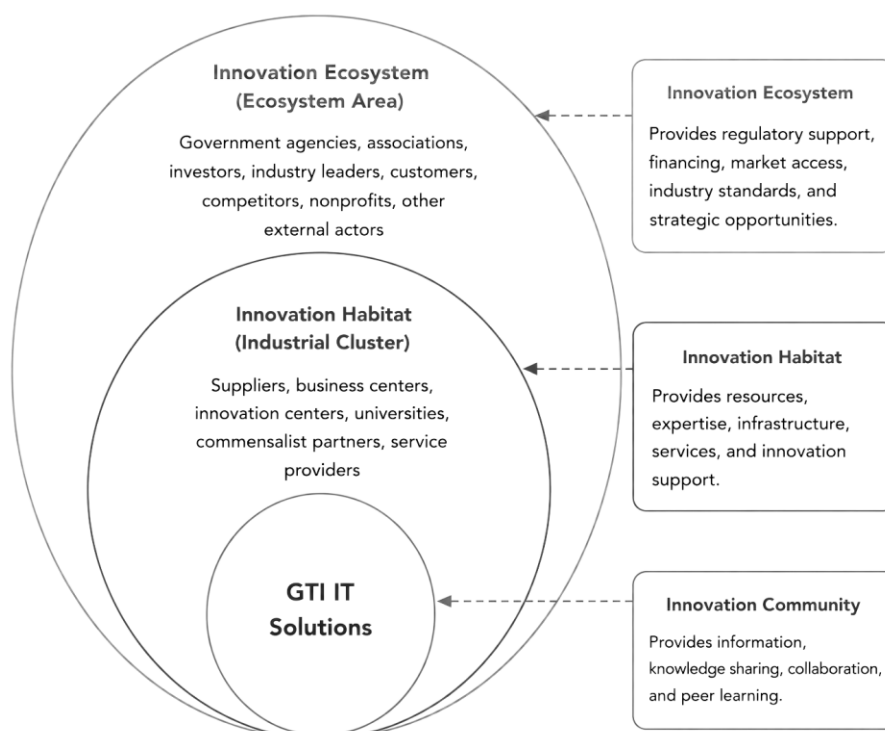


Fig 4. Layers of GTI IT Solutions and Innovation Ecosystem

The ecosystem was designed at three levels of analysis and layering. The first is the innovation community (population) that includes mainly firms in the same industry, sharing knowledge, expertise, experience and collaborative resources. The second one is the innovation habitat (industrial cluster) of suppliers, business centers, innovation centers, universities, commensalist partners and other organisations with complementary capabilities and support services. The third is the phenomenon of the larger innovation ecosystem, all of the other government agencies, investors, associations, industry luminaries, consumers, competitors, nonprofits and other external factors that affect the firm's access to resources and opportunities. This layered structure transforms GIT IT Solutions into an inter-connected system, and not an exclusive internal process for innovation within the company.

The firm's relationship with these layers of the ecosystem is described as:

$$\mathcal{E} = \{C, H, X\} \quad (6)$$

where C is the technology community, H is the innovation habitat and X is the larger innovation ecosystem. The actor set for layer l is denoted by V_l , where:

$$V = V_G \cup V_H \cup V_X \quad (7)$$

where V_G is the actors in the innovation community, V_H is the actors in the technological habitation and V_X is the players in the wider network. The definition notes that the company's ecosystem comprises actors in different structural positions and carrying out diverse activities in the innovation process.

Analytical Framework and Logic of Development

The analytical framework conceptualizes the analysis of digitalization changes as changes of ecosystem players, relationships, transferred assets and innovation consequences. The analytical sequence employed by the framework is given in Fig. 5.

$$D \rightarrow E \rightarrow R \rightarrow A \rightarrow O \quad (8)$$

where D is the digitalization stage, E is the ecosystem actors, R is the interorganizational links, A is the exchanged assets, and O is the innovation outputs. The methodology does not presuppose that the digitalization generates the innovation results independently of the ecosystem. Instead, it views the links and resource exchanges between the ecosystems as mechanisms through which the enterprise acquires complementary resources needed for innovation.

At the lower-digitalization stage $D = L$, the dominant correlations are connected to commercialization and operational continuity. Customers buy items and services and hence generate revenue. Suppliers contribute the resources to provide the offers. The key assets transferred are items, services, payments and operational resources. The structure of the relationship can be calculated by:

$$R_L = R_{\text{commercial}} \cup R_{\text{supplier}} \quad (9)$$

where R_L is the relationship structure at the lower-digitalization stage, $R_{\text{commercial}}$ represents commercialization relationships, and R_{supplier} is supplier relationships. The design is financially sustainable and provides the economic platform from which the company can invest resources into innovation. At the level of higher digitization, $D = H$, the structure of relations becomes more diversified and increasingly oriented at knowledge-intensive tasks. The company partners with other stakeholders such as customers and suppliers in areas including information sharing, networking, training, consultancy, collaboration in R&D, investment, and access to specialized expertise. The structures of the higher stage relations can therefore be written as:

$$R_H = R_{\text{commercial}} \cup R_{\text{knowledge}} \cup R_{\text{collaboration}} \cup R_{\text{investment}} \cup R_{\text{access}} \quad (10)$$

where R_H is higher-digitalization relationship structure. It is not a case of the old business relationships being eradicated by the equation. They are part of the ecosystem and new categories of interactions are generated around digital innovation. It also distinguishes the asset types that are being exchanged in such exchanges. The lower level is mainly concerned with the exchange of products, services, payments and the operational resources. The higher level exchanged portfolio includes information, knowledge, networking, training, consultation, technology, expertise, investments and funding. Thus, the transition can be interpreted as:

$$A_L \rightarrow A_H \text{ with } \|A_H\| > \|A_L\| \quad (11)$$

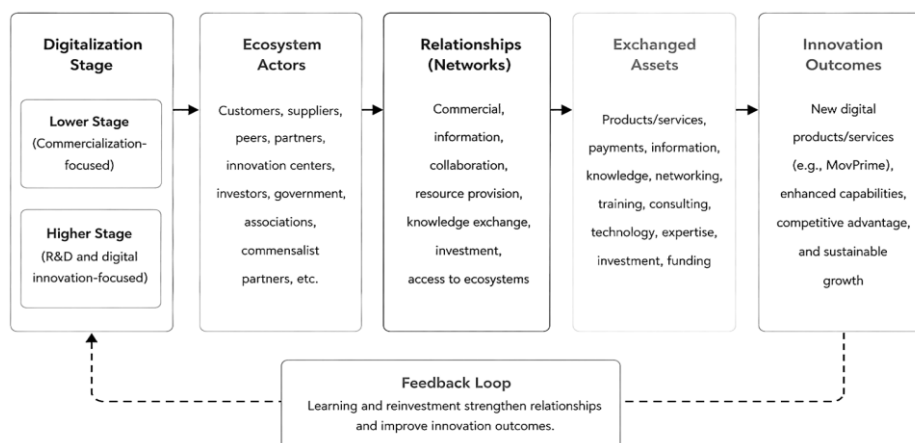


Fig 5. Developing the Digitalization and Innovation Ecosystem

where A_L and A_H are diversity of the assets transferred in the lower- and higher-digitalization stages, respectively. The imbalance is the analytical assumption that more digitalization indicates a greater number of resources transferred. A major part of the framework is the link between commercialisation and the investment in innovation. The firm is financially stable as the revenues from the products/services can be used to support part of the funding for the revolutionary innovation, and R&D. These are so interlinked commercial and innovation programmes at the firm:

$$\text{Revenue}_{\text{existing}} \rightarrow \text{Investment}_{\text{R\&D}} \rightarrow \text{Innovation}_{\text{new}} \rightarrow \text{Market Value} \rightarrow \text{Revenue} \quad (12)$$

This is especially the case with GTI IT Solutions, where the existing portfolio provides the financial framework for the development of MovPrime, while the entire innovation ecosystem provides complementing knowledge, skills, networking and other resources. The analytical framework is a process, rather than a classification of ecosystem actors as seen in Fig. 5.

The paradigm that emerges from this allude to a trade of increasingly knowledge-rich and diverse, ecosystem-like formats with the advancement of digitization, as opposed to still very concentrated transactional forms. This transformation is an experimental assessment, which compares the transferred actors, relationships and assets found at the two stages of development. The framework provides a conceptual connection between the methodological techniques (Section III) and the empirical results (Section IV below), especially the analytical ecosystem representation (Fig. 1) and SNA comparison (Fig. 2).

V. RESULTS

We explored pattern matching in which the qualitative data set was compared in an in-depth way with the data assessment processes. So, 349 evidences were identified and categorized using over 160 criteria from the literature according to four analytical levels which represented different levels of technological ecosystems. The technique of data exposure examined and presented facts well. The information enabled an investigative portrait of the case firm to be produced in the context of their technology surroundings. This technique was used to identify the various stakeholders the organization has related with. The systematic image of the technological system of GTI IT developments, analyzed in two periods of the firm's history, is shown in Fig. 6.

Different levels of innovation ecosystem were analyzed. The first one is the company itself. Secondly, the population that surrounds the company (the innovation community of industry peers who share ideas). Third, the habitation region related to the sector cluster where the innovation ecosystem is found, including supporting organizations. Finally, the general innovation ecosystem area comprising different organizations and key stakeholders [14]. Linkages between the company's growth trajectory and different levels of digitalization indicate a number of patterns.

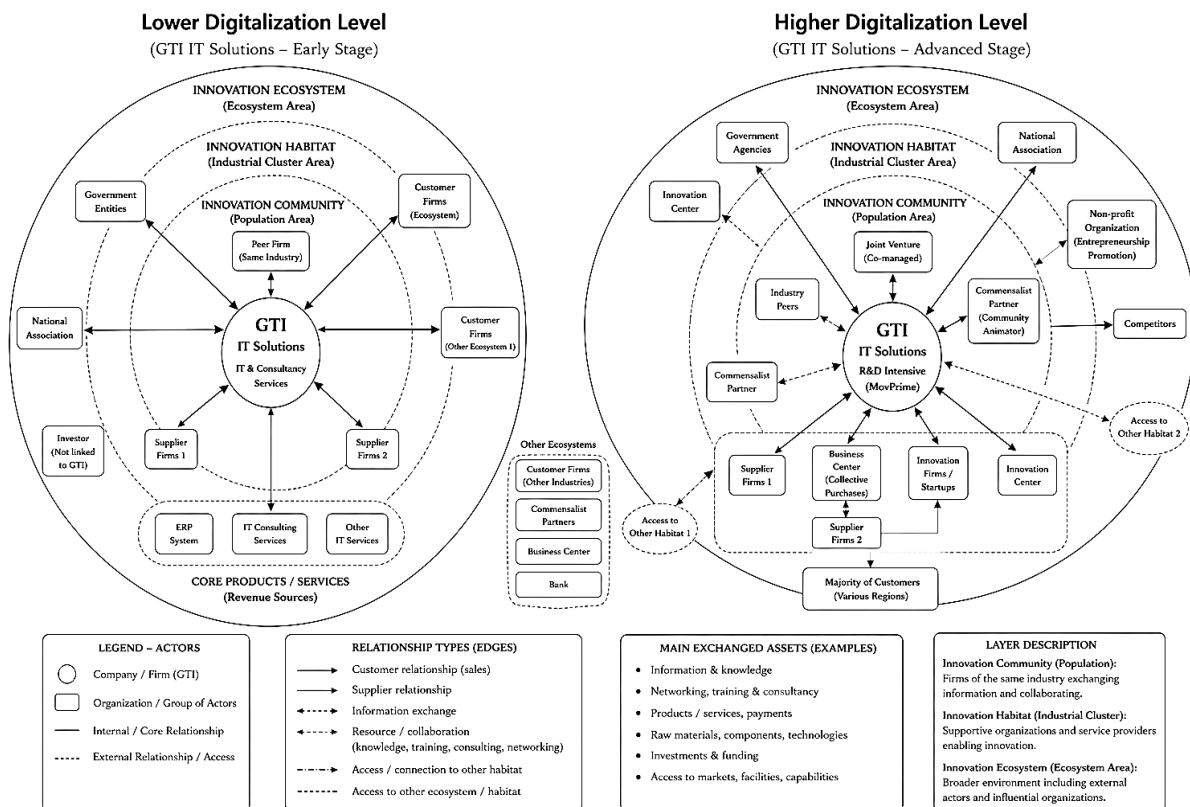


Fig 6. GTI IT Solutions Innovation Ecosystem Setup at Different Digitalization Levels

Besides enterprises in the industry, GTI corporation also provides IT and consulting services at a lesser level of digitalization. Much of its innovation environment was to do with client firms and two other ecosystems. The organization disseminated information to another organization that was also operating a space for the innovation community. The supplier enterprises of habitat region played an important role in the organization's services and products. Within the ecological area, the company's clients presented the products to the clients who had their own links with the academic institutions and specialists. There are a big firm and a country-wide organization in this field, both in contact with the government. There is an investor who is linked to a lab but not the GTI company. There were two other commensal partners in the ecosystems beyond the client businesses with which the research firm-built partnerships to commercialize their services or products, a commercial center and a financial institution that supports firms inside these ecosystems.

The corporation moves towards the more advanced digitalization steps, and invests heavily in R&D and introduces the MovPrime system. It also hinted at developing more varied interactions with other actors on the technology scene. Firms that are the closest to the firm and with more frequent interactions are: firms in the technology network; a combined business managed by the firm and other merged enterprises; and a commensalist co-manager in charge of developing the innovation ecosystem. For the innovation habitation phase, there is a commercial hub, which is responsible for joint procurement and providing benefits to the followers of the technological network including the GTI firm, as well as two commensal collaborators [15].

Along this tier, the firm's sellers and a technological center are located and provide support to develop ties with the innovation community. At this level, only a small number of customers use the GTI company's stuff. For the innovation ecosystem level, government institutions, industry leaders linked to the firm, a national association as an information source and a non-profit organization promoting entrepreneurship were identified, as well as most of the firm's clients and competitors. Thanks to the links built up with commensalist partners of these environments, the organization has access to two further innovation environments. GTI corporation has established links with the innovation ecosystems of its client organizations to promote itself and attract potential clients.

The results show that the example business has acquired significant enablers regarding data at the three exterior layers, i.e. the comprehensive technological network. The organization's offerings are targeted to patrons mostly located in the stage of the technological network. GTI employs its commercial scale products to provide financial security and invests excess cash flow in creative product investment. The company's portfolio includes two sets of things that are employed to tap into market targets at various tiers of the technological network. The corporation utilizes methods to acquire resources to foster innovations in its operations. The aim is to collect insights, information and experience mostly from the technological group, as the members of this society share incorporeal resources principally with two important industry executives.

Beyond financial returns gained from the sale of things, fiscal resources are also safeguarded by commensalist members that provide merits to society members through group purchase. The corporation acquires its investments mostly from an ecosystem level investor and from publicly advertised competitions run by the government in partnership with the habitation's commensalist member. The firm merits from the insights of professionals who revolve among the society's enterprises and are previous students of the habitation's education institutions. The results showed that the technological environment of the case firm is built mostly on two relationship clusters.

The first dimension is related to the monetization of core solutions that the company has been delivering to the customer base since conception (ERP ecosystem and consultancy operations) and that guaranty the financial health of the business. The income from the services and software commercialization allows the firm to dedicate extra funds to the second network focused on the research and development of MovPrime [16]. The organization has developed relations with many players in the technological environment and is stimulating more collaborations with other organizations working on product development, improvement, and eventual commercialization as it moves forward with its new product. The SNA methodology was used and the importance of the identified links was exposed. Using the quantitative data, a Social Network Analysis visualization was designed for two phases of the firm's history, showing the linkages and components of GTI IT innovations (see **Fig. 7**).

From the primary and secondary data, we created the SNA graph to determine the significance of the relations for the GTI business and the resources traded. **Fig. 7** traces networks at a lower level of digitization, featured by IT services/products commercialization, indicates the strongest links are focused on three revenue-generating products, produced with both consumers and suppliers. At a high level of digitization, a wider and stronger set of interactions can be observed. To promote digital innovation, GTI company had to extend its current customer relationships (connected to 3 products) to relations based on information and insights, and an increased set of exchanged resources (including consulting, training, and networking by experts and partners).

Researchers such as Cooke [17]; and Tejero, Pau, and Leon [18] have highlighted the “static aspects of the innovation systems model” and have called for a new dynamic analytical paradigm called innovation ecosystems, a notion inspired by biology. An ecosystem refers to evolutionary properties of individual interactions, their links to innovative ventures and their relationships with the environment. An innovation ecosystem is made up of economic actors and their linkages and non-economic factors such as technology, institutions, social dynamics, and cultural characteristics.

Innovation ecosystems are adaptive systems. They are not only molded by public policies but also evolve according to changes in market situations and the efforts of different actors and institutions. The ecosystem is a market-driven event and is not related to governmental considerations as innovation systems are [19]. Fundamentally, ecosystem thinking is about

extending an actor's possibilities beyond its own bounds and spreading knowledge to encourage collaborative creativity. While the innovation systems approach has a strong focus on organizations and institutions, the ecosystem framework is more bottom-up and highlights the key role of entrepreneurs.

This has led to an expanded set of connections with players of the innovation ecosystem (e.g. innovation hub, cluster management, academic institutions, national organizations, research companies). As in any stage of the company's development, key relationships are also product- and revenue-heavy, meaning that the primary and ongoing relationships the company has developed are geared towards selling its products to various parts of the country. Moreover, the results indicate that core relationships are associated with the transfer of intangible resources such as manufacturing, information and networking processes mainly from the collaborative venture within the ecosystem, various commensal associates at the technological habitation level, and sector executives at the technological network level, after the new product introduction [20].

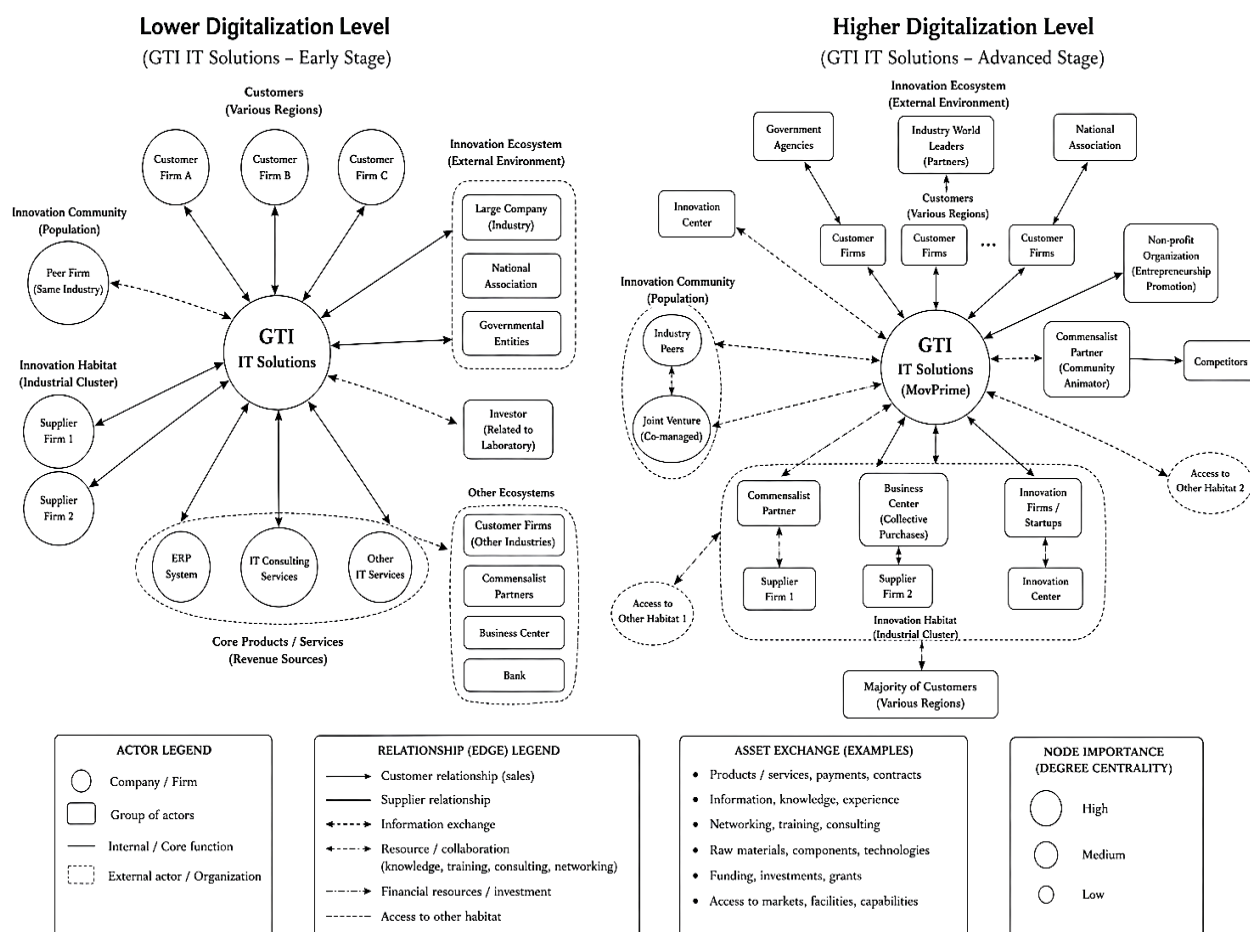


Fig 7. Social Network Structure of GTI IT Solutions: Low Vs. High Levels of Digitalization

The commensal partner which supports the technological ecology at the habitation level offers primarily training and consultancy services. The major sources of funding and financial assets are the business partner and the investor. It is intangible assets that stockpile the ingredients needed for the innovation and continual improvement development within the organization.

VI. CONCLUSION

The study shows that digitalization is linked to the transformation of the structure and functioning of GTI IT solutions' innovation ecosystem. The contrast between the lower and higher phases of digitization shows that there are still commercial ties to consumers and suppliers that are important for financial sustainability, but that other knowledge-intensive ties have a positive effect on them. The company developed R&D and created MovPrime application, as well as extended the existing network of relationships with innovation centers, business centers, specialists, associations, government agencies, joint venture partners and actors of the ecosystem. These collaborations provided access to information and knowledge, networking, training, consultancy, technology, expertise and financial resources. The higher the digitalization, the more diverse and intense the relationships, and this is significantly reflected in SNA results. The ecosystem facilitated resource sharing that provided a source of innovation, rather than the company's own resources.

CRedit Author Statement

The author reviewed the results and approved the final version of the manuscript.

Data Availability

The datasets generated during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interests

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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