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Digital Innovation Ecosystem on Digital Entrepreneur:
Social Network Analysis Approach

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ABSTRACT

This study aims to produce a network structure in the digital innovation ecosystem to determine the position of each actor involved in it as an effort to support digital innovation in digital startups in West Java. This study uses a mixed method with an exploratory sequential strategy involving digital startup actors in West Java. To get the network structure in the digital innovation ecosystem in order to find out the actors who play the most important roles, the research uses a social network analysis approach by utilizing the Gephi application. The network structure is based on four dimensions of centrality. The results of this study confirm that the actor with the most connections (degree centrality), as well as the most important actor (Eigen centrality), in the digital innovation ecosystem in West Java is PT. Sharing Vision. A framework of digital innovation ecosystem is developed to explain the importance of actor positions in the digital innovation ecosystem.

KEYWORDS

Digital Entrepreneur, Digital Innovation, Digital Innovation Ecosystem, Digital Startups, Social Network Analysis

INTRODUCTION

Digital technology marks a new era in entrepreneurship (Azzahra et al., 2021), which can expand various entrepreneurial opportunities and challenge business owners and their companies to digitize immediately (Beliaeva et al., 2020). Digital technology is a driver of entrepreneurial activity (von Briel et al., 2018) and manifests itself in various forms as one of them is digital innovations (Kuester et al., 2018; Elia et al., 2020; Purbasari et al., 2021). Digitalization has set the stage for innovations that have the potential to trigger new technological revolutions (Deng et al., 2020) and encourage the emergence of multi-sided platforms (Purbasari et al., 2021) inhabited by digital entrepreneurs (Sussan & Acs, 2017; Purbasari et al., 2021). Digital entrepreneurs identify and take advantage of

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various business opportunities based on the Internet, the World Wide Web, mobile technology, digital media, cloud computing, big data, robotics, and other information and communication technologies (Richter et al., 2017; Ulas, 2019). Due to the various possibilities available from advances in digital technology, digital entrepreneurs have been considered an essential pillar for economic growth and innovation and have become one of the top priorities in many countries (Shen et al., 2018; Beliaeva et al., 2020; Bagale et al., 2021).

In recent years, digital entrepreneurship has attracted much research interest as a new and developing research field (Kraus et al., 2019; Beliaeva et al., 2020). Digital entrepreneurship broadly refers to creating new ventures and transforming existing businesses by developing new digital technologies and new uses of those technologies (Sahut et al., 2019; Elia et al., 2020). In addition, digital entrepreneurship is also recognized as an important driver in the innovation system (Perwita, 2021). It can also be said that digital entrepreneurship is the process of creating a digital startup as a new business or within an established company (Perwita, 2021; Muafi et al., 2021). A *startup* can be understood as a company in the early stages of its business operations. Startups try to enter existing markets or sometimes open new ones with innovative products or services (Riyanto & Jamaaluddin, 2018).

More companies, including digital startups, have used digital technology to create digital innovations in terms of offering new products and services that provide significant benefits to the economy (Soto-Acosta, 2020). However, digital startups cannot develop innovations separately because the innovation process is complex and non-linear (Walrave et al., 2018; Wagemans & Witschge, 2019). As a nascent technology venture, digital startups rely heavily on external actors to enhance their innovation capabilities (Fukugawa, 2018; Ojaghi et al., 2019; Marcon & Ribeiro, 2021). The size and limited resources of digital startups make them more vulnerable to forming strong bonds with different actors that help them overcome internal shortcomings and create shared value (van Rijnsoever, 2020; Marcon & Ribeiro, 2021). Many digital startups protect their knowledge of using intellectual property (IP) and patents through several open innovation relationships (Yuana et al., 2021), indicating that innovation has progressed beyond the boundaries of single firms towards a more network-based approach (Klimanov & Tretyak, 2019; Iovanella et al., 2019), which consists of many actors with various categories of stakeholders (Reypens et al., 2019; Bittencourt et al., 2021). Companies create value from their activities and interactions with stakeholders in interdependent relationships within their ecosystems, as innovation and digital technology are also interdependent in the so-called innovation ecosystem (Suseno et al., 2018; Benitez et al., 2020; Wang, 2021). The emergence of the interconnectedness of digital startups and the innovation ecosystem lead to a potentially important new context for entrepreneurship (von Briel et al., 2018; Nambisan et al., 2019), which is from now on called the *digital innovation ecosystem* concept.

The concept of a digital innovation ecosystem has become one of the focus concepts used in several recent studies where digital product and service innovation is recognized as a process of reconfiguration or recombination of existing resources available in the ecosystem (Kahre et al., 2017; Chae, 2019; Øvrelid & Kempton, 2020). In much the same way, the digital innovation ecosystem models the interactions and relationships between companies and stakeholders in creating new products and services using digital technologies to create value (Suseno et al., 2018; Wang, 2021). The digital innovation ecosystem is considered an analytical framework built on the more networked nature of digital entrepreneurs. It adopts a holistic and multilevel view by analyzing it within the entire innovation ecosystem (Beliaeva et al., 2020). The digital innovation ecosystem is a dynamic collection of interdependent actors and the resources they use to innovate with digital technology (Wang, 2021). It consists of components such as business actors, customers, suppliers, and complements (other business actors, government, universities, banks, investors, social communities, and information media; Chae, 2019; Beltagui et al., 2020; Elia et al., 2020; Beliaeva et al., 2020).

Both scholars and policymakers recognize the need for a supportive ecosystem for digital entrepreneurs, but current studies do not sufficiently explore which elements are most important for nurturing and shaping digital entrepreneurs at various stages of development (Elia et al., 2020;

Beliaeva et al., 2020). Despite the implicit assumptions about the importance of stakeholder interaction in the digital innovation ecosystem, the role of interaction between stakeholders for value creation has not been widely discussed in the digital entrepreneurship and innovation literature (Suseno et al., 2018; Autio & Thomas, 2019; Wang, 2021). The term *digital innovation ecosystem* refers to a network of heterogeneous elements continuously evolving together over time, so it becomes crucial to identify the diverse actor elements and explain the emergence and evolution of the ecosystem or network of these elements (Chae, 2019). In addition, given the social and networked nature of digital entrepreneurship, conventional research methods are still considered limited for discovering the complexities and dynamic interactions between digital technology and entrepreneurship, and new methodological approaches have been encouraged to help explain the phenomenon (Nambisan, 2017; Beliaeva et al., 2020). Thus, it is understandable that there is a need for an integrative and holistic approach to testing a digital innovation ecosystem.

This research was conducted on digital startups in West Java, Indonesia. In Indonesia, various efforts have been made to create digital entrepreneurs based on digital platforms to face the era of the digital industry. The Indonesian Ministry of Communication and Information Technology has launched a policy of 1,000 digital startups until 2025 (Kharisma, 2021). According to Startup Ranking, startup growth in Indonesia continues to show a positive trend, with the number reaching 2,219 local startups in early 2021 (Barus, 2021). Unfortunately, the development of startups in Indonesia is not accompanied by explicit direction and synergy from relevant stakeholders (HumasITS, 2022). In addition, most startups in Indonesia have many problems, including limited digital innovation, digital talent, a supportive ecosystem, and access to funding (StartupStudio Indonesia, 2022; Dihni, 2022). In fact, digital startups have a central role in producing innovations that can advance the creative economy, especially in Indonesia, which has a huge potential market share along with the birth of the middle-income class (Saputra, 2015; Lutfiani et al., 2020; Patrickson, 2021). Meanwhile, West Java has been designated as one of the provinces as the center of excellence for the digital creative industry after DKI Jakarta (Rofaida et al., 2019). Also, according to the East Ventures Digital Competitiveness Index (EV-DCI) 2021 report, West Java is the most superior province in the availability of digital human resources, with a score of 57.14. The Central Bureau of Statistics (BPS) West Java Province stated that the information and communication sector could grow to 39.75% throughout 2020 to absorb a large enough workforce (Rizaty, 2021). One example of a program carried out by the Province of West Java to develop digital talent is the Candradimuka Coding Camp program, which focuses on producing digital talent in Indonesia (Ayu, 2022). With the power of digital talent, West Java has become the province with the second highest digital competitiveness after Jakarta, with a score of 58.5 based on the Digital Competitiveness Index 2022 (EV-DCI 2022; Rizaty, 2021; Mediaindonesia, 2022). In addition, West Java has also declared itself a digital province and hopes to be used as a reference for other regions in encouraging the achievement of Digital Indonesia (Ayu, 2022). With the potential of digital talent owned by West Java, it should be able to support digital startup innovation if the digital innovation ecosystem model can be developed adequately and appropriately.

Against the background of the problems of limited digital innovation, digital talent, a supportive ecosystem, and access to funding in digital startups in Indonesia, as well as the limited approaches used in digital innovation ecosystem research and the need to find the actors who play the most role in the digital innovation ecosystem, and also to get the proper analysis of the position and function among the actors involved in the digital innovation ecosystem, then this research intends to complete some of the shortcomings regarding the study of digital entrepreneurs and digital innovation ecosystems from previous research by examining more deeply the network structure in the digital innovation ecosystem with a holistic approach.

Therefore, the questions to be answered in the research are the network structure in the digital innovation ecosystem and the framework that can describe the digital innovation network in digital startups in West Java. This study aims to produce a network structure in the digital innovation ecosystem to determine the position of each actor involved in it as part of an effort to support digital

innovation in digital startups in West Java. This study also fills in the gaps from previous research using the social network analysis (SNA) approach to analyze network structures in the digital innovation ecosystem. This research is critical because it helps identify actors with the most important positions in the digital innovation ecosystem, namely, actors as factors driving the dynamism of interaction in the digital innovation process so that they can increase digital innovation and the competitiveness of digital startups.

LITERATURE REVIEW

Digital Entrepreneur

Digital entrepreneurship is recognized as the process of creating digital value for entrepreneurship through the use of various socio-technical digital enablers to support the effective acquisition, processing, distribution, and consumption of digital information. This definition can be expanded and applied to certain types of businesses, such as nascent businesses and digital entrepreneurs. For example, some of these drivers can be used to support new venture creation processes, from idea generation and opportunity recognition to intellectual property protection, production, marketing, and distribution. Technologies such as social media, open-source software and hardware, crowdsourcing, crowdfunding, electronic trust assessment, online reputation management, 3D printing, digital imaging, and big data empower aspiring entrepreneurs to significantly reduce the barriers between discovery and creation (Steininger, 2019). Multiple definitions of *digital entrepreneurship* have been offered, and research contributions can be grouped into two primary groups. First, analyses of whether and how digitization is altering the entrepreneurship and new business formation processes as we know them (digital technologies as enablers). Second, the study of the entrepreneurial prospects created by digital technology innovation and the formation of new businesses in the digital sector (digital technologies as both enablers and outputs; Sahut et al., 2019).

Digital entrepreneurship involves the process of creating a digital startup as a new business or within an established company, where digital technology enables at least one component of the business model in a way that is not only functional but vital to the company (Mcmullen & Dimov, 2013; Perwita, 2021). Digital startups are start-up companies and are usually very fast at producing cutting-edge technology. These companies develop software in highly uncertain conditions with a fast-growing market and limited resources. In general, digital startups come with innovative ideas to solve certain problems through a technological approach (Paternoster et al., 2014). The startup business sector can be divided into five areas with the largest market coverage, namely: e-commerce (marketplaces, malls direct to consumer), transport and food (transport, food delivery), online media (advertising, gaming, video on demand, music on demand), online travel (flights, hotels, vacation rentals) dan financial services (payment, remittance, lending, insurance, investing; Kharisma, 2021).

DIGITAL INNOVATION ECOSYSTEM

Innovation ecosystems have also become an important research topic in strategic management due to their effect on a company's performance and strategy. In innovation ecosystems, co-created value is based on innovations, specifically on co-innovations, which are reached through the exploitation of innovation co-creation relationships (Klimas & Czakon, 2021). An innovation ecosystem consists of customers, suppliers, and complements who work together and compete to seek survival and dominance (Moore, 1993; Beltagui et al., 2020). The innovation ecosystem provides resources that help startups innovate and successfully reach the market (Walrave et al., 2018). Conceptually, an *innovation ecosystem* refers to a business environment in which actors under a multilayer social network interact to create shared value for an innovation actor or actor population (Ritala & Almpanopoulou, 2017; Tsujimoto et al., 2018; Granstrand & Holgersson, 2020; Huo et al., 2022). Adner & Kapoor

(2010) state that the concept of an innovation ecosystem helps to understand how external actors influence value creation (Gomes et al., 2018; Wang, 2019; Marcon & Ribeiro, 2021). An innovation ecosystem enables players to access resources and complementary assets that exceed the capacity of a single company (Pushpananthan & Elmquist, 2022).

Within the innovation ecosystem, digital innovation can grow and develop. Digital innovation is the creation of new goods, services, processes, and business models via the development and usage of digital technology (Nambisan, 2017; Li et al., 2022). This definition stresses two concurrently crucial components. First, digital innovation is built on the integration of several digital technologies, which may be categorized into four categories: information, computing, communication, and networking technologies. Second, the consequences of digital innovation efforts include digital goods, processes, organizations, and business models (Li et al., 2022).

The term *digital innovation ecosystem* refers to the concept of an innovation ecosystem in the digital area, with a complex network of heterogeneous social and technical elements, which is developed together over time and is used to refer to technological settings, methodologies, concepts, business application areas, organizations, and contexts. complex institutions (Chae, 2019). The digital innovation ecosystem is also considered an analytical framework, which connects the digital entrepreneur and the innovation ecosystem. It is built on the more networked nature of the digital entrepreneur and adopts a holistic and multilevel view by analyzing it in the entire innovation ecosystem (Beliaeva et al., 2020). The digital innovation ecosystem consists of components such as business actors, customers, suppliers, and complements (other business actors, government, universities, banks, investors, social communities, and information media; Chae, 2019; Beltagui et al., 2020; Elia et al., 2020; Beliaeva et al., 2020).

SOCIAL NETWORK ANALYSIS

In recent years, social network analysis has succeeded in characterizing the interactions among constituents of various complex systems, ranging from biological systems to technological systems and social systems (Boccaletti et al., 2014). It has also long been known to be influential in human communication and interaction, which explains why networks for interpersonal interaction and exchange feature prominently in distance studies (Fahy et al., 2001; Park et al., 2019). The mechanisms and processes of interaction within the network structure to achieve specific outcomes for individuals and groups are referred to as social network analysis (Fritsch et al., 2008; Borgatti & Halgin, 2011; Neumeyer & Santos, 2017). A network is made up of actors or nodes that are connected by various types of bonds (such as friendships). These relationships are interrelated to achieve the same goal forming a pathway that indirectly connects actors who are not directly connected or bound. Bonding patterns in the network produce certain structures, and actors occupy positions in these structures. Most of the analysis of network theory looks at the characteristics of the network structure and the position of actors (centrality) and tries to relate them to the achievement and outputs produced by groups and actors (Borgatti & Halgin, 2011). The use of social network analysis in the digital innovation ecosystem is considered relevant because an ecosystem consists of discrete elements that interact with different network configurations. Social network analysis can be used to describe relationships between organizations that have common or complementary features that facilitate access to resources and information or to determine the structure of social interactions among organizations (Ben Letaifa et al., 2016; Purbasari et al., 2018; R Purbasari et al., 2020). The relational structure between various stakeholders in the entrepreneurial ecosystem is an implicit aspect of the social network analysis approach, which investigates the level of connectivity between entrepreneurs, entrepreneurs, government agencies, incubators or members of accelerator organizations, and investors or members of higher education organizations that affect social network connectivity (Neumeyer & Santos, 2017; Purbasari et al., 2020).

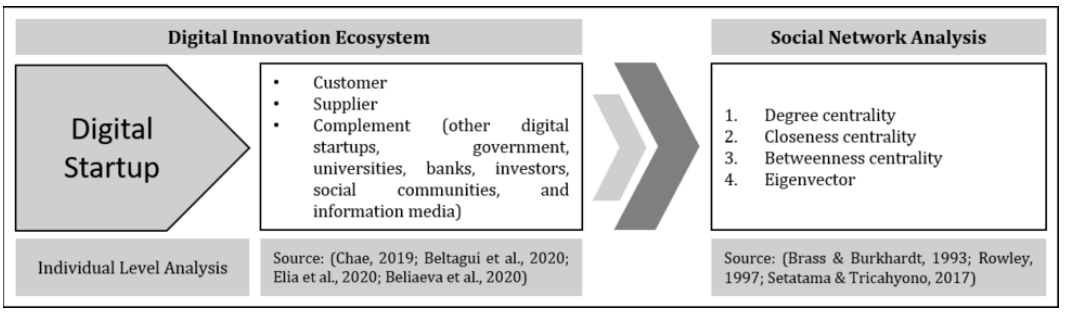
In the previous couple of decades, the greatest waves of digital innovation were sparked by billion-dollar digital startups. It is not surprising that the topic of digital entrepreneurship has gained a great deal of interest in the academic community and has been the subject of a number of reviews and special issues from a variety of fields (Sahut et al., 2019). But current studies need to adequately explore which elements are most important for maintaining and shaping digital entrepreneurs at various stages of their development (Elia et al., 2020; Beliaeva et al., 2020). Similarly, the role of interaction between stakeholders in the digital innovation ecosystem for value creation has not been widely discussed in the literature on entrepreneurship and digital innovation (Suseno et al., 2018; Autio & Thomas, 2019; Wang, 2021). In addition, digital entrepreneurship, which is social and networked, requires a new methodological approach to help explain the phenomenon of complexity and dynamic interaction between digital technology and entrepreneurship (Nambisan, 2017; Beliaeva et al., 2020). Thus, it is understood that an integrative and holistic approach is needed to test digital entrepreneurship and an innovation ecosystem to expand the outlook of digital entrepreneurship to more actors and interactions, especially related to the digital innovation ecosystem. The relationship between the variables of the digital innovation ecosystem and the social network analysis (SNA) approach can be seen in the Figure 1.

METHODOLOGY

This study uses mixed methods (mixed methods) with an exploratory sequential strategy (sequential mixed methods; Creswell, 2014). Data was collected using questionnaires and interviews. The questionnaire used is a composite questionnaire that combines choice answers and open fields. Through 18 statements in the questionnaire, digital startup actors will further confirm their relationship with other actors involved in the digital innovation ecosystem in the context of digital innovation, such as the digital startups (as business actors), customers, suppliers, and complements (other digital startups, government, universities, banks, investors, communities and information media) based on the concept developed by Chae (2019), Beltagui et al., (2020) and Beliaeva et al., (2020). In this study, questionnaires were designed and aimed at looking for the mode and frequency of data, which did not show associate statistical tests like purely quantitative researchers who applied statistical methods to establish the validity and reliability of research findings (Smith & Noble, 2014; Azungah, 2018). Therefore, this questionnaire does not require validity and reliability tests (Long & Johnson, 2000; Ghafouri, 2016) but instead emphasizes the use of triangulation strategies to ensure the validity of the research findings.

The dataset was collected and then analyzed descriptively. Descriptive research is a type of research to create a picture of a situation or event, as it is by the research question, then also analyzes the words behind the respondent's behavior (thinking, feeling, and acting), reduced, triangulated, concluded (given meaning by the researcher), and verified (Krauss, 2005; Yilmaz, K., 2013).

Figure 1.
Research framework of digital innovation ecosystem and social network analysis approach Source: The authors



Data Collection

The population in this study is a digital startup in West Java recorded at https://www.startupranking.com/top/jawa-barat, which inlcudes as many as 86 digital startups. Respondents in this study were selected by purposive sampling, a sampling technique based on specific characteristics, namely characteristics related to the population's characteristics (Bougie & Sekaran, 2019). These characteristics consist of the following:

- Digital startups have been established for at least one year; and
- Digital startup located in West Java

The following sample size will be determined by how many questionnaires were managed to get a response from the total distributed to all respondents (startup). Of the 86 questionnaires distributed online, only 32 respondents met the characteristics and responded by filling out the questionnaire completely. The lack of startups responding to online questionnaires is caused by several factors, including changes in email or contact numbers on the website startupranking.com, the Jawa Barat area, and the status of startups that are no longer active. However, this sample size has met the minimum number of respondents needed in descriptive quantitative research as explained by Gay and Diehl (1992) that for descriptive method research, a minimum of 10% of the population, for a relatively small population of at least 20%, while for correlation research a sample of thirty respondents (Kamolson, 2007; Torrentira, 2020). Even for sample sizes greater than 20, the normal distribution can approximate the binomial distribution (Agung, 2006; Alwi, 2015). This research also involved fifteen digital startups as key informants in group discussion forum activities. Respondents and research informants consisted of digital startups with several business fields, including animation, photography, videography, content creation, the services sector, business consulting, digital marketing, IT, finance, software development, application, and web development.

In this study, the determination of startup actors involved in the digital innovation ecosystem is based on the individual-level analysis (digital startup actors) used in this study. Kantis and Federico (2012) state that the digital innovation ecosystem has one of the characteristics of complexity, which is characterized by a large network of actors and factors (relational structure) involved, so it will be challenging to analyze the ecosystem as a whole. Thus, it was necessary to limit the analysis level (Ben Letaifa et al., 2016). In addition, an entrepreneurial ecosystem places business actors (digital startup actors) as the driving force (Mason & Brown 2014). Thus, the network structure generated in this study was developed based on the perspective of digital startups as business actors. Business actors are not seen only as the result of a healthy ecosystem but as key players in producing and sustaining it (Mason & Brown, 2014).

Data Analysis

The research uses a theoretical Social Network Analysis approach by utilizing the Gephi 9.2 application to determine the most important actors in the network structure of the digital innovation ecosystem. The application builds a network structure with data from the questionnaire results. Gephi is a visualization and exploration tool for all graphs and networks (Bastian et al., 2009). For the concept of social network analysis, the dimension used is centrality, commonly used in network theory research (Burt, 1992; Hanneman, 2005; Fritsch et al., 2008; Neumeyer & Santos, 2017). Dimensions are also often used to determine the central node or actor in a network, including node centrality (degree centrality, closeness centrality, betweenness centrality, and eigenvector), to identify actors who influence or have a high interaction value in the network (Brass & Burkhardt, 1993; Rowley, 1997; Setatama & Tricahyono, 2017). The data from the questionnaires were processed first using the SPSS application, which later developed into laboratory data. Then, the results are processed using the Gephi 9.2 application to generate a network structure. Furthermore, the network structure was analyzed using descriptive methods and

triangulated with the results of focus group discussions. This study proved valid by establishing precise data, using various data sources, collecting different data, and using data analysis techniques.

RESULT AND DISCUSSION

THE following will be presented as a descriptive analysis of the digital innovation ecosystem network structure based on the social network analysis approach on digital startups in West Java.

Degree Centrality

Degree centrality is the number of connections a node or actor has. It describes how many nodes or actors can be contacted directly by other nodes or actors. The results of laboratory data from the ten actors with the highest scores (see Table 1), supported by the results shown by the degree centrality network structure, indicate that PT. Sharing Vision Indonesia (digital startup actor) is the actor with the most connections (21) in the digital innovation ecosystem in West Java.

PT. Sharing Vision Indonesia, one of the digital startup actors involved in the digital innovation ecosystem in West Java, is a startup company active in the information technology field. PT. Sharing Vision Indonesia was established in 2001. Currently, PT. Sharing Vision Indonesia has held regular seminars more than four hundred and fifty times, in-house meetings with partner companies more than one hundred and fifty times, and international events ten times. PT. Sharing Vision Indonesia with its partners has completed hundreds of projects and mega projects. At the end of 2013, PT. Sharing Vision Indonesia received the Telkom Best Supplier Award for the IT Consultant Category.

Based on the data on the processed questionnaire, it is known that PT. Sharing Vision Indonesia is connected with several other digital startups, customers, the government (DISKOMINFO), state universities (SBM ITB and UNPAD), several banks, communities (Bandung Startup Community and BIM Indonesia), and also with the media (www.cnnindonesia.com). PT. Sharing Vision Indonesia is just not connected with investor actors. However, the network of actors from various categories is connected to PT. Indonesia's Sharing Vision in the digital innovation ecosystem in West Java is far greater than that of other digital startups.

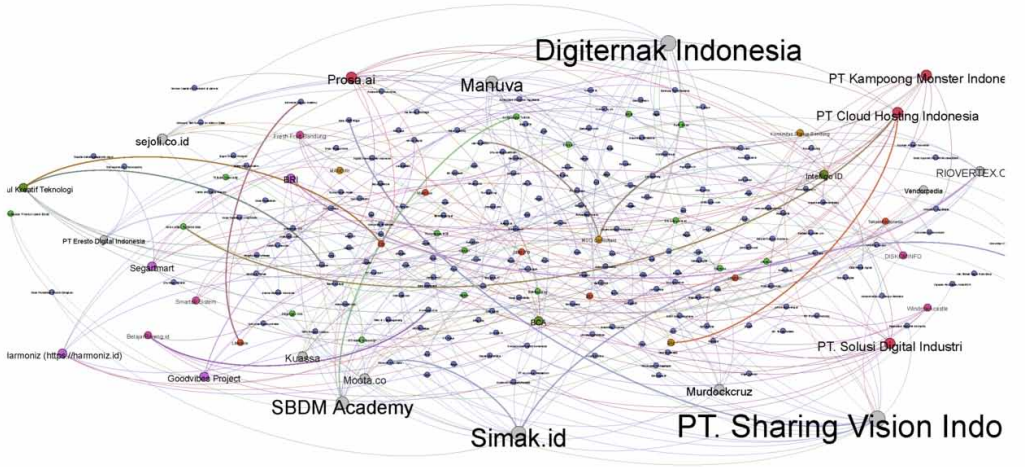
In the digital innovation ecosystem, the role of digital startups as drivers of entrepreneurship can be considered as an effort to strengthen the social environment and concentrate geographically as individuals who follow social situations and can be influenced by the success achieved by others in entrepreneurship

Table 1.
Laboratory data of degree centrality

No	Startup Digital	Degree Centrality
1	PT. Sharing Vision Indonesia	21
2	Digiternak Indonesia	20
3	Simak.id	18
4	SBDM Academy	15
5	Manuva	14
6	PT Cloud Hosting Indonesia	11
7	Prosa.ai	11
8	PT Kampoong Monster Indonesia	11
9	PT. Solusi Digital Industri	11
10	sejoli.co.id	10

Source: the authors.

Figure 2.
The degree centrality network structure Source: The authors



(Feldman, 2001; Minniti, 2008; Huggins & Williams, 2011). Startups rely on a different pool of resources during each growth phase and interact with a specific set of actors to access and utilize these resources (Fukugawa, 2018; Marcon & Ribeiro, 2021). The extraordinary connectivity and attachment of digital technology allow innovation to be carried out by a series of interdependent actors in an ecosystem, in this case, the digital innovation ecosystem. The success of the digital innovation ecosystem can produce countless innovations with substantial social and economic value (Wang, 2021).

Closeness Centrality

Closeness centrality is the average length of the shortest path between a node or actor and all nodes or actors in the graph. Thus, increasing the number of central nodes or actors also increases their proximity to all other nodes or actors. Closeness centrality describes how fast this node or actor can reach all nodes or actors in the network.

Based on the results of laboratory data from the ten actors with the highest score (see Table 2) and supported by the results of the Closeness centrality network structure (see Figure 3), the actor with the shortest path (i.e., the highest closeness centrality of 1) is PT. Industrial Digital Solutions (digital startups). PT. Industrial Digital Solutions has developed into a digital startup with the best ability to disseminate knowledge and information to all actors involved in the digital innovation ecosystem in West Java.

As one of the digital startup actors involved in the digital innovation ecosystem in West Java, PT. Industrial Digital Solutions is a digital startup company consisting of two words, namely Digital Solutions, which also represents the company's vision and mission as a company in the IT consulting field in Indonesia. PT. Industrial Digital Solutions strives to be a solution for business development in this Internet-focused digital era. PT. Industrial Digital Solutions was established in 2017, with more than five years of experience developing IT products and services in Indonesia.

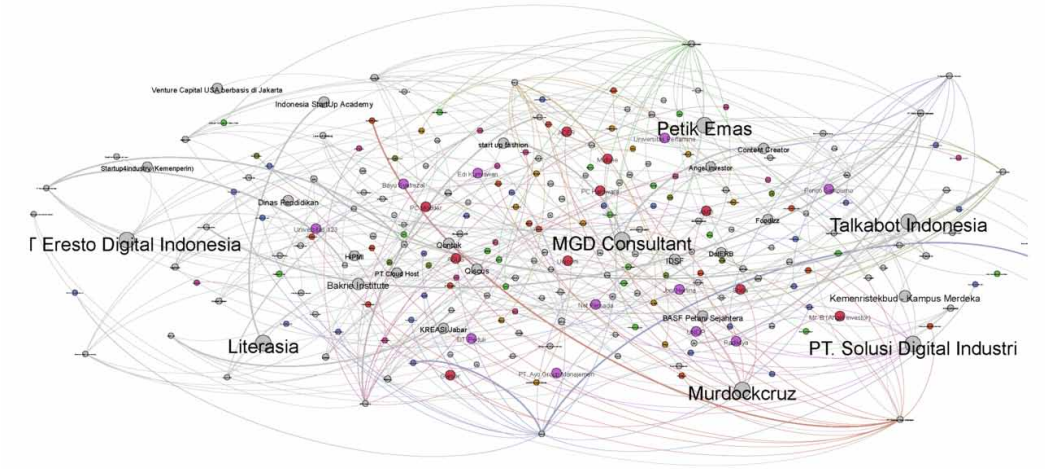
Based on the data on the processed questionnaire, it is known that PT. Industrial Digital Solutions is connected with several other digital startups, customers, state universities, and investors. PT. Industrial Digital Solutions are not connected to suppliers, the government, banks, the community, and information media actors. However, the position of PT. Industrial Digital Solutions, with all the networks connected to them on a network structure in the digital innovation ecosystem in West Java, make it an actor who can reach all actors in the network and spread knowledge and information to all actors faster than other actors involved in the digital innovation ecosystem in West Java.

Table 2.
Laboratory data of closeness centrality

No	Startup Digital	Closeness Centrality
1	PT. Solusi Digital Industri	1.0
2	Murdockcruz	0.9
3	PT Eresto Digital Indonesia	0.9
4	MGD Consultant	0.9
5	Literasia	0.8
6	Talkabot Indonesia	0.7
7	Petik Emas	0.7
8	Bakrie Institute	0.7
9	Kemenristekbud-Kampus Merdeka	0.7
10	Dinas Pendidikan	0.6

Source: the authors.

Figure 3.
The closeness centrality network structure Source: The authors



The situation of sharing knowledge and information between actors involved in the digital innovation ecosystem continues to apply even though technology has developed very rapidly. Businesses have had a sufficient investment to sustain the business because some digital startups are always trying the most effective methods to distribute knowledge and utilize and ensure that knowledge users share knowledge. Innovation and creativity are needed to develop and create creative ideas in a startup business (Nugraha & Wahyuhastuti, 2017). Digital innovation often requires a combination of internal and external assets, so companies become increasingly interconnected and interact within ecosystems (Skog, 2019). In a digital innovation ecosystem for products, services, or technologies, resources are available to digital startups in their respective populations and resources across communities and ecosystems. While most material resources, such as enterprise software and digital platforms, are owned by specific actors, intangible resources, such as information and

knowledge, can be owned by any actor beyond organizational boundaries industry and spread to every corner of the ecosystem. In the end, each actor contributes and utilizes collective attention and knowledge to understand innovation collectively (Nambisan, 2017; Wang, 2021).

Betweenness Centrality

Betweenness centrality is a measure of centrality in a graph based on the shortest path by counting the number of times a node acts as an intermediary (direct intermediary) along the fastest way between two other nodes. Based on the results of laboratory data from the ten actors with the highest scores (see Table 3) and supported by the results of the betweenness centrality network structure (see Figure 4), the actor with the most direct route (directly mediation) between two nodes or actors in the network is Prosa.ai (digital startups); an actor with the highest level of betweenness centrality (8,146.9). This finding means that Prosa.ai is a digital startup actor with the most direct path (direct mediation) between two nodes or actors in the digital innovation ecosystem network in West Java.

Prosa.ai, as one of the digital startup actors involved in the digital innovation ecosystem in West Java, is a digital startup company engaged in consulting services providing Artificial Intelligence solutions, specializing in Indonesian natural language processing (NLP). Prosa.ai was founded in 2018 to focus on increasing productivity, performance, efficiency, and business value and accelerating digital transformation in Indonesia, using deep learning techniques that produce various highly innovative AI solutions. Prosa.ai's resources have the advantage of being composed of leading experts in the field of AI-NLP and Indonesian linguistics experts. Prosa.ai is connected with several other digital startups, with many customers, with the government (BRIN and DISKOMINFO), state universities (SBM ITB and UNPAD), banks, investors, and the community. Prosa.ai is not connected with supplier actors and information media.

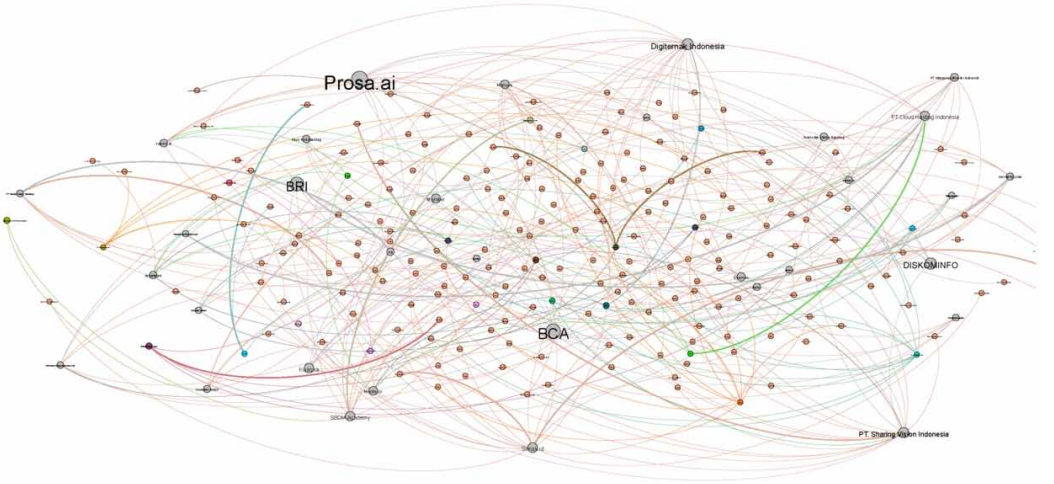
In the digital innovation ecosystem network, the actor's position will support the speed of the information and knowledge transformation process in creating digital innovation. In this study, Prosa.ai has a position that mediates the two actors with the most significant number in the digital innovation ecosystem so that many actors will depend on Prosa.ai in the context of interaction with other actors to obtain the necessary resources related to digital innovation. Innovation, creativity, and the ability to find a new opportunity are characteristics of successful entrepreneurship. Therefore, most companies have invested their money to improve the company's ability to innovate to have a positive impact on the economy (Tavakoli & Fayolle, 2017; Azzahra et al., 2021).

Table 3.
Laboratory data of betweenness centrality

No	Startup Digital	Betweenness Centrality
1	Prosa.ai	8146.9
2	BCA	6813.4
3	BRI	6345.3
4	DISKOMINFO	4570.6
5	Digiternak Indonesia	4342.0
6	PT. Sharing Vision Indonesia	3823.5
7	Simak.id	3230.0
8	Kuassa	3207.4
9	SBDM Academy	3056.4
10	PT Cloud Hosting Indonesia	2981.7

Source: The authors.

Figure 4.
The betweenness centrality network structure Source: The authors



Eigencentrality

Eigencentrality (also called *eigenvector centrality*) is a measure of the influence of nodes or actors in the network. It describes how well this node or actor is connected to other nodes or actors that are well connected. This measurement shows the importance or value of a node or actor in a social network.

Based on the results of laboratory data from the ten actors with the highest scores (see Table 4) and supported by the results of the eigencentrality network structure (see Figure 5), PT. Sharing Vision Indonesia (digital startup) is an actor who has good connections and is well connected with other nodes or actors in the digital innovation ecosystem network in West Java, with the highest degree of eigencentrality (1). Thus, PT. Sharing Vision Indonesia, as part of a digital startup, can be understood as the most important actor in the digital innovation ecosystem in West Java.

This finding is validated by the measurements on the previous dimensions that PT. Sharing Vision Indonesia is an actor with the highest degree of centrality compared to other digital startup actors in the digital innovation ecosystem in West Java. Based on the results, besides having the most connections, PT. Sharing Vision Indonesia also has a position as the most important actor in the digital innovation ecosystem in West Java.

PT. Sharing Vision Indonesia, a digital startup actor, certainly has the competence capital to create digital innovations, with factors that are conducive to creating new businesses. The digital innovation ecosystem can function as a business environment that encourages business activities to continue to grow, such as an innovative environment, the existence of formal and informal networks, market acceptance of digital startup products, and business funding to share risks and benefits (Chae, 2019).

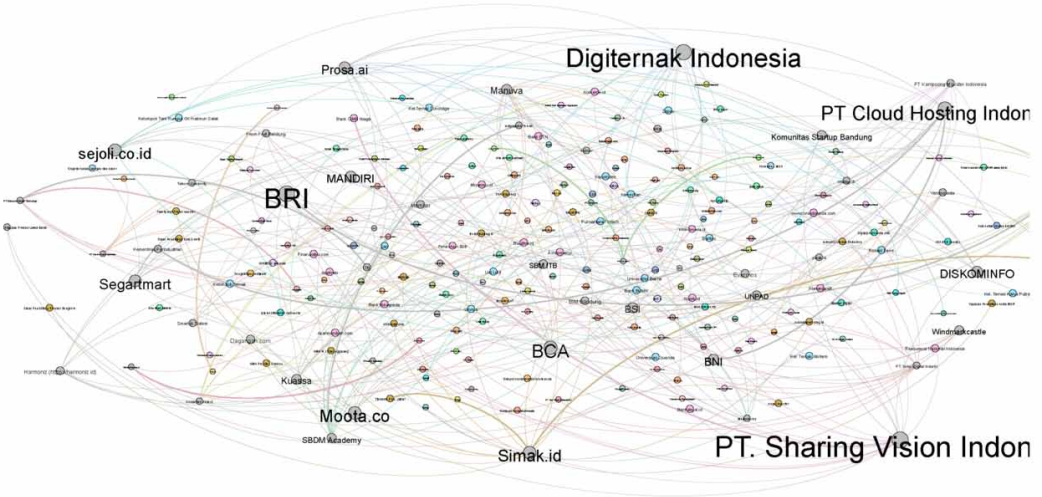
From the results, it is known that other startup actors are the main actors in all dimensions of social network analysis. The interview results show that other startup actors are the most willing to discuss and interact with digital startup actors. It is because there is a sense of mutual understanding and harmony between fellow digital startup actors, thus encouraging a more robust bond when compared to other actors. Startups frequently make deliberate decisions to rely on the resources of ecosystem actors because they wish to concentrate on resources relating to their core business (Marcon & Ribeiro, 2021). The United States, the United Kingdom, and Germany share many similarities, such as the remarkable interaction between large corporations, such as Google or Microsoft, and startups, the development of policies and government programs that encourage entrepreneurship and high-quality education, and the interaction between universities and firms. Countries with thriving

Table 4.
Laboratory data of Eigencentrality

No	Startup Digital	Eigencentrality
1	PT. Sharing Vision Indonesia	1.00
2	BRI	0.97
3	Digiternak Indonesia	0.93
4	PT Cloud Hosting Indonesia	0.77
5	BCA	0.73
6	Moota.co	0.69
7	Simak.id	0.69
8	sejoli.co.id	0.65
9	Segartmart	0.61
10	Prosa.ai	0.55

Source: The authors

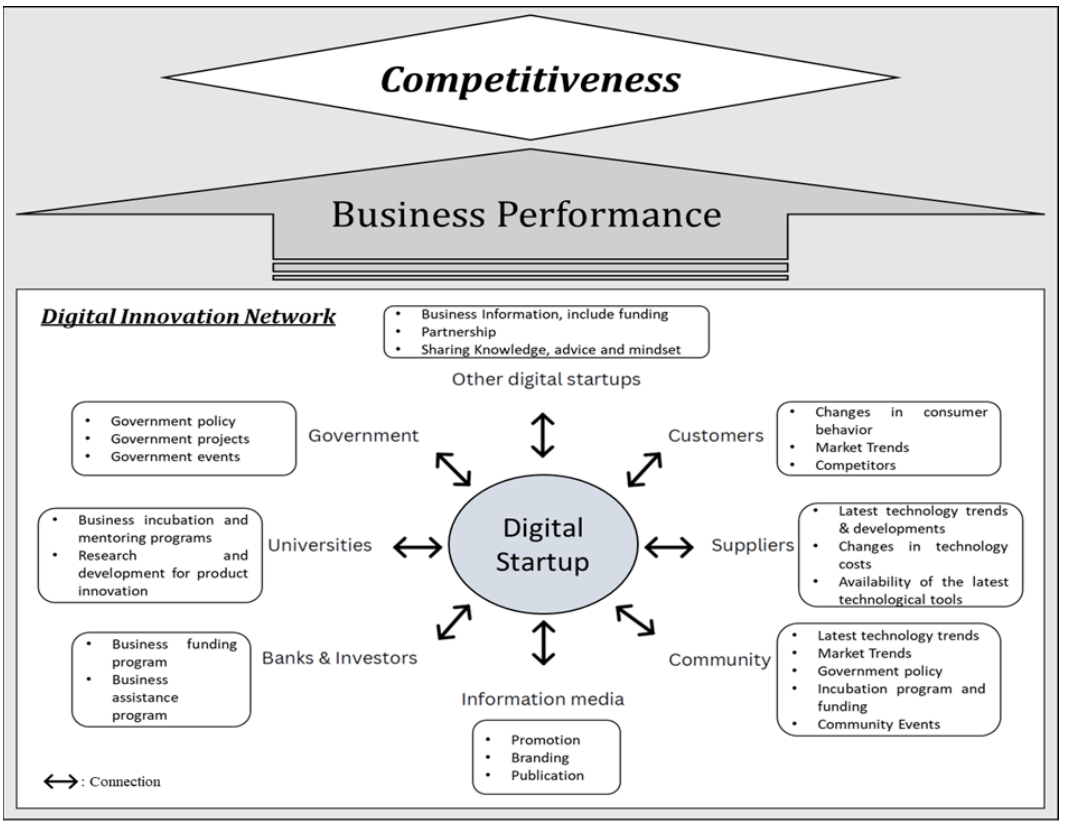
Figure 5.
The eigencentrality network structure Source: The authors



startup ecosystems, for instance, the United States, are continually enacting rules and legislation that directly or indirectly benefit the ecosystem (Flechas et al., 2022).

Based on the analysis above, a framework is developed to explain the importance of actor positions in the digital innovation ecosystem. This framework (see Figure 6) can be a reference for every digital startup actor to get the best position in its ecosystem. It was proposed that a particular ecosystem be developed to facilitate the new digital entrepreneurship generation's access to an adequate collection of knowledge, skills, financial resources, and entrepreneurial culture (Passaro et al., 2020). This should be taken into consideration by policymakers, incubators, universities, and other actors offering support to entrepreneurs because it is pretty much in line with their objective to develop the ecosystem (Cavallo et al., 2021).

Figure 6.
Digital innovation ecosystem framework for digital startups Source: The authors



By understanding the position of degree centrality, closeness centrality, betweenness centrality, and eigen centrality, digital startups can be contacted by other nodes or actors in the digital innovation ecosystem in West Java. It means digital startups will have more resource networks to support their digital innovations. These resources can be in the form of information resources, technology, projects, funds, promotions, and market opportunities, and they can even reach out to government policies. Increasingly digital startup actors are connecting with many actors such as other digital startups, customers, suppliers, government, universities, banks, investors, community, and information media, digital startups can get all the resources needed for digital innovation more easily, quickly, and cheaply. These advantages will support digital startups to have high competitiveness in their ecosystem. Digital innovation ecosystem support related to the diversity of actors that make up the ecosystem shows that the more diverse the types of actors who support digital entrepreneurs, the ecosystem will be more productive (Elia et al., 2020; Beliaeva et al., 2020). Therefore, digital startups should pay attention to and develop a digital innovation network as a business strategy that can encourage the company's position to improve its business performance to be competitive in its digital innovation ecosystem.

CONCLUSION AND RECOMMENDATION

Based on the centrality dimension used to measure the network structure, this study confirms that the actor who plays the most role in the digital innovation ecosystem in West Java is PT. Sharing Vision (digital startup actor). PT. Sharing Vision is the actor with the most connections (degree

centrality) and has a position as the most important actor in the digital innovation ecosystem in West Java (eigencentrality). As for PT. Industrial Digital Solutions is a digital startup with the best ability to disseminate knowledge and information (closeness centrality) to all actors involved in the digital innovation ecosystem in West Java. Meanwhile, Prosa.ai is a digital startup actor who acts as an intermediary with the most direct path (direct mediation) between two actors (betweenness centrality) in West Java's digital innovation ecosystem network. This study also develops a framework of the digital innovation ecosystem to explain the importance of actors' positions in the digital innovation ecosystem. This framework can be a reference for every digital startup actor to get the best position in its ecosystem.

Based on the results, some practical advice can be given. Digital startups should open their connections so they can connect with the government, universities, investors, and information media by exploring opportunities that can open up opportunities for collaboration, especially in the context of digital innovation. In addition, PT. Sharing Vision and PT. Industrial Digital Solutions, which has an important position in the digital innovation ecosystem network in West Java, can provide information, knowledge, and networks to other digital startups involved in the ecosystem. They can develop together to contribute to the progress and competitiveness of the digital startup digital innovation ecosystem in West Java in particular and in Indonesia in general. Also, the results of this research can be used by stakeholders (startups, customers, suppliers, governments, universities, banks, investors, communities, and information media) in the digital innovation ecosystem to formulate and define appropriate strategies and policies related to the development of digital startups in West Java, Indonesia.

Further research is recommended to expand the study of the digital innovation ecosystem by involving the position of the customer, supplier, government, university, bank, investor, community, and information media actors in the network structure because these actors have not been thoroughly discussed in this research. In addition, further analysis can also examine forms of collaboration, synergy, and harmony in the interaction between actors involved in the digital innovation ecosystem, primarily related to the digital innovation process because the integration of actors can improve the performance of the digital innovation ecosystem which is needed to create a productive and competitive digital startup.

As research implications, this study develops scientific knowledge in the academic field about the digital innovation ecosystem by utilizing a social network analysis approach, which can be used as a new approach in the study of the entrepreneurial ecosystem, especially the digital innovation ecosystem which has not received attention in previous research. Practically, the results of this research can be used by stakeholders (Startups, customers, suppliers, governments, universities, banks, investors, communities, and information media) in the digital innovation ecosystem to formulate and define appropriate strategies and policies related to the development of digital startups in West Java, Indonesia. This result is also an effort to build quality digital startups by producing innovative products or services that can increase market demand both domestically and globally. This condition will certainly have a positive impact on regional and global competitiveness.

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