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Technopreneurship in the digital business ERA of silk industry SMEs in Wajo Regency: The role of ecosystem and collaboration

Hasanuddin Remmang[1+]
Seri Suriani[2]
Haeruddin Saleh[3]
Indrayani Nur[4]
Herminawati Abubakar[5]

[1,2,4,5]*Department of Management, Faculty of Economic and Business, University Bosowa, Urip Sumoharjo Road, No. 45 KM 4, Sinrijala, Panakkukang, Makassar, South Sulawesi, 90232, Indonesia.*
[1]*Email: hasanuddin.remmang@universitasbosowa.ac.id*
[2]*Email: seri.suriani@universitasbosowa.ac.id*
[4]*Email: indrayani.nur@universitasbosowa.ac.id*
[5]*Email: herminawaty.abubakar@universitasbosowa.ac.id*
[3]*Department of Economic Development, Faculty of Economic and Business, University Bosowa Makassar, Indonesia.*
[3]*Email: haeruddin@universitasbosowa.ac.id*


(+ Corresponding author)

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ABSTRACT

This study aims to analyze the determining factors for SME technopreneurship success in the Wajo Regency silk industry. The research approach used is a combination of qualitative and quantitative research. Data were obtained through observation, in-depth interviews, surveys, and documentation. The results of the study indicate that product innovation, technology adoption, human resource capabilities, financial support, network strength, and local government policies determine the success of SME technopreneurship. The silk industry in Wajo Regency has great potential to improve the regional economy but faces challenges adapting to the digital business era. The role of ecosystems and collaboration in technopreneurship in the digital business era directly impacts the acceleration of digitalization, which increases business efficiency, market access both nationally and internationally, and operational efficiency by reducing production and distribution costs. Technopreneurship, a form of technology-based entrepreneurship plays an important role in supporting the growth of SMEs in the digital business era. Utilization of digital platforms, partnership networks, and appropriate policy support can increase production efficiency, market access, and product innovation. Strengthening the digital capacity of SMEs, facilitating business incubation, and developing sustainable collaboration models in the technopreneurship ecosystem of the silk industry in Wajo Regency.

Contribution/Originality: The originality of this study on technopreneurship which combines entrepreneurship with the use of digital technology is a potential strategy to increase the competitiveness and growth of silk SME businesses in Wajo Regency. Digitalization of silk industry SMEs in Wajo Regency can encourage inclusive and sustainable economic growth.

1. INTRODUCTION

The silk industry in Wajo Regency has a long history as one of the leading sectors in the local economy. However, silk industry SMEs face major challenges in maintaining their competitiveness in the era of digital business (Alcalde-Heras & Carrillo Carrillo, 2023; Weis & Nikolić, 2024). The silk industry in Wajo Regency is a leading sector that has high economic and cultural value (Anatan & Nur, 2023). Wajo Regency has a tradition-based business ecosystem that has been passed down from generation to generation as one of the largest silk-producing centers in Indonesia (Bahtiar & Karim, 2021). However, the silk industry is experiencing various challenges that

hinder its growth and competitiveness, both in the domestic and international markets in the face of the digital business era.

One of the main challenges faced by silk industry SMEs is increasingly tight global competition, especially with the entry of cheaper silk products from abroad that are produced with modern technology. In addition, limitations in access to the digital market, low digital literacy, and lack of technology-based innovation are obstacles to increasing the scale of local SME businesses (Hernita, Surya, Perwira, Abubakar, & Idris, 2021). Without the right adaptation strategy, the sustainability of the silk industry in Wajo Regency could be threatened, given changes in consumption patterns and market preferences that are increasingly moving towards digital transactions (Hendrawan, Chatra, Iman, Hidayatullah, & Suprayitno, 2024).

In this context, technopreneurship, namely the use of technology in entrepreneurship is a strategic solution for silk industry SMEs to survive and thrive (Hasan, 2023). The application of digital technology such as e-commerce-based marketing, the use of digital payment systems, the use of social media for promotion, and innovation in the production process can increase business efficiency while expanding market reach (Lestari, Abd Hamid, Shamsuddin, Kurniasari, & Yaacob, 2024). Digitalization not only allows SMEs to reach consumers more widely but also helps them increase their competitiveness through product innovation and more modern production processes.

However, the success of technopreneurship implementation does not only depend on the readiness of individual business actors but also on the support of a strong business ecosystem. The availability of digital infrastructure, access to training and mentoring, and government policies that support the digital transformation of SMEs are important factors in driving the success of the digitalization of the silk industry (Wardana, Heriyati, Oktafiani, & Gaol, 2022). In addition, collaboration between business actors, government, academics, communities, and the private sector is needed to create a business environment that supports the growth of technopreneurship in a sustainable manner (Hidayani, 2024).

Although the potential for technopreneurship in the silk industry is quite large, there are still various challenges that need to be overcome (Abbas, 2023). Low understanding of digital technology, lack of capital for investment in digital infrastructure, and minimal collaboration networks between SMEs and external parties are some of the main obstacles to the digital transformation of the silk industry in Wajo Regency. Therefore, this study examines the role of business ecosystems and collaboration in encouraging technopreneurship in the silk industry sector, as well as formulating strategies that can accelerate the adoption of technology by SMEs in the digital business era (Halim, Ahmad, & Waqas, 2025). It is hoped that silk industry SMEs in Wajo Regency can develop more competitively, innovatively, and sustainably in facing the digital business era by understanding the dynamics of the digital business ecosystem and building strong collaboration between stakeholders.

2. LITERATURE REVIEW

2.1. Technopreneurship in the Digital Business Era

Technopreneurship is a combination of technological innovation and entrepreneurship that is the key to success in the digital business era (Wibowo et al., 2022). Technopreneurship offers solutions to face challenges and take advantage of opportunities that exist in the digital world of fast technological development. Technopreneurs create technology-based solutions that can change traditional business models such as e-commerce platforms, fintech applications, and artificial intelligence technology (Fuerst, Sanchez-Dominguez, & Rodriguez-Montes, 2023; Pigola, Fischer, & Moraes, 2024; Yordanova, Filipe, & Pacheco Coelho, 2020). Technology allows businesses to run more efficiently and easily expand globally, reducing geographical and time constraints. Technology-based businesses contribute to the growth of the digital economy that is increasingly becoming the backbone of the national economy (Afraah, Sutopo, & Hisjam, 2024). Technopreneurship encourages SMEs and startups to utilize technology in operational management, marketing, and product development (Ba Awain, Jaboob, Ferasso, Alsheyadi, & Acevedo-

Duque, 2024; Ferrigno, Del Sarto, Piccaluga, & Baroncelli, 2023). Furthermore, the utilization of technologies such as cloud computing, big data, artificial intelligence, block chain, and IoT (Internet of Things) is at the core of every technopreneur's business (Conti et al., 2023; Hisrich & Kearney, 2014; Massa, Annosi, Marchegiani, & Petruzzelli, 2023). Technopreneurship can see problems as opportunities with innovative approaches in creating new solutions (Lux, Macau, & Brown, 2020; Marvel & Lumpkin, 2007). The success of technopreneurship relies heavily on an ecosystem that includes government, investors, academics, and business partners (Marinelli, Bartoloni, Pascucci, Gregori, & Briamonte, 2022; Nikraftar et al., 2022). Business in the digital era allows technopreneurs to collaborate across countries and cultures, expand markets, and increase competitiveness (Mueller, 2024; Shet, Raut, Shet, Argade, & Piekara, 2024). Furthermore, startups often face difficulties in securing funding to develop their technology ideas (Nawaz, Hina, Sharma, Srivastava, & Farina Briamonte, 2024). The digital market is global, so competition comes not only from local but also international players. Unequal access to technology and digital infrastructure can be an obstacle for aspiring technopreneurs. Technology-based businesses must ensure the protection of customer data amid growing cybersecurity threats. Furthermore, technopreneurship success strategies should identify consumer needs and create relevant technology-based solutions (Golgeci, Arslan, Kentosova, Callaghan, & Pereira, 2023). It joins startup communities, incubators, or accelerators for support and guidance. The product or service developed should provide an easy and satisfying user experience. Technopreneurs should be ready to adapt to changing markets and consumer needs (Dzogbenuku & Keelson, 2019; Fernández-Portillo, Ramos-Vecino, Calzado-Barbero, & Robina-Ramírez, 2023; Kirkley, 2016). It encourages job creation and increases productivity through innovation (Moghrabi, Bhat, Szczuko, AlKhaled, & Dar, 2023). It helps address social and environmental issues through technology. Technology-based businesses strengthen the country's position in global economic competition (Krasyuk, Kolgan, & Medvedeva, 2022). Thus, technopreneurship is the key to economic transformation in the digital era. Technopreneurship can drive economic growth, create sustainable solutions, and open up new opportunities in the global market by using technology and creating innovations. Strong ecosystem support and cross-sector collaboration are essential to ensure the success of technopreneurship in the digital business era.

2.2. Ecosystem Technopreneurship

The technopreneurship ecosystem is an environment that supports the growth and development of technology-based entrepreneurs (Rosário, Varum, & Botelho, 2024). This ecosystem includes various elements that interact synergistically to create innovation, business opportunities and sustainability of technology-based businesses (Soam et al., 2023). The technopreneurship ecosystem can play an important role in supporting silk industry SMEs to adopt digital technologies, such as e-commerce-based marketing, blockchain for supply chain transparency, and IoT for production monitoring (Patnaik, 2023).

Government: It creates policies that support the development of technopreneurship such as tax incentives, ease of regulation, and protection of intellectual property rights (Lange, Rezepa, & Zatrochová, 2024; Li, 2023) and provide funding, training, or incentive programs for technology startups and encourages collaboration between the public and private sectors (Massa et al., 2023). Education and Research Institutions: Universities, research institutes, and innovation centers provide relevant science, technology, and experts become innovation incubators by integrating education with technology entrepreneurship practices (Halim et al., 2025) and encourage collaboration between academia and industry to create technology-based solutions (Terán-Bustamante, Martínez-Velasco, & López-Fernández, 2021). Startups and technopreneurs are the main actors in this ecosystem who create technology-based solutions to answer market needs (Annamalah, Aravindan, Raman, & Paraman, 2022) and technopreneurs act as innovators and creators of new jobs (Zhou, Guo, Chen, & Chen, 2022).

Investors and capital providers include angel investors, venture capital, and crowdfunding that provide funding for technology startups at various stages of development, and capital providers also act as mentors and strategic

partners in guiding technopreneurship (Wasim, Youssef, Christodoulou, & Reinhardt, 2024). Communities and networks, startup communities, technology forums, and industry associations create spaces for sharing experiences, knowledge, and collaboration opportunities and increase connectedness between technopreneurship actors to accelerate innovation. Infrastructure and technology, physical infrastructure such as coworking spaces, labs, and data centers, digital infrastructure such as fast internet access, technology platforms, and online collaboration tools and enabling technologies such as AI, IoT, and block chain that underpin innovation (Barker Scott & Manning, 2024).

Markets and consumers, being key drivers of the success of technopreneurship through demand for technology-based products or services and feedback from consumers help technopreneurs refine products (Abubakre & Mkansi, 2024). Media and publications: Media helps build public awareness of technology products and provides visibility for technopreneurship. Media also plays a role in promoting the technopreneurship ecosystem to global investors and partners (Giuggioli & Pellegrini, 2023). Incubators and accelerators provide mentorship, training, and facilities to help technopreneurs in the early phases of business development, and accelerators focus on accelerating startup growth and increasing competitiveness in the market (Tao, 2001).

2.3. Technopreneurship Collaborative

Collaborative technopreneurship refers to an approach where different parties in the technopreneurship ecosystem work together to create innovation, accelerate the growth of tech startups, and generate greater impact for society and the economy. This collaboration creates synergies between different actors who have different but complementary expertise, resources, and goals. Collaboration enables a faster exchange of ideas, technologies, and knowledge so that innovations can be generated in a shorter time (Jindal & Kaur, 2021). By sharing resources and experience, financial, operational, and technical risks can be minimized. Technopreneurs gain access to infrastructure, funding, networks, or technology that they may not have individually (Tarmizi, Septiani, Sunarya, & Sanjaya, 2023). Collaboration with larger or more experienced partners helps startups expand markets and develop operational scale (Pigola et al., 2024). Technopreneurship can create more complex and competitive solutions by working together (Del Soldato & Massari, 2024). Furthermore, forms of collaboration in technology entrepreneurship include (1) collaboration with academia; cooperation between technopreneurs and universities or research institutions to develop new technologies. (2) Collaboration with Industry: Technopreneurs can work with established companies to share technology or integrate their products. (3) Collaboration with government: The government provides policies, funding, or facilities for technopreneurs. Example: Technology grants, incubation support, or cooperation in national digital transformation projects; (4) Inter-startup collaboration: Startups share experiences, expertise, or even products to create solutions together. (5) Community collaboration: Technopreneurs engage local communities to gain insights and build relevant products. (6) Global collaboration: Cooperation with international partners to share markets, technologies, or resources.

Furthermore, factors that support technopreneurship collaboration are as follows: Trust: all parties must have trust in the commitment and good intentions of collaboration partners. Common Goals: There is an aligned vision and mission to achieve the desired results. Effective Communication: An open and transparent communication process to ensure all parties understand their respective roles. Long-term commitment: Collaboration requires patience and consistency to achieve optimal results. Supportive Environment: An open and inclusive ecosystem encourages ease of collaboration. Benefits of collaboration in technopreneurship in improved productivity: Sharing responsibilities allows focus on each party's key strengths. Ecosystem support: Collaboration strengthens relationships between elements in the technopreneurship ecosystem. Strengthening Social Impact: Technology-based products or services can be more relevant to the needs of society. Collaborative technopreneurship is not just about sharing profits but also sharing values and responsibilities to create sustainable innovation.

3. MATERIALS AND METHODS

3.1. Research Design

This research is designed to understand technopreneurship in the digital business era, the business ecosystem, business collaboration, and its impact on the innovation and growth of SMEs in developing countries. This research uses a mixed-methods approach (qualitative-quantitative). Case studies were chosen in this research with the following considerations: First, the complexity of technopreneurship problems of silk industry SMEs in Wajo Regency. Second, the role of the business ecosystem has an impact on the growth of silk industry SMEs in Wajo Regency. Third, the role of business collaboration of silk industry SMEs in Wajo Regency. These three things are very strategic issues in the development and sustainability of SMEs. This means that technopreneurship in the digital business era will encourage the birth of a good SMEs ecosystem, increase business collaboration and have an impact on innovation and SMEs growth.

3.2. Study Area

This research was conducted in Wajo Regency related to the potential of the silk industry business developed by SMEs entrepreneurs. The selection of the research location was based on the consideration that Wajo Regency plays an important role in the silk industry in Indonesia (Nikraftar et al., 2022). Wajo Regency has an area of 2,506.19 km² consisting of 14 sub-districts and 190 villages and sub-villages with a population of 479,455 (Ardeshir et al., 2024). Furthermore, this research was conducted for 6 months starting from April to October 2024. The data collection area is adjusted to each SME location spread across 14 sub-districts. Furthermore, there are 5,387 silk industry SMEs currently developing in Wajo Regency. The silk industry SME ecosystem is dominantly developed in Tanasitolo sub-district and Tempe sub-district which are centers of economic activity and are very strategically located in terms of accessibility and make it easier for consumers to get services according to their expected needs. The existence of silk industry SMEs currently dominantly uses technological devices in marketing its products although it is still limited to simple applications, innovation is still needed in the use of more appropriate digital platforms, the involvement of labor is still relatively small, non-standardized and limited capital.

3.3. Method of Collecting Data

The data used in this study are primary and secondary. Primary data was obtained directly in the field by conducting visits and interviews using questionnaire instruments with respondents in 14 sub-districts in Wajo Regency (Nakabuye, Mayanja, Bimbona, & Wassermann, 2023). Secondary data is obtained by accessing reports and documents relevant to the research topic such as reports on the development of the number of silk industry SMEs in Wajo Regency. Furthermore, the object of this research is the silk industry SMEs that have developed in Wajo Regency while the subject of this research is the role of the technopreneurship ecosystem, the role of technopreneurship collaboration, the innovations made, the ways or efforts used in developing the business, and the sustainability of the silk industry SMEs in Wajo Regency. The population for this study was the silk industry SMEs in Wajo Regency. After considering the number of definitions of SMEs, the researcher selected a sample from the population of companies that have 5 to 99 employees. It was difficult to identify a sampling frame for this study due to the lack of a comprehensive database of silk industry SMEs in Wajo Regency, so the researchers used the direct visit technique to identify eligible silk industry SMEs and select an appropriate sample. The researchers started by having a telephone conversation with the SME owners where we requested information on the number of employees, if the number was between 5 and 99, then we invited the SMEs to participate in the study and arranged to visit their premises to collect the data if they agreed.

Structured questionnaires were used to collect the data. Such questionnaires are an efficient method of collecting data on the values, opinions, attitudes or beliefs of a sample. Questionnaire surveys allow for the collection of data from a representative sample distributed across many industries and geographical areas, which is

useful as SMEs are geographically dispersed throughout Wajo Regency. The questionnaire was based on questions used in different contexts previously. The questionnaire was sent to five employees of the cooperatives and SMEs office in Wajo Regency and five silk industry SME owners to gauge its validity. Some items were modified or rephrased to better fit the context of Wajo Regency based on their feedback. The final questionnaire consisted of five main sections. Data were collected from 300 silk industry SME owners. Owners were selected as respondents because of their involvement and responsibility in the development, ecosystem and cooperation of their organizations. Nine questionnaires were excluded from the analysis due to missing data, so the final sample of 291 questionnaires was completed. The sectoral distribution of the participating SMEs is as follows: 41.2% of silk industry SMEs with a net worth of IDR 50,000,000, 30.3% of silk industry SMEs with a net worth of IDR 50,000,000 to IDR 500,000,000, and 28.5% of silk industry SMEs with a net worth of IDR 500,000,000 to IDR 10,000,000,000. More than a quarter (27.8%) had 21-40 employees, 27.1% had 41-60 employees, 16.5% had 61-80 employees, 16.2% had 5-20 employees, and 12.4% had 81-99 employees. Almost a third of the SME sample (30.6%) had been in operation for 6-15 years, 29.2% of SMEs had been established for 16-25 years, 22% were newly established and 18.2% of SMEs had been established for 26 years or more (see Figure 1).

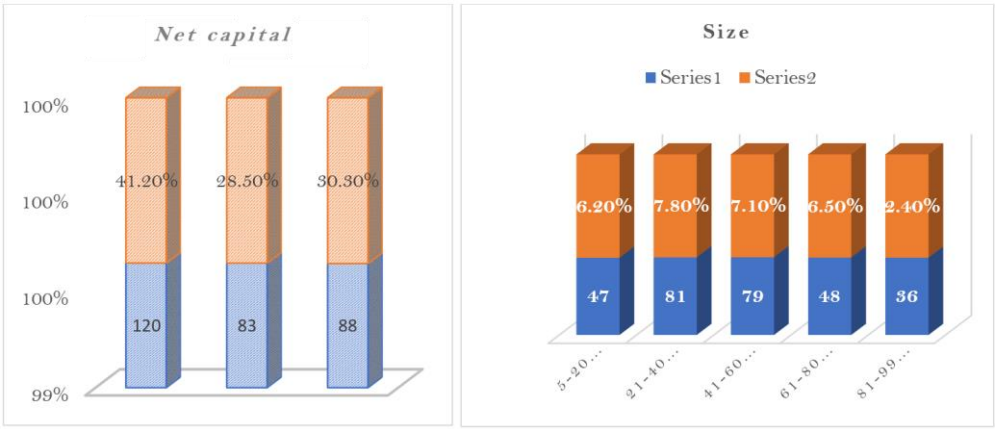

Figure 1. Business profile.

Meanwhile, the average length of time a business has been running starting from five years and under to 26 years and over is shown in Figure 2.

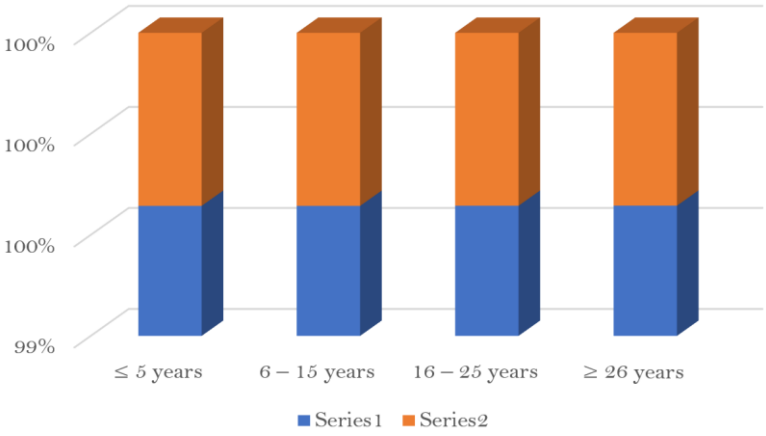

Figure 2. Business age.

Data analysis involves organizing, sorting, classifying, coding and categorizing the data that has been collected (the data includes field notes, drawings, photographs, and documents in the form of reports). Data organization is done by contrasting the situation of SME businesses that are developing with the aim of establishing themes

according to the theory used. Furthermore, in-depth interviews were conducted with informants with the aim of comparing respondents' answers to obtain more detailed explanations from respondents and non-respondents who had been interviewed previously. Researchers asked informants to provide detailed explanations regarding the type of business, business capital used, business stability, and economic business sustainability. The quantitative approach was used to reproduce information by developing several questions that had been previously collected and given alternative answers. The questions compiled by the researcher in the questionnaire were based on the results of preliminary observations in the field. Data analysis was conducted in the field during data collection, separating information into categories, organizing information in a story, and presenting the writing qualitatively by describing the situation and condition of SMEs that are developing and the efforts made to increase business productivity. Questionnaires were used to analyze the direct and indirect effects of economic growth, technological innovation, and business diversification on product marketing and business stability of the people's economy (Hasniati, Indriasari, Sirajuddin, & Karim, 2023). Furthermore, emic and ethical data which are the main data in this research were used to collect information from informants and respondents.

Thus, data analysis in a qualitative approach begins with data collection in the field, and then the data is grouped according to the research objectives. The grouped data was used to interpret and verify the data based on the theory used as a reference. A comparison was made of the characteristics of SMEs developed in the community to interpret the data in question. Then the data were analyzed by displaying tables and frequencies related to technological innovations developed to maintain the stability of the business developed. Thus, data analysis in this study includes data reduction, data presentation, and conclusions. This research further uses the Structural Equation Modeling Partial Least Square (SEM PLS) equation using software in the form of SmartPLS version 4.0.

4. RESULTS

4.1. Determinants of the Role of Technopreneurship Ecosystem of Silk Industry SMEs in the Digital Business Era

Technopreneurship has a strategic role in supporting silk industry SMEs in Wajo Regency so that they can survive and thrive in the digital business era. The use of technology in the silk fabric production process such as machine looms or digital dyeing techniques can increase product efficiency and quality. The use of social media and digital marketing allows SMEs to build brand awareness and increase product appeal through storytelling and engagement with customers (Suriani, Nur, Mardjuni, Baharuddin, & Karim, 2024).

The silk ecosystem in Wajo Regency has a strategic role in supporting the development of technopreneurship. Wajo Regency is known as one of the best silk-producing centers in Indonesia. Abundant raw materials such as silkworms and mulberry plants are a strong basis for the development of innovative technology-based industries, from silk thread production to final products such as fabrics, clothing and accessories (Abduh, Remmang, Abubakar, & Karim, 2024). The tradition of silk weaving that has been passed down from generation to generation is a rich cultural foundation for technopreneurship.

The technopreneurship ecosystem can encourage silk industry SMEs to implement sustainable fashion principles such as the use of environmentally friendly materials and recycling of production waste. Encouraging a circular economy business model in the silk industry can create added value and stronger competitiveness in the global market (Daga, Karim, Nawir, Lutfi, & Jumady, 2024; Wahyuni, Kalsum, Asmara, & Karim, 2022). The technopreneurship ecosystem has a crucial role in driving digital transformation for silk industry SMEs in the Wajo Regency. Combining modern technology and local wisdom, Wajo silk products can gain added value such as unique designs, culture-based branding, and environmentally friendly innovations. In the silk industry SMEs in Wajo Regency, the role of the technopreneurship ecosystem can be seen from the distribution of respondents' answers in Table 1.

Table 1. Respondents' responses to the role of the technopreneurship ecosystem.

Indicators	Answer scores										Mean
	1		2		3		4		5		
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Product innovation	8	2.6	27	8.7	32	10.3	113	36.5	130	41.9	4.06
Digital marketing	8	2.6	34	11.0	56	18.1	98	31.6	114	36.8	3.89
Adapting to digital business trends	11	3.5	31	10.0	51	16.5	76	24.5	141	45.5	3.98
Empowerment of silk farmers and artisans	10	3.2	36	11.6	54	17.4	78	25.2	132	42.6	3.92
Community-based economy	9	2.9	19	6.1	52	16.8	134	43.2	96	31.0	3.93
Sustainability	1	0.3	20	6.5	93	30.0	99	31.9	97	31.3	3.87
Access to capital and investment	4	1.3	61	19.7	61	19.7	105	33.9	79	25.5	3.63
Global collaboration	10	3.2	55	7.7	72	23.2	100	32.3	73	23.5	3.55
Average											3.85

A solid technopreneurship ecosystem can be a major driver for silk industry SMEs to thrive in the digital business era. Factors such as technological infrastructure, digital talent, access to funding, government policies, market access, and collaboration between stakeholders determine the success of the digital transformation of silk industry SMEs. With the right strategy, silk SMEs in Wajo Regency can adapt and compete in the global market through digitalization and technology-based innovation.

4.2. Determinants of the Role of Collaboration in Silk Industry Technopreneurship in the Digital Business Era

Wajo Regency is known as the center of the silk industry in South Sulawesi. In facing the digital business era, collaboration is a major factor in developing a technopreneurship ecosystem for silk industry SMEs. Business actors can adopt digital technology, increase production efficiency, and expand market reach through cooperation between various parties. Collaboration in the technopreneurship ecosystem of the silk industry in Wajo Regency is key to increasing competitiveness in the digital business era. The main factors that determine the success of collaboration include partnerships with academics, government support, cooperation with technology startups, access to funding, community synergy, and global market penetration through e-commerce.

Determining the role of technopreneurship collaboration in the silk industry in the digital business era lies in how various parties can work together to create added value, expand markets, and integrate technology into business processes. Technologists can help integrate automation, IoT or artificial intelligence (AI) into the silk production process to improve efficiency, quality, and production capacity. Silk SMEs in Wajo Regency can utilize digital technology to improve efficiency, expand markets, and keep the cultural heritage of silk fabrics relevant in the modern era with the right collaboration strategy. Technopreneurship, academics, government, and technology companies, the silk industry ecosystem can develop more inclusively and adaptively in the digital era with the synergy between craftsmen. Furthermore, the role of technopreneurship collaboration can be seen in the distribution of respondents' answers in Table 2 in the silk industry SMEs in Wajo Regency.

Table 2. Respondents' responses to the role of technopreneurship collaboration.

Indicators	Answer scores										Mean
	1		2		3		4		5		
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%	
Technology integration in production	8	2.6	19	6.1	44	14.2	137	44.2	102	32.9	3.99
Digital marketing and global branding	1	0.3	22	7.1	76	24.5	134	43.2	77	24.8	3.85
Transformation of supply chain ecosystem	4	1.3	20	6.5	53	17.1	100	32.3	133	42.9	4.09
Empowerment and training	5	1.6	22	7.1	34	11.0	102	32.9	147	47.4	4.17
Funding and capital access	8	2.6	15	4.8	48	15.5	81	26.1	158	51.0	4.18
Focus on sustainability	2	0.6	18	5.8	45	14.5	128	41.3	117	37.7	4.10
Development of local and global markets	4	1.3	18	5.8	78	25.2	104	33.5	106	34.2	3.94
Digital customer experience	2	0.6	21	6.8	55	17.7	108	34.8	124	40.0	4.07
Regulation and policy	3	1.0	30	9.7	64	20.6	105	33.9	108	34.8	3.92
Average											4.03

Collaboration plays a crucial role in the development of technopreneurship, especially in a tradition-based industry such as the silk industry. In the era of digital business, the success of technopreneurship depends not only on individual innovation but also on synergy between various stakeholders. Entrepreneurs can share data and information by using technology. It can share knowledge and develop innovations together through collaboration. Collaboration allows small entrepreneurs to combine resources and increase their production capacity. A larger scale of production allows them to meet the demands of a wider market, both nationally and internationally. The collaborating silk entrepreneurs can jointly conduct training and education programs for workers and the community. Collaboration gives silk entrepreneurs greater bargaining power in national and international markets, both in terms of price and product quality. Consolidation and innovation of Wajo silk products can compete with products from other regions or even from abroad. The collaboration of silk entrepreneurs in Wajo Regency not only improves production efficiency and product innovation but also opens up opportunities for the development of modern technology-based technopreneurship. The silk industry ecosystem in Wajo can become a successful example of the application of technology in traditional businesses, generating greater economic and social value through solid cooperation.

4.3. Direct and Indirect Effects of Ecosystem and Collaboration on Business Sustainability of Silk Industry SMEs through Technopreneurship

The next test is to see the significance of the influence between the independent and dependent constructs and answer what has been hypothesized. If the t-statistic value> 1.96 then the null hypothesis (H0) is rejected with a significance level of 5%. The t-statistic value of the latent construct influence coefficient is obtained from PLS bootstrapping.

Table 3. Coefficient value (Original sample), *standard error* and *t-statistics.*

Variables	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Ecosystem → Technopreneurship	0.873	0.879	0.048	18.277	0.000
Collaboration → Technopreneurship	-0.007	0.022	0.135	0.052	0.959
Ecosystem→ Business Sustainability	0.989	0.958	0.132	7.472	0.000
Collaboration → Business sustainability	-0.144	-0.132	0.069	2.078	0.038
Technopreneurship → Business sustainability	0.055	0.059	0.051	1.068	0.286

Table 3 shows that the coefficient value of the effect of collaboration on business sustainability is -0.144, the standard error value is 0.069, the t-statistic value is 2.078 and the p-values are 0.038. These results state that collaboration has a negative and significant effect on business sustainability. The coefficient value of the effect of technopreneurship on business sustainability is 0.055, the standard error value is 0.051, the t-statistic value is 1.068 and the p-values is 0.286. These results state that technopreneurship has a positive and insignificant effect on business sustainability. Furthermore, the coefficient value of the influence of the ecosystem on technopreneurship is 0.873, the standard error value is 0.048, the t-statistic value is 18.277 and the p-values are 0.000. These results state that the ecosystem has a positive and significant effect on technopreneurship. The coefficient value of the effect of collaboration on technopreneurship is -0.007, the standard error value is 0.135, the t-statistic value is 0.052 and the p-values are 0.959. This result states that collaboration has a negative and insignificant effect on technopreneurship. The coefficient value of the ecosystem's influence on business sustainability is 0.989, the

standard error value is 0.132, the t-statistic value is 7.472 and the p-values are 0.000. These results state that the ecosystem has a positive and significant effect on business sustainability.

Table 4. Indirect effects.

Variables	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T- statistics (|O/STDEV|)	P- values
Ecosystem → Technopreneurship→ Business sustainability	0.863	0.840	0.112	7.690	0.000
Collaboration → Technopreneurship→ Business sustainability	-0.142	-0.130	0.076	1.882	0.060

Table 4 shows that the coefficient value of the effect of collaboration on business sustainability through technopreneurship is -0.142, the standard error value is 0.076, the t-statistic value is 1.882 and the p-values are 0.060. These results state that collaboration has a negative and insignificant effect on business sustainability through technopreneurship. Furthermore, the coefficient value of the ecosystem's influence on business sustainability through technopreneurship is 0.863, the standard error value is 0.112, the t-statistic value is 7.690 and the p-values are 0.000. These results state that the ecosystem has a positive and significant effect on business sustainability through technopreneurship.

5. DISCUSSION

5.1. The Utilization of Silk Industry Technopreneurship in the Era of Digital Business Based on Collaboration and Community

The utilization of technopreneurship in the silk industry based on collaboration and community is an important strategy in the digital business era. It integrates technology with collective efforts to create added value, improve sustainability, and reach a wider market. Research and development-based innovation will involve collaboration between technopreneurs, academics, and research centers to create innovative silk products such as fabrics with smart fabric technology or eco-friendly dyeing (Karim, Ruslan, Burhanuddin, Taibe, & Sobirin, 2023). The designer community can work with local artisans to produce products that combine traditional and modern elements. Using block chain technology to trace the origin of raw materials, ensures transparency, and builds consumer trust in silk products, speeding up product delivery by collaborating with technology-based logistics service providers, using digital platforms that connect small producers in silk communities with global consumers such as local community-based marketplaces or large e-commerce, engaging a community of influencers and content creators to promote silk products through social media and digital campaigns and providing online training for silkworm farmers and artisans to learn the latest technologies in cultivation, production and marketing.

The technopreneur community can share experiences and innovative solutions through online forums, webinars, or community-based apps. Furthermore, the technopreneur community can form strategic partnerships, connecting local artisans with technopreneurs and non-profit organizations to create business models that benefit all ecosystem members and collaborate with fintech to provide access to microfinance to the artisan community and silkworm farmers. The technopreneur community can also do sustainability promotion, encouraging collaboration with environmental organizations to create environmentally friendly silk production practices, such as the use of renewable energy. Local communities can work with technopreneurs to preserve traditional weaving techniques through digital documentation and youth training. Market expansion through collaboration can also be created.

The technopreneurship community can use consumer community technology to provide virtual product try-on experiences, increasing consumer engagement with the producer community and using AI to understand consumer preferences based on buying patterns to offer more relevant products. In addition, the technopreneur community

can also facilitate access to funding and community-based investment technopreneurship can use crowdfunding platforms to raise funds from a community of supporters. The local investor community can work together to support the development of the technology-based silk industry. Communities can be agents of change, empowering communities to act as ambassadors for silk products, promoting local uniqueness and value to the digital marketplace. It connects diaspora communities with the silk industry to expand marketing networks and gain global market insights and leveraging collaboration and community-based technopreneurship in the silk industry brings many benefits, including product innovation, local economic empowerment and global market expansion (Karim, Musa, Sahabuddin, & Azis, 2021). The silk industry can develop more dynamically and competitively in the digital business era by integrating technology and building an inclusive ecosystem. Close collaboration between local communities, technopreneurs and global partners will be key to success.

5.2. Innovation Management and Technopreneurship Growth of the Silk Industry in the Business Era

Innovation management is a key factor in driving the growth of technopreneurship in the silk industry, especially in the competitive era of digital business. Innovation in the production process, design, marketing, and distribution enables silk industry SMEs to increase efficiency, create added value, and expand market reach, both locally and globally. Technopreneurship in the silk industry depends not only on the adoption of technology but also on the sustainability of a supportive business ecosystem. Collaboration between the government, academics, communities and business actors is essential in providing access to technology, funding, and digital skills training for SMEs. Although the opportunities for digital transformation in the silk industry are enormous, challenges such as limited digital infrastructure, low technological literacy, and the need for continuous innovation in business models still need to be overcome. With the right innovation management strategy and a supportive ecosystem, the growth of technopreneurship in the silk industry can grow further, creating global competitiveness and driving the sustainability of the silk industry in the digital business era.

The growth of technopreneurship in the silk industry in the digital business era is highly dependent on effective innovation management, process digitalization, and close collaboration with academic institutions. Partnerships with universities and research institutions play a vital role in creating technology-based solutions that suit the needs of the silk industry. Through digital platforms, technopreneurs and craftsmen can share ideas, develop prototypes, and disseminate research results to improve industry competitiveness. Digitalization in the production and distribution process is a strategic step in increasing efficiency and transparency. The adoption of automation technology in spinning and weaving can increase productivity and product quality. In addition, the use of blockchain technology allows transparent recording of the origin of raw materials, production processes, and distribution, which can increase market confidence in silk products. On the marketing side, integration between e-commerce platforms and offline stores allows silk industry SMEs to reach a wider market seamlessly (Karim, Asrianto, Ruslan, & Said, 2023). Technopreneurship in the silk industry can develop sustainably, create impactful innovations, and increase industry competitiveness at the global level with a planned digital strategy and strong ecosystem support.

Capacity building of human resources by providing online training and certification programmes to upgrade the skills of silkworm farmers, artisans and technopreneurs; supporting technopreneur start-ups in the silk industry through business mentoring programs, access to mentors and product development and establishing a technology-based learning community to share knowledge and best practices in innovation in the silk industry. Product innovation strategy by merging technology with tradition creates products such as smart silk or silk fabrics with added features (antibacterial, anti-UV, etc.) offering products tailored to consumer preferences through data analytics or AI-based platforms, and integrating eco-friendly principles in silk production to attract the attention of modern consumers who care about the environment. Market management and branding, using digital marketing strategies such as social media campaigns and global e-commerce to reach international consumers and tell the

story behind silk products such as cultural traditions and eco-friendly processes, to build an emotional connection with consumers, as well as partnering with well-known designers, fashion influencers or celebrities to increase product appeal and exposure.

Access to finance and investment by raising funds from communities or consumers interested in silk product innovation and sustainability, seeking strategic partners willing to support technology development and business expansion, and using fintech to provide micro-credit to artisans or technopreneurs in the silk supply chain. It focuses on sustainability by reducing environmental impact through the use of natural materials, renewable energy and innovative waste management techniques; promoting the recycling of silk production waste to create new products such as recycled textiles or accessories made from silk waste and seeking international certifications such as fair trade or EcoLabel to increase consumer confidence and leveraging digital technology by analyzing market data to identify trends, consumer preferences and new opportunities for product development, providing interactive shopping experiences for consumers such as virtual product try-on, and integrating AI to personalize consumer experiences such as product recommendations based on shopping history.

Developing collaborative networks by creating networks between business actors, artisans and start-ups to strengthen the technopreneurship ecosystem in the silk industry, collaborating with global companies for research, distribution or product innovation based on international markets, and working with industry associations and the government to create policies that support the growth technopreneurship. Furthermore, managing innovation and technopreneurship growth in the silk industry requires a holistic approach that integrates technology, community empowerment, sustainability and strategic collaboration. The silk industry can grow sustainably and become more competitive in the digital business era by focusing on product innovation, process efficiency and network strengthening.

6. CONCLUSION

Technopreneurship in the silk industry in Wajo Regency is the key to transforming SMEs towards a more competitive digital business era. Technology in production, marketing, and distribution allows SMEs to increase efficiency, expand market reach, and create added value for silk products. The role of ecosystems and collaboration is a crucial factor in supporting the digitalization of silk industry SMEs. The synergy between the government, academics, communities, and business actors creates a conducive environment for innovation and technology adoption. The government can provide supportive regulations. Academics play a role in research and education, and communities and business actors can strengthen business networks and share experiences in implementing digital technology. The digital business era provides great opportunities for silk industry SMEs to increase competitiveness and business sustainability. The use of digital technology in various aspects of business from production and marketing allows silk SMEs to be more efficient, innovative, and able to reach a wider market, including the global market. Although the opportunities for technopreneurship in the silk industry are enormous, there are still challenges, such as limited digital infrastructure, low technological literacy, and the need for innovation in business models. Collaboration-based strategies and ecosystem empowerment are important steps in accelerating the digital transformation of silk SMEs in Wajo Regency so that they can compete in a wider and more sustainable market.

Local economic empowerment creates collaboration with communities in empowering potential. This creates significant social and economic impacts for the community. The synergy between environmental communities, technopreneurs, and the government encourages environmentally friendly production practices and preserves traditional techniques and cultural values in silk production. The community functions as a connection center that connects various stakeholders, including the government, the private sector, and consumers, creating an ecosystem that sustains technopreneurship growth. It is necessary to build a community-based digital platform that supports collaboration, innovation and active involvement of various parties to continue to encourage the growth of silk

industry technopreneurship. Effective collaboration can be a major driver of the transformation of the silk industry into a more relevant, dynamic and competitive sector globally.

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