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Pentahelix Model for Eco-Industrial Development: A Collaborative Policy Approach

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ABSTRACT

Currently, industrial sector has been facing challenges in terms issues where the industrial activities impact the environment. The industrial sector in Ngawi Regency is one of the sectors that contributes the fourth largest to the region's economy. This study identifys the factors that influence industrial sectors namely the aspects of revenue growth, sales growth, and production growth by using multiple linear regression analysis and applying Pentahelix Model as a collaboration model towards eco-industrial development. The findings of the study revealed the variables which significantly influenced the aspect of revenue growth namely raw material, capital, and infrastructure. The production growth is affected by raw materials, capital, marketing, production, and institutional. Supported by the result of industrial development factors, Pentahelix synergy is expected to be applied in the practice of eco-industrial development based on the roles of each actor in Pentahelix.

1. INTRODUCTION

In developing countries, industrial sector has been the mainstay sector which drives the economy [1]. The industrial sector is the first priority in the development of a region. It leads and supports other supporting sectors. It is one of the sectors that greatly contribute to the gross domestic product (GDP) in a region [2]. Industrial sector is strategic and important to realize development goals. Therefore, industrialization is more aimed at supporting the development of industry to mobilize and increase the regional economic growth rate and open wide opportunities for employment [3]. To reach the purpose, good cooperation between economic sectors is needed so that it can have an impact on the activities of the production sector which has attractiveness and support in each sector [4, 5]. By industrial sector, it is expected that a stronger regional economic structure can be achieved.

On the other side, industrial sector development is currently facing challenges where industrial activities are potential in causing new problems such as environmental damage, social problems, disturbance in sustainable development process [6, 7]. Industrial activity is one of the main causes of environmental degradation which negatively impacts on the life of surrounding community [7, 8]. This environmental problem includes toxic industrial waste, excessive natural resources exploitation, and social problems such as poverty and social disparity [9, 10].

Eco-Industrial Development is an industrial development concept that focuses on achieving sustainable economic growth by minimizing negative impacts on the environment [11]. One of the strategies is collaboration between companies, governments, communities and other organizations that must collaborate to create a sustainable industrial ecosystem. This collaboration involves exchanging information, resources and knowledge to encourage innovation and best practices in reducing environmental impact [12].

Industrial sector in Ngawi Regency, preceded by agriculture, construction, and trade, is one of the sectors with fourth largest contribution to the economy [13]. The contribution of industrial sector in Ngawi Regency increases every year. Based on the Central Bureau of Statistic of Ngawi Regency in 2022, the contribution of industrial sector to the gross regional domestic product (GRDP) was 8.80% in 2018, then increased to 8.94% in 2019. In 2020, it reached 9.02% which decreased to 8.73%. The decrease was caused by the COVID-19 pandemic which also impacted sectors. In 2021, the GRDP of industrial sector of Ngawi Regency increased to 9.31%. The data showed that the industrial sector has become one of the leading sectors in Ngawi Regency that boosts the surrounding economy of the community due to its considerable contribution.

The food and drink industries are the leading industries with largest contribution, followed by industries of timber, wood and cork products, bamboo woven products, rattan and the like, and tobacco processing (Directory of Small and Medium Enterprises of Ngawi Regency, 2016). The three types industry is potential to develop due to their large contribution to GRDP.

The Pentahelix Model is a synergy of 5 main actors of sustainable development, namely government, institutions, communities, media and business or the business world to mutually build and develop the industry [14]. In order to achieve the optimal results in the sustainable industrial development, synergy and collaboration between the 5 actors are needed. This study aims at identifying the influential factors in the industrial sector development. The findings of the study can be used to know the influential aspects in the development of industry. This study also formulates the Pentahelix Model in industrial development. The model is expected to be able to be applied in the sustainable industrial development in Ngawi Regency.

2. METHODOLOGY

2.1 Data collection and sampling

Data were collected through interviews, and observations [15]. Observations were made to see the condition of the industrial characteristics consisting of internal and external aspects in Ngawi Regency Observations were intended to determine the condition of supporting facilities for industrial activities: trade facilities, transportation, and utility networks. Questionnaires were used to know the internal and external characteristics of the industry as well as the industrial development in Ngawi Regency which consisted of sales growth, production growth, and revenue growth.

This study used non-random sampling with the purposive sampling technique. Purposive sampling techniques are used in determining samples based on researchers' considerations about which samples are most appropriate, useful and considered representative of a population (representative). Based on data of microenterprises of Ngawi Regency in 2022, the number of small and medium enterprises (SMEs) in Ngawi Regency reached 1,764 industries spread throughout the sub-district area. There were 396 industrial businesses in Ngawi District used as samples in the study. Sample selection was based on consideration of diversity, number, and distribution of industries. The diversity, distribution, and number of industries are the highest in Ngawi sub-district so that the area is considered to be representative of the existing population.

The respondents observed were all workers in several industrial categories namely industries of food and beverage, cigarette, wood, bamboo, rattan, grass and the like, chemical and petroleum, coal, rubber, and plastic, paper and paper goods, printing and publishing, textile, clothing and leather Figure 1 (a).

The characteristics of the respondents were classified based on gender, age, and levels of education. Based on the survey, it was found that the respondents frequency by gender was dominated by males. The proportion of respondents based on gender was 65% or 258 male respondents. Meanwhile, female respondents were 35% or 138 respondents Figure 1 (b).

Besides gender, the respondents were reviewed based on age. The frequency of respondents by age was dominated by the age group of 35-44 years old. The proportion of respondents based on age was 12% or 47 respondents in the age group of 15-24 years old. 24% or 94 respondents were in the age group of 25-34 years old. 33% or 129 respondents were in the age group of 35-44. 23% or 90% respondents were in the age group of 45-54 years old or 31 respondents were in the age group of more than (>) 55 years old Figure 1 (c).

Based on the survey, it could be identified that the frequency of respondents based on the latest education level was dominated by senior high school graduates. There were 60% or 23 respondents of junior high school graduates. 57% or 226 were senior high school graduates. There were 25% or 98 respondents with diploma degree and 12% or 49 respondents with bachelor degree Figure 1 (d).
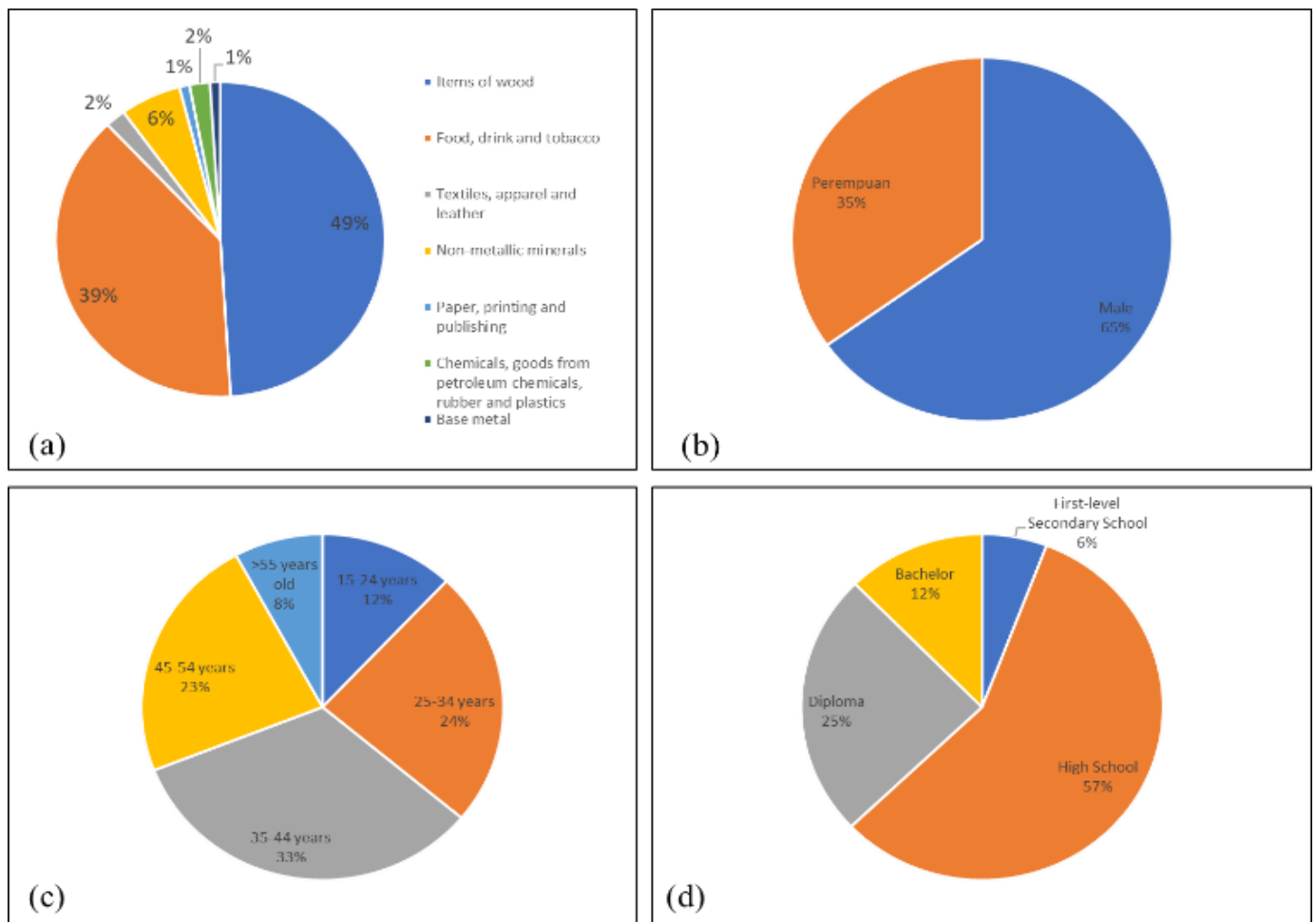
Figure 1. Pie chart of: (a) Frequency of small and medium industry types, (b) Characteristics of respondents by gender, (c) Characteristics of respondents by age, (d) Characteristics of respondents by level of education

Variables and sub-variables in the study were obtained based on previous studies. They are detailed in Table 1.

Table 1. Research variables

No	Variable	Indicator	Source
1	Raw Material	Price of raw material	[16-18]
2	Workforce	Wage	[17, 18]
3	Capital	Value for money	[19]
4	Marketing	Marketing strategy	[17, 18]
5	Production	Number of productions	[17, 19]
6	Technology	The use of technology	[18, 19]
7	Accessibility	Transportation costs	[18]
8	Institution	Forms of cooperation	[20]
9	Source of energy	Type of energy	[21]
10	Infrastructure	Type of infrastructure	[18]
11	Space	Land size	[18]
12	Revenue growth	Amount of revenue	[22]
13	Production growth	Production capacity	[23]
14	Sales growth	Selling price	[22]

2.2 Multiple linear regression analysis

This study examines the influence and relationship of more than two independent variables on dependent variables to determine the influential factors in the industrial development. Multiple linear regression formula was used as a method [24]. The equation of the multiple linear regression model is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \epsilon_i \qquad (1)$$

Descriptions:
Y = bound variable (dependent)
β_0 = intercept
β_i = coefficient (slope) of the ith variable or attribute
X_{ij} = j^{th} predictor independent variable of ith respondent, also known as attribute
ε_i = fallacy that occurs in an attempt to achieve the expected price, with i =1, 2, 3, ..., n.

The hypotheses were formulated based on a conceptual model adapted from previous studies and findings, namely factors that influence the industrial sector development: raw materials, capital, infrastructures, marketing, production and institutions [17, 25-27]. The factors that influence the revenue growth cover resources, customers, suppliers, complements, competitors, and research institutions [22]. Factors that influence the sales revenue growth are product quality, product price, sales amount, sales location, competitors, and marketing [22, 28].

There are efforts that can be made to improve the industrial sector sustainability. First, it can be done through production optimization. The suggested approach is by innovatively combining the obstacles with sustainable efficiency in the resource reallocation modeling. Second, it is performed by adjusting the scale of production. The third effort is by considering the characteristics of energy consumption [23]. Figure 2 describes the hypothesis formula for this research.

- H1. There is a positive relationship between revenue growth and raw materials
- H2. There is a positive relationship between revenue growth and capital
- H3. There is a positive relationship between revenue growth and infrastructure
- H4. There is a positive relationship between sales growth and marketing
- H5. There is a positive relationship between sales growth and production
- H6. There is a positive relationship between production growth and raw materials
- H7. There is a positive relationship between production growth and capital
- H8. There is a positive relationship between production growth and marketing
- H9. There is a positive relationship between production growth and institutional
- H10. There is a positive relationship between production growth and production
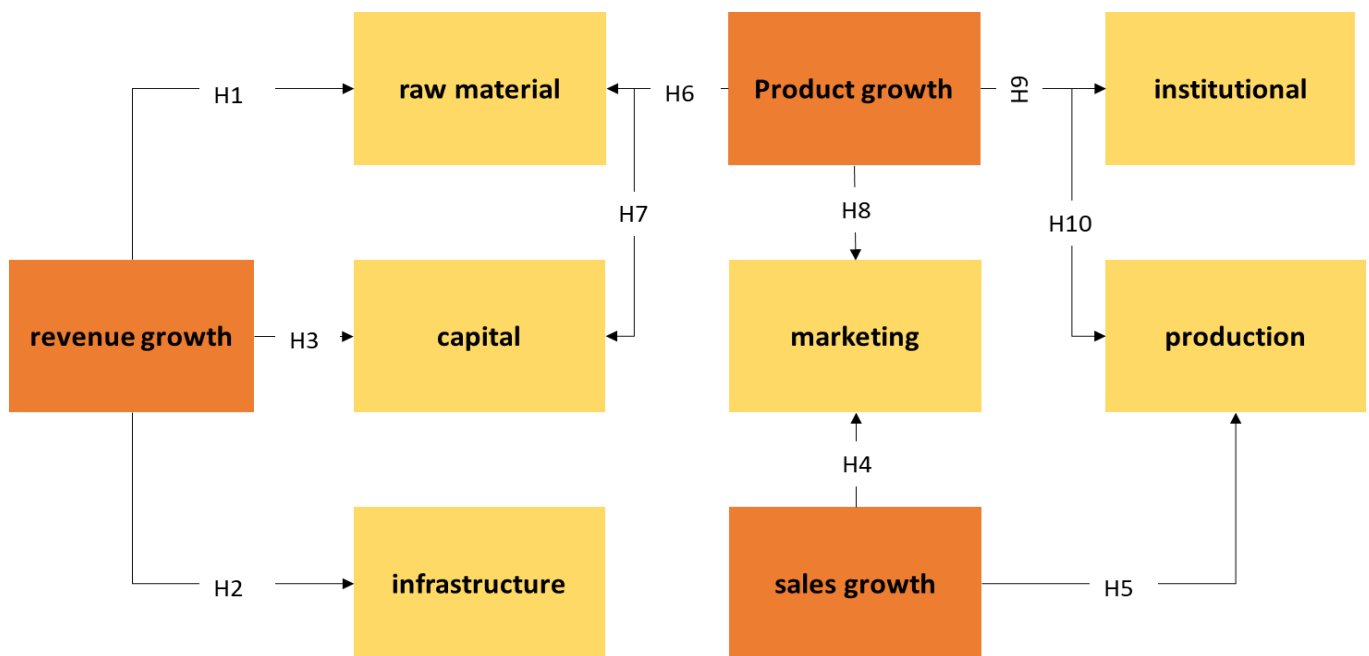
Figure 2. The model of conceptual and research hypotheses

2.3 Pentahelix Model

Pentahelix is an innovative model of development of the Quadruple Helix Model which connects academics, business practitioners, communities, government and media to create an ecosystem based on creativity and knowledge [29]. Collaboration between the stakeholder has become a strategy to optimize industrial development in Ngawi Regency. Involvement and collaboration between the stakeholders in optimizing eco-industrial development in Ngawi Regency synergize based on the main tasks of each actor. The Pentahelix Model in this study was used to see the stakeholders' collaboration in developing the industries in Ngawi Regency on 5 main actors. Figure 3 describes the five main actors of the Pentahelix Model as follows.

a) Academics

Academics provide knowledge, training, and also and new business idea to support the industrial sector development in Ngawi Regency.

b) Business

The business aspect provides capital and marketing strategies of industrial products.

c) Community

This means people who share the same interest in making and distributing products in the industry in Ngawi Regency. In this case, the community means the industrial practitioners in Ngawi Regency.

d) Government

Government is the actor who manage the regulations on industry in Ngawi Regency. In the industrial sector development in Ngawi Regency, the government formulates policies and conduct supervision.

e) Media

Stakeholders of the media in industrial sector in Ngawi Regency are the social media and radio broadcasts. Media helps to streamline the communication process between the stakeholders and the industrial marketing in Ngawi Regency.
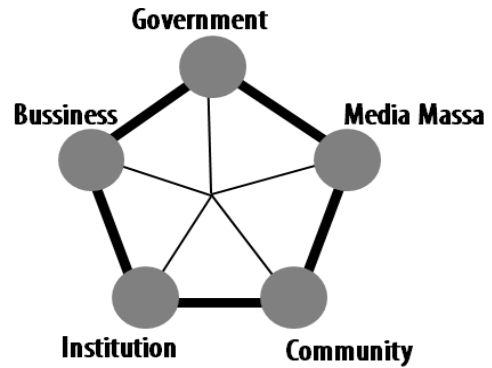

Figure 3. The collaboration of Pentahelix Model

3. RESULTS AND ANALYSIS

3.1 Multiple linear regression analysis

There are three aspects of multiple linear regression analysis: revenue growth, sales growth, and production growth.

3.1.1 Revenue growth

Table 2 explains the multiple regression analysis on the revenue growth aspect. In the aspect of revenue growth, there are three significant influential variables namely raw material, capital, and infrastructure. The following is the equation in the regression model.

$Y = 8,092,603.05 + 0.56X_1 + 0.24X_3 + 992,047.80X_{10}$
$R^2 = 41.1\%$.

Table 2. The result of multiple linear regression analysis of revenue growth

	Coefficients				
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	8,092,603.05	1,854,836.14		4.36	0.00
Raw Material	0.56	0.13	0.29	4.26	0.00
Labor	-0.19	0.13	-0.09	-1.38	0.17
Capital	0.24	0.04	0.46	6.05	0.00
Marketing	-311,439.76	165,824.82	-0.15	-1.87	0.06
Production	338.27	275.12	0.08	1.23	0.22
Technology	-295,918.49	210,832.37	-0.09	-1.40	0.16
Accessibility	0.20	0.13	0.11	1.49	0.13
Institution	-279,444.25	155,719.21	-0.12	-1.79	0.07
Source of energy	-25,772.66	127,267.69	-0.01	-0.20	0.84
Infrastructure	992,047.80	469,693.92	0.13	2.11	0.03
Space	-7,800.39	10,780.53	-0.04	-0.72	0.47
a. Dependent Variable: Revenue Growth					

Source: SPSS processing result, 2022

The t-test result show that raw material has a significant effect with p value of 0.00 (p<0.05). The raw material variable demonstrates a regression coefficient of 0.56 with t value of 4.26. The results of the calculations exhibit that the availability of raw material can affect the income earned by industrial business practitioners. It influences industrial activities, thereby impacting on the income. Every increase of 1 value (rupiah) in raw material will cause an increase in the value of revenue growth of 0.56.

From on the t-test result, it has been found that capital variable is significantly influential with p value of 0.00 (p<0.05) The capital variable shows a regression coefficient of 0.24 with t value of 6.05. The result of the calculation presents that capital availability can be influential in the amount of revenue increase. The greater the capital owned by an entrepreneur, the greater the income. Every increase of 1 value (rupiah) in capital will result in an increase in the value of revenue growth of 0.24.

The t-test calculation revealed that the infrastructure variable is significantly influential with p value of 0.03 (p<0.005). The infrastructure variable shows regression of 999,047.80 with t value of 2.11. Every increase of 1 value (quality) in infrastructure will cause an increase in the value of revenue growth of 992,047.80. Infrastructure development directly influences the industrial sector development. The infrastructural service development has impact in terms of reduced production costs, increased productivity of the workforce, access to the workplace, and increased macroeconomic stability. In other words, the availability of infrastructure supports the integration of processes from upstream to downstream in the industrial sector [30].

3.1.2 Sales growth

Table 3 explains the result of multiple linear regression analysis on sales growth aspect. The test result present four variables that have significant influence on the sales growth namely marketing and production variables. The following is the equation in the regression model.

$$Y=70.69+9.49X_4+11.99X_5$$
$$R^2=13.1\%.$$

Table 3. The results of multiple linear regression analysis of sales growth

			Coefficients			
	Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig
		B	Std. Error	Beta		
1	(Constant)	70.69	33.06		2.13	0.03
	Raw Material	1.18	0.00	0.00	0.50	0.61
	Labor	6.71	0.00	0.00	0.27	0.78
	Capital	-4.77	0.00	0.00	-0.66	0.50
	Marketing	9.49	2.95	0.00	3.21	0.00
	Production	11.99	0.00	1.00	2,447.01	0.00
	Technology	6.03	3.75	0.00	1.60	0.11
	Accessibility	-3.07	0.00	-.00	-1.28	0.19
	Institutional management	-1.79	2.77	0.00	-0.64	0.51
	Source of energy	-3.37	2.26	-.00	-1.48	0.13
	Infrastructure	5.85	8.37	0.00	0.70	0.48
	Space	0.26	0.19	0.00	1.37	0.17
	a. Dependent Variable: Sales growth					

Source: SPSS processing results, 2022

The t-test reveals that marketing variable significantly influences the sales growth with p value of 0.00 (p<0.05). This is indicated by the regression coefficient value of 9.49 with t value of 3.21. The calculation shows that marketing strategy will positively influence the furniture and metal products sales [28]. Every increase in 1 value (strategy) in the marketing will increase the value in the sales growth of 9.49.

The t-test result explains that the production variable significantly influences the sales growth. This is shown by the regression coefficient of 0.00 with t value of 2,447.01 and p value of 0.00 (p<0.05). The more production increases, the more the number of products offered [31]. Every increase in the value (number) in production will cause an increase in the value in production growth 0.00.

The t-test unveils that the capital variable is significantly influential in sales growth with p value of 0.00 (p<0.05). This is indicated by the value of regression coefficient of 9.49 with t value of 3.21. The results of the calculation suggest that marketing strategy will positively affect the sales of furniture and metal products [28]. Every increase in 1 value (strategy) in marketing will increase the value in the sales growth of 9.49.

The result of t-test exhibits that the production variable is significantly influential in sales growth. This is indicated by the regression coefficient value of 0.00, with t value of 2,447.01 and p value of 0.00 (p<0.05). As production increases, the number of goods offered increases [31]. Every increase of 1 value (amount) in production will result in an increase in the value of production growth of 0.00.

3.1.3 Production growth

Table 4 details the result of multiple linear regression analysis on the production growth aspect. The test result informs five variables which are significantly influential in production growth aspect namely raw material, capital, marketing, production, and institutional. There are six insignificant influential variables. Therefore, they are not included in the regression model. The following is the equation in the regression model.

$$Y=166.84+1.77X_1+2.03X_3+4.01X_4+0.01X_5+2.12X_8$$
$$R^2=60.8\%.$$

Table 4. The results of multiple linear regression analysis of production growth

			Coefficients			
	Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.2	12.52		0.09	0.92
	Raw Material	1.77	0.00	1.11	2.02	0.04
	Labor	0.08	0.33	0.01	0.24	0.80
	Capital	2.03	0.00	0.46	7.50	0.00
	Marketing	4.01	1.11	0.24	3.58	0.00
	Production	0.001	0.01	0.20	3.76	0.00
	Technology	0.70	1.40	0.02	0.50	0.61
	Accessibility	2.15	0.00	0.01	0.23	0.81
	Institutional	2.12	1.05	0.11	2.01	0.04

Coefficients					
Source of energy	1.13	0.85	0.07	1.33	0.18
Infrastructure	-2.49	3.14	-0.04	-0.79	0.42
Space	-0.12	0.07	-0.09	-1.69	0.09
a. Dependent Variable: Production Growth					

The t-test result suggests that capital variable is significantly influential with p value of 0.00 (p<0.05). The capital variable shows a regression coefficient of 2.03 with t value of 7.50. The result of the calculation presents that capital availability can be influential in the amount of revenue increase. It is because the greater the capital owned by an entrepreneur, the greater the income [19]. Every increase of 1 value (rupiah) in capital will result in an increase in the value of revenue growth of 0.24.

The t-test result indicates that the marketing variable is significantly influential in production growth with p value of 0.00 (p<0.05). This is shown by the regression coefficient value of 4.01 with t value of 3.58. It can be concluded that marketing can increase the production value. By marketing, the demand for products will increase, thereby positively affecting the production growth [22]. Every increase of 1 value (strategy) in marketing will result in an increase in the value of production growth of 0.04.

The result of t-test informs that the production variable is significantly influential in sales growth. This is indicated by the value of regression coefficient of 0.01, with t value of 3.76 and p value of 0.00. It other words, increasing the production number will increase production growth as well. Production growth can increase the employment [17]. Every increase of 1 value (strategy) in marketing will result in an increase in the production growth value of 0.01.

The result of t-test shows that variable of institutional is significantly influential in production growth. This is indicated by the value of regression coefficient of 2.12 with t value of 2.01 and p value of 0.04. In sum, the activities conducted by institution can increase the industrial production growth [32, 33]. Every increase of 1 value (activity) in production will cause an increase in the value of production growth of 2.121.

3.2 Pentahelix Model

3.2.1 Actor's behaviours and roles in eco-industrial development
(1) Government
Government has a role related to transparency, inclusivity, justice, legitimacy, integration, capability, accountability and adaptability. Collaboration between industry practitioners and the government determines to construct policies governance in the industrial sector [7, 34].

Government should act as regulator and controller in the regulation and responsibility of the business development process [35]. The government, as the lead sector, has a goal to improve the welfare and prosperity of the people fairly nad equally by utilizing funds, natural resource, and/or cultivation products and by taking into account the balance and sustainability of the environment in industrial development. In this context, it involves all kinds of activities such as planning, implementation, monitoring, control, promotion, financial allocation, licensing, planning, legislation, development and knowledge, public policy innovation, networking innovation support and public-private partnership [36]. The role of government is very important in the industrial sector sustainability. The government as a catalyst, facilitator, and advocacy actor provides stimulation, challenges and encouragement, so that business ideas get to a higher level of competence. The support can be the government's commitment to use political power proportionally and by giving public administrative service well as well as financial aid, incentive, or protection to industrial sector. The government as a policy maker can accelerate industrial development if policies that create a conducive business climate for industry in Ngawi Regency are made. Government is also responsible to the coordinate holders who contribute to the potential development in the industrial sector [7, 20, 37].

The variables that influence the government are institutional and infrastructure. Institutional variable is influential in terms of production growth. This is because the government has training programs for acquisition and knowledge transfer, infrastructure development, establishment of research laboratories, technology and science park centers, training centers and incubation centers, service consulting, skills and technology transfer and others. In return, the government invites academic experts to become members of the national advisory and consultation committee. For this reason, the government is considered to be a support on technology growth. Therefore, it is necessary to create an appropriate environment for technology-related businesses to achieve [35] prosperity. Good collaboration between the government and the institutions and infrastructure will have impact in creating appropriate facilities and infrastructure that support sustainable industrial sector.

(2) Institution
Institutions builds a new paradigm for society in economic development. The worldview on maximizing development-oriented profits is essential in establishing a new rationality which leads to community-based preferences. Based on the preferences, society will act with new rationalities, such as awareness to preserve the environment and knowledge of the negative impacts in the future [38].

Institution serves as conceptors in identifying the potential and certification of products and skills and also acts as the source of power to support human improvement. Institution is a source of knowledge of the latest concepts, theories, and relevance to the potential development of conditions in the industrial sector [39-41]. In the process of industrial sector development, institution conducts scientific studies, various research and community service which are related to the industrial sector development. The findings of scientific studies and community service can be used as guidelines in supporting the success of the industrial sector by cooperating and communicating with the academics in the process of industrial sector development.

Institutions have right to solve industrial environmental problems, and are independent of the government [40]. Institution is a source of knowledge with the latest concepts, theories which is relevant to the conditions of industrial potential development in Ngawi Regency. Thus, institutions will influence and have the responsibility of assessing the true price of production through pro-environmental economics with the concept of valuation, including existing externalities created by production activities.

The variable that influences the Pentahelix Model in institutional actors is institutional variable. It is influential in production growth. It is a system regarding community activities, while the institutions help in providing studies or knowledge in an organized group to conduct activities [7]. These two things influence each other because in the management, institution provides knowledge in terms of innovation, concepts, and theories to perform activities to achieve a goal. Good collaboration between the institutions will impact on the concept or knowledge about the development of the industrial sector that is environmentally sound.

(3) Social/Community

There are two points of society role in Pentahelix Model according to the Solow II Growth Model [42]. First, research and educational institutions will make society an effective labor. In addition, an educated individual has paradigm that may improve future economy. Second, education gives an understanding or worldview which provides preferences of environmentally friendly products [43, 44]. Smart decision of the consumers will directly support the application of sustainable industry [38, 45].

The community in the Pentahelix Model acts as an accelerator. This means those who have similar interests which are relevant to the developed potentials. Community acts as an intermediary or a liaison between the stakeholders and support the whole process, and also streamline the adoption of economic processes. Besides that, the community also has a role to promote products or services [41].

Community has the aim of becoming a fun forum for the sustainability and industrial development. Community is a dynamic and continuous process of social interaction and communication in which groups form networks or bonds of interpersonal relationships. The relationship is based on shared activities such as socializing, sharing information, having a sense of belonging and social identity.

The involvement of community in industrial sector affects the increase in support, attention, and awareness of social maintenance. Community also acts directly in mobilizing the surrounding community. Various types of community with different idealism can be used to accelerate the implementation of industrial development in Ngawi Regency.

The variable which has influence on community actors in the Pentahelix Model is the production and raw materials. Production variable affects the sales growth and production growth. It is influential because the production process needs to be run by a community or society to produce an item and add its utility. Raw material variable affects the revenue growth and production growth, because in the manufacture or the materials processing, it takes a community with certain skills to create a useful production [36]. Thus, in this case, community is considered important in the sustainability of industrial sector especially in the process of production and provision of raw material.

(4) Media

Media acts as an extender. New media which continues to evolve is useful for social interaction between digital, networked and computerized humans as an effect of the advance in technology, information and communication [46]. Media publish, promote and create brand image in the industrial sector. Promotion and marketing in the inclusive industry by utilizing social media needs to be considered.

Media aims to promote products and create brand image. Social media is important to disseminate information related to the program development. Standard platform such as Twitter, Facebook, and Instagram can be used by public to publish daily life. Media has positive impact to distribute information because in digital era, social media is attached to society. If used well, the feedback received by the industrial actors to improve their business through the support of media and other four actors will be optimal. Social media has strategic role in digital era because it can help distribute information to public quickly and easily. Social media can be used personally by the industry practitioners to develop their business.

The variables which influence the Pentahelix Model and media are marketing and production. Marketing and production variable affects sales growth and production growth. Marketing variable affects the Pentahelix media model because it is easier for a company to find consumers and provide interesting information to attract potential consumers through social media. Media is also a cost-effective digital marketing method [46, 47]. The production variable is influential because the higher the interest in the products displayed in the media, the more production will be produced, resulting in high sales and production growth. In this case, media has a considerable role in industrial sector sustainability. Appropriate promotion will increase demand towards industrial products in Ngawi Regency.

(5) Business/Private

The application of the Pentahelix Model in economic development presupposes the addition of the diaspora as the fifth helix in the Quad Helix Model. In economic development, diaspora is important in terms of partnerships and cooperation by making business investments to support the provision of facilities and infrastructure. One of which is the introduction of modern technology. Applying the Pentahelix Model by involving diaspora accelerates the economic development. The involvement is supported by a stable legal framework and support from governments, investors and by cooperation with entrepreneurs, universities or research institutions, and civil society to achieve faster economic development [48].

NGOs are the benefit in the three-sector model which consists of the government as the first sector, business as the second sector, and voluntary institution as the third sector. NGOs serve as intermediaries that mediate between governments and citizens in various issues. The existence of NGOs/private parties can give a good impact to help the development in industrial sector. They serve as the "ear" to listen the community's aspiration, and as the intermediaries in conveying the people's aspiration to the government. They also participate in policymaking and the preparation of important comprehensive development plans and programs. Therefore, it takes the role of NGOs in social innovation and product development programs [48].

Business/private parties in the Pentahelix Model acts as an enabler that delivers technology and capital infrastructure. Business/private parties are an entity that carries out business processes in creating added value and maintaining sustainable growth [49]. In the process of industrial development, business is important to implement business in the industrial sector which prioritizes ethics, professionalism, responsibility and sustainability [20, 38]. The business world which is profit oriented will be responsible for environmental sustainability which is important in the industrial sector.

The private sector aims to deliver technological infrastructure and capital. It also aims to develop useful innovations and solve problems. Non governmental organizations (NGOs) are the groups that contribute to social development both locally or regionally. They have a role in receiving donations, dues, and government subsidies [50]. Related to business, the variable which is influential in Pentahelix Model is capital. Capital variable is influential in the revenue growth and production growth [37, 50]. Capital is important in business operations. Capital is needed in the procurement of raw material to products production. Capital is considered as creativity that will develop the business in the future. In this case, the involvement of private/business parties can help in providing capital to increase income in industrial sector.

3.2.2 Actor's performances and roles in Pentahelix

The collaboration of the Pentahelix Model on academic, private, community, government and media is needed [34, 35, 37]. Cooperation and interdependence are required between the actors. Constructive idea integration, joint decisions, and shared responsibilities are important to create agreements or regulations which specifically direct the actors to officially cooperate in pursuing the Pentahelix Model Collaboration [40, 51].

The Pentahelix Model is a reference in developing a synergy between the institutions to reach goals [52]. Pentahelix collaboration has purposes, innovations, and contribution to a region's economic and social development [53]. The Pentahelix collaboration focuses on social issues and environmental damage, ranging from disparity between the east and west regions of Indonesia to disasters caused by environmental damage which have been the issue in industrial development in Indonesia. The application of the Pentahelix Model has a contribution in creating a sustainable industry both on environmental, social, and economic aspects [53, 54]. Pentahelix Model synergizes 5 actors: (i) government, (ii) research and education centers as the innovators, (iii) specialized institutions made by governments to monitor the environmental and social aspects, (iv) society, and (v) industry as the main focus of the model [38].

Based on the multiple linear regression analysis of the t-test, there are 3 aspects tested to determine the relationship between variables in the aspects in the Pentahelix Model. Based on the t-test result, the three aspects related to the Pentahelix Model are a) revenue growth: raw material, capital, and infrastructure, b) sales growth: marketing and production, and c) production growth: raw material, capital, marketing, production, and institutional. A support system is needed in developing a sector through the optimization of the role of business, government, community, academic, and media or BGCAM [55]. The Pentahelix Model and function are aiming at achieving sustainable development which is open to innovations from various systems. The existing innovations come from 5 systems: political, educational, economic, natural environment, media and culture-based public Figure 4 (a).

In sustainable development goal, input is very important as an initial process to determine the influential factors in making successful output. Input provides various aspects to support the future success Figure 4 (b). Therefore, analyzing the input is necessary to achieve success.
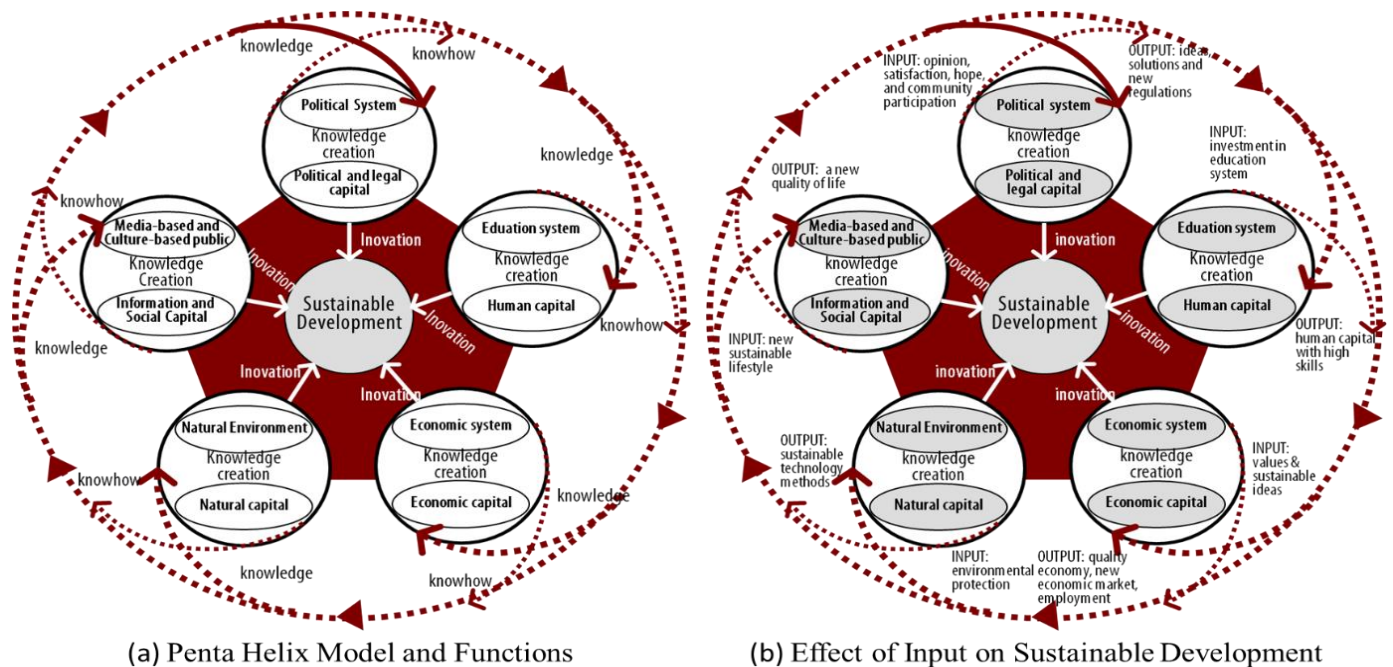

Figure 4. (a) Pentahelix Model and function [56, 57], (b) The effect of input on sustainable development

4. CONCLUSION

The findings inform that raw material, modal and infrastructure significantly influence the revenue growth with coefficient of determination of 41.1%. Meanwhile, in the marketing growth, the influencing factors are marketing and production with coefficient of determination of 13.1%. In the aspect of production growth, the significant influential factors are raw material, modal, marketing, production, and institutional with coefficient of determination of 60.8%. The influential factors in the industrial sector development in Ngawi Regency are integrated in Pentahelix Model. Cooperation between governments and institutions is essential to achieve successful and sustainable development.

Institutions help create the concepts or knowledge about environmentally sound-industrial sector development. Community plays role in the production process and the supply of raw material. Media is important in the promotion of industry, while the private/business parties influence the capital development. The synergy of five main actors must be balanced with strong political will and a goal to improve the industry and harness the potential. It is able to harmonize a sustainable regional development.

This study was conducted only in Ngawi district area. It is expected that future studies can be carried out in a wider scope to get the results of significant factors that affect the industrial development in Ngawi Regency.

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REFERENCES

[1] Seth, D., Rehman, M.A.A., Shrivastava, R.L. (2018). Green manufacturing drivers and their relationships for small and medium (SME) and large industries. Journal of Cleaner Production, 198: 1381-1405. https://doi.org/10.1016/j.jclepro.2018.07.106

[2] Wiemer, C., Tian, X. (2001). The measurement of small-scale industry for China's GDP accounts. China Economic Review, 12(4): 317-322. https://doi.org/10.1016/S1043-951X(01)00063-3

[3] Amoah, C., Jehu-Appiah, J. (2022). Factors driving industrialization in Africa: A panel two-stage least square approach. Modern Economy, 13(2): 144-158. https://doi.org/10.4236/me.2022.132010

[4] Jiang, T., Huang, S., Yang, J. (2019). Structural carbon emissions from industry and energy systems in China: An input-output analysis. Journal of Cleaner Production, 240: 118116. https://doi.org/10.1016/j.jclepro.2019.118116

[5] Hartwig, J., Kockat, J., Schade, W., Braungardt, S. (2017). The macroeconomic effects of ambitious energy efficiency policy in Germany-combining bottom-up energy modelling with a non-equilibrium macroeconomic model. Energy, 124: 510-520. https://doi.org/10.1016/j.energy.2017.02.077

[6] Yeşilkaya, M., Daş, G.S., Türker, A.K. (2020). A multi-objective multi-period mathematical model for an industrial symbiosis network based on the forest products industry. Computers & Industrial Engineering, 150: 106883. https://doi.org/10.1016/j.cie.2020.106883

[7] Boons, F., Spekkink, W. (2012). Levels of institutional capacity and actor expectations about industrial symbiosis: Evidence from the dutch stimulation program 1999-2004. Journal of Industrial Ecology, 16(1): 61-69. https://doi.org/10.1111/j.1530-9290.2011.00432.x

[8] Chopra, S.S., Khanna, V. (2014). Understanding resilience in industrial symbiosis networks: Insights from network analysis. Journal of Environmental Management, 141: 86-94. https://doi.org/10.1016/j.jenvman.2013.12.038

[9] Öko-Institut, W.I.P. (2020). Towards a climate-neutral germany, 31. https://www.agora-energiewende.de/en/publications/towards-a-climate-neutral-germany-executive-summary/.

[10] Muhammad, S., Pan, Y., Agha, M.H., Umar, M., Chen, S. (2022). Industrial structure, energy intensity and environmental efficiency across developed and developing economies: The intermediary role of primary, secondary and tertiary industry. Energy, 247: 123576. https://doi.org/10.1016/j.energy.2022.123576

[11] Fan, Y., Fang, C. (2020). Assessing environmental performance of eco-industrial development in industrial parks. Waste Management, 107: 219-226. https://doi.org/10.1016/j.wasman.2020.04.008

[12] Geng, Y., Fujita, T., Park, H.S., Chiu, A.S., Huisingh, D. (2016). Recent progress on innovative eco-industrial development. Journal of Cleaner Production, 114: 1-10. https://doi.org/10.1016/j.jclepro.2015.09.051

[13] Ngawi, B.P.S. (2022). Statistik daerah ngawi.

[14] Fitriani, S., Diponegoro, A., Wahjusaputri, S. (2020). The synergy effect of "ABCGM" for small and medium-sized enterprises. In 23rd Asian Forum of Business Education (AFBE 2019). Atlantis Press, pp. 40-46. https://doi.org/10.2991/aebmr.k.200606.007

[15] Phellas, C.N., Bloch, A., Seale, C. (2011). Structured methods: Interviews, questionnaires and observation. Researching Society and Culture, 3(1): 23-32.

[16] Wang, W., Jiang, D., Chen, D., Chen, Z., Zhou, W., Zhu, B. (2016). A material flow analysis (MFA)-based potential analysis of eco-efficiency indicators of China's cement and cement-based materials industry. Journal of Cleaner Production, 112: 787-796. https://doi.org/10.1016/j.jclepro.2015.06.103

[17] Hassler, M. (2004). Raw material procurement, industrial upgrading and labor recruitment: Intermediaries in Indonesia's clothing industry. Geoforum, 35(4): 441-451. https://doi.org/10.1016/j.geoforum.2003.11.002

[18] Jiang, Y., Timmermans, H.J., Yu, B. (2018). Relocation of manufacturing industry from the perspective of transport accessibility-An application of percolation theory. Transport Policy, 63: 10-29. https://doi.org/10.1016/j.tranpol.2017.11.003

[19] Wadley, D. (2021). Technology, capital substitution and labor dynamics: Global workforce disruption in the 21st century? Futures, 132: 1028. https://doi.org/10.1016/j.futures.2021.102802

[20] de Oliveira Neto, G.C., Tucci, H.N.P., Correia, J.M.F., da Silva, P.C., da Silva, D., Amorim, M. (2021). Stakeholders' influences on the adoption of cleaner production practices: A survey of the textile industry. Sustainable Production and Consumption, 26: 126-145. https://doi.org/10.1016/j.spc.2020.10.001

[21] Yu, F., Guo, Y., Le-Nguyen, K., Barnes, S.J., Zhang, W. (2016). The impact of government subsidies and enterprises' R&D investment: A panel data study from renewable energy in China. Energy Policy, 89: 106-113. https://doi.org/10.1016/j.enpol.2015.11.009

[22] Endres, H., Helm, R., Dowling, M. (2020). Linking the types of market knowledge sourcing with sensing capability and revenue growth: Evidence from industrial firms. Industrial Marketing Management, 90: 30-43. https://doi.org/10.1016/j.indmarman.2020.06.004

[23] Du, J., Xu, Y., Wang, Y. (2023). How to improve sustainability for industrial sectors: Optimizing production scales based on performance-oriented

resource reallocation. Energy Economics, 119: 106525. https://doi.org/10.1016/j.eneco.2023.106525

[24] Maaouane, M., Zouggar, S., Krajačić, G., Zahboune, H. (2021). Modelling industry energy demand using multiple linear regression analysis based on consumed quantity of goods. Energy, 225: 120270. https://doi.org/10.1016/j.energy.2021.120270

[25] Aisyah, S., Sulastri, S. (2020). Tracing the labor absorption rate in the medium and large industrial sectors. EcceS (Economics, Social, and Development Studies), 7(2): 220-239. https://doi.org/10.24252/ecc.v7i2.17992

[26] Signé, L. (2018). The potential of manufacturing and industrialization in Africa: Trends, Opportunities, and Strategies. African Growth Initiat. https://www.brookings.edu/wp-content/uploads/2018/09/Manufacturing-and-Industrialization-in-Africa-Signe-20180921.pdf.

[27] Loučanová, E., Olšiaková, M., Štofková, J. (2022). Open business model of eco-innovation for sustainability development: Implications for the open-innovation dynamics of Slovakia. Journal of Open Innovation: Technology, Market, and Complexity, 8(2): 98. https://doi.org/10.3390/joitmc8020098

[28] Binh, V.T.T., Huong, H.T. (2021). Critical factors affecting sales revenue in supermarket chains: A critical review of literature. Journal of Science & Technology, 57: 130-134.

[29] Sundari, S., Yusuf, C., Kusuma, A.A. (2021). The influence of Pentahelix model on organizational innovativeness and product innovation performance at creative economy supporting jember district tourism destination. In the First International Conference on Social Science, Humanity, and Public Health (ICOSHIP 2020), Atlantis Press, pp. 170-174. https://doi.org/10.2991/assehr.k.210101.038

[30] Lin, B., Chen, Y. (2019). Will economic infrastructure development affect the energy intensity of China's manufacturing industry? Energy Policy, 132: 122-131. https://doi.org/10.1016/j.enpol.2019.05.028

[31] Vanbergen, N., Irmak, C., Sevilla, J. (2020). Product entitativity: How the presence of product replicates increases perceived and actual product efficacy. Journal of Consumer Research, 47(2): 192-214. https://doi.org/10.1093/jcr/ucaa006

[32] Djibo, B.O.S., Horsey, E.M., Zhao, S. (2022). Government institutional support and eco-innovation: The moderating role of market performance in Benin's industrial sector. Journal of Cleaner Production, 378: 134598. https://doi.org/10.1016/j.jclepro.2022.134598

[33] Kwak, K., Kim, N. (2022). Industrial leadership changes without technological discontinuity: Modularization, institution-led market discontinuity, and market development strategy. Technological Forecasting and Social Change, 180: 121688. https://doi.org/10.1016/j.techfore.2022.121688

[34] Cabrera-Flores, M., López-Leyva, J., Peris-Ortiz, M., Orozco-Moreno, A., Francisco-Sánchez, J., Meza-Arballo, O. (2020). A framework of penta-helix model to improve the sustainable competitiveness of the wine industry in Baja California based on innovative natural resource management. In E3S Web of Conferences. EDP Sciences, 167: 06005. https://doi.org/10.1051/e3sconf/202016706005 Ansell, C., Gash, A. (2008). Collaborative governance in theory

and practice. Journal of Public Administration Research and Theory, 18(4): 543-571. https://doi.org/10.1093/jopart/mum032

[35] Halibas, A.S., Sibayan, R.O., Maata, R.L.R. (2017). The penta helix model of innovation in Oman: An hei perspective. Interdisciplinary Journal of Information, Knowledge & Management, 12: 159-174.

[36] Meshram, A., Jha, R., Varghese, S. (2021). Towards recycling: Understanding the modern approach to recover waste aluminium dross. Materials Today: Proceedings, 46: 1487-1491. https://doi.org/10.1016/j.matpr.2020.11.423

[37] Cabrera-Flores, M., López-Leyva, J., Peris-Ortiz, M., Orozco-Moreno, A., Francisco-Sánchez, J., Meza-Arballo, O. (2020). A framework of penta-helix model to improve the sustainable competitiveness of the wine industry in Baja California based on innovative natural resource management. In E3S Web of Conferences. EDP Sciences, 167: 06005. https://doi.org/10.1051/e3sconf/202016706005

[38] Amrial, A., Muhamad, E., Adrian, A.M. (2017). Penta helix model: A sustainable development solution through the industrial sector. Social and Human Sciences, 14(1): 152-156.

[39] de Oliveira, J.A., Silva, D.A.L., Ganga, G.M.D., Godinho Filho, M., Ferreira, A. A., Esposto, K.F., Ometto, A.R. (2019). Cleaner production practices, motivators and performance in the Brazilian industrial companies. Journal of Cleaner Production, 231: 359-369. https://doi.org/10.1016/j.jclepro.2019.05.013

[40] Hong, H., Gasparatos, A. (2020). Eco-industrial parks in China: Key institutional aspects, sustainability impacts, and implementation challenges. Journal of Cleaner Production, 274: 122853. https://doi.org/10.1016/j.jclepro.2020.122853

[41] Setianingsih, E.L., Herawati, A.R., Hariani, D. (2022). Penta helix model tourism development in the city of palembang. Devotion Journal of Community Service, 3(13): 2221-2226. https://doi.org/10.36418/dev.v3i13.274

[42] Bateman, I.J., Burgess, D., Hutchinson, W.G., Matthews, D.I. (2008). Learning design contingent valuation (LDCV): NOAA guidelines, preference learning and coherent arbitrariness. Journal of Environmental Economics and Management, 55(2): 127-141. https://doi.org/10.1016/j.jeem.2007.08.003

[43] Voth, D.E., Brewster, M.L. (2019). Community development. In American Rural Communities.

[44] Shaw, M. (2008). Community development and the politics of community. Community Development Journal, 43(1): 24-36. https://doi.org/10.1093/cdj/bsl035

[45] Romero-Rodríguez, J.M., Ramírez-Montoya, M.S., Aznar-Díaz, I., Hinojo-Lucena, F.J. (2020). Social appropriation of knowledge as a key factor for local development and open innovation: A systematic review. Journal of Open Innovation: Technology, Market, and Complexity, 6(2): 44. https://doi.org/10.3390/joitmc6020044

[46] Wu, G., Yang, R., Li, L., Bi, X., Liu, B., Li, S., Zhou, S. (2019). Factors influencing the application of prefabricated construction in China: From perspectives of technology promotion and cleaner production. Journal of Cleaner Production, 219: 753-762. https://doi.org/10.1016/j.jclepro.2019.02.110

[47] Li, X., Hamblin, D. (2016). Factors impacting on cleaner production: Case studies of Chinese pharmaceutical manufacturers in Tianjin, China. Journal of Cleaner Production, 131: 121-132. https://doi.org/10.1016/j.jclepro.2016.05.066

[48] Tonkovic, A.M., Veckie, E., Veckie, V.W. (2015). Aplications of penta helix model in economic development. Economy of Eastern Croatia Yesterday, Today, Tommorow, 4: 385-393.

[49] Calzada, I. (2021). Chapter 3-Democratising smart city citizenship: Penta helix multi-stakeholders policy framework from the social innovation perspective. In Smart City Citizenship, pp. 79-115.

[50] Lutz, C., Zieschank, R., Drosdowski, T. (2017). Measuring Germany's transition to a green economy. Low Carbon Economy, 8(1): 1-19. https://doi.org/10.4236/lce.2017.81001

[51] Kagungan, D., Duadji, N., Meutia, I.F. (2021). Kolaborasi model pentahelix dalam kebijakan pengembangan industri pariwisata di kabupaten pesawaran. Prosiding IICIS 2021.

[52] Yuwono, M.A.B. (2016). Impact of coffee product packaging and labeling on purchase intentions with mediating of brand image. Academy of Strategic Management Journal, 15: 150-154.

[53] Romero-Rodríguez, J.M., Ramírez-Montoya, M.S., Aznar-Díaz, I., Hinojo-Lucena, F.J. (2020). Social appropriation of knowledge as a key factor for local development and open innovation: A systematic review. Journal of Open Innovation: Technology, Market, and Complexity, 6(2): 44. https://doi.org/10.3390/joitmc6020044

[54] Hastjarjo, S., Wahyunengseh, R.D., Hidayah, S.A. (2021). Communicating sustainable environment and pro-poor policy in tourism in Indonesia: A discourse network analysis. In IOP Conference Series: Earth and Environmental Science. IOP Publishing, 905(1): 012143. https://doi.org/10.1088/1755-1315/905/1/012143

[55] Purnomo, E.P., Fathani, A.T., Setiawan, D., Fadhlurrohman, M.I., Nugroho, D.H. (2021). Penta-helix model in sustaining Indonesia's tourism industry. In Advances in Digital Science: ICADS. Springer International Publishing, pp. 477-486. https://doi.org/10.1007/978-3-030-71782-7_42

[56] Carayannis, E.G., Campbell, D.F. (2010). Triple helix, quadruple helix and quintuple helix and how do knowledge, innovation and the environment relate to each other? A proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. International Journal of Social Ecology and Sustainable Development (IJSESD), 1(1): 41-69. http://doi.org/10.4018/jsesd.2010010105

[57] Carayannis, E.G., Barth, T.D., Campbell, D.F. (2012). The quintuple helix innovation model: Global warming as a challenge and driver for innovation. Journal of Innovation and Entrepreneurship, 1: 1-12. https://doi.org/10.1186/2192-5372-1-2