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The structural model of a sustainable coffee - based agrotechnology parks development in Bengkulu Province, Indonesia

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Abstract Development of Science and Technology Parks (STP) is included in the Indonesia national development plans targeting 100 units during 2015-2019. Lack of understanding of the concept of technology parks causing the operation is not optimal. The influence of coffee-based agrotechnology parks (ATP) development factors in Kepahiang Regency was investigated. The obtained results by SEM pathways revealed variables with statistically significant effects, i.e., firstly, resource management strategies; secondly, social management strategies; thirdly, cooperation system strategies. These factors had a significant effect on ATP development. Resource management strategies and environmental management strategies had a significant effect on ATP development through cooperation system development. Identification of factors on the development of ATP and the relationship among factors are expected to help planners and decision-makers in strengthening development strategies of coffee agroindustry in the agrotechnology parks.

Keywords: Agrotechnology parks, Coffee, Structural equation model, Sustainability

Introduction

Science and Technology Parks (STP) is a regional development model that has been adopted by many countries. This model can accommodate needs of business and science development that mutually support regional economic growth. The first STP was established at the Stanford University campus in 1951, which turned the poor undeveloped area of Silicon Valley into a technology, finance, education, and global research centre. Based on UNESCO data in 2019, the number of STPs around the world was 524 units, i.e., in the United States (72 units), France (60 units), China (80 units), United Kingdom

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(63 units), Finland (24 units), and Japan (23 units). The definition of technology parks was determined by the focus of technological innovation developed and the involvement of the tenant companies in its applications.

According to UNESCO, the term "science and technology parks" includes all types of high-tech clusters such as technopolises, science parks, science cities, cyber parks, hi-tech parks (industry), innovation centre, R&D parks, university research parks, science and technology parks, technology incubators, technology parks, technoparks, technopoles, and business incubators. STP has a slight difference because it requires large area of land for incubation and accommodation spaces of companies at very different stages of development, as well as having a focus on a specific technology. The success of a technology parks is influenced by many factors, such as access to the nearest local market, access to component suppliers, local innovation culture, entrepreneurship and cooperation, access to skilled labor, access to capital, good ventures and communication. The other factors are attractive working environment, shared support facilities such as office services, meeting facilities, information technology, management training services, risk-taking culture, existence of well-known companies, common vision among stakeholders, suitable services according to needs, legal services, transportation, resource sharing capacity, scale of parks, technology parks relations with universities and research centers (Bellini *et al.*, 2012; Kharabsheh, 2012; Zieliński *et al.*, 2014; Pourfateh *et al.*, 2015; Weng *et al.*, 2019).

The design and development of STP must consider opportunities and difficulties in a specified area. Based on local excellence, the STP structure can be designed in such a way so that it becomes the parks specialties (Gursel, 2014). One model that has been developed is the coffee-based agrotechnology parks (ATP). Coffee has a significant contribution to the Indonesian economy, with the export value reached around US$ 806 thousand and a volume of around 277 million tons in 2018 (BPS, 2019). Coffee plantations are a source of income of 1.84 million households spread across almost all provinces in Indonesia, except DKI Jakarta (Dirjenbun, 2018).

Sun *et al*. (2007) mentioned that the framework for the operation of science and technology parks is related to natural resource factors, facilities, and human resources. The linkages between these factors are placed in one location together with the expectation of forming a symbiosis between industries in the use of energy, materials, or information (Ashton, 2009). The main purpose of this management is economic development through the establishment and growth of technology-based business activities, property development to support economic activities, and technology transfer from research institutions or universities (Zhang, 2005).

The development of new STPs is a challenge for planners because there is no general model of a technology parks. Based on its function, a technology parks is a business model that has certain entities with the support of advanced technology (Zieliński *et al.*, 2014; Faria *et al.*, 2019) The difficulty of replicating the STP was stated by Muhammad *et al.* (2017), in which of the 100 STPs targeted in the 2015-2019 National Medium-Term Development Plan (RPJMN), only a few STPs were included in the established category. Muhammad *et al.* (2017) mentioned that the developed STPs were mostly in the form of SME development, technology dissemination, demonstration plots, and training centers.

The design of agrotechnology parks as a form of sustainable agriculture area management was carried out using the structural equation approach. Structural Equation Modeling (SEM) is recommended in field of social science and behavioural science researches which are exposed to multivariate data that is not normally distributed, require more complex models (many observed constructs and variables), are formative models, have data and models with less theoretical support (Hair *et al*., 2011). According to Hwang *et al*. (2016), three dimensions of eco-industrial development parks consist of the development of a resource circulation system, cooperation systems, and the ecological environment are developed using the structural equation model. The aim of this study was to analyze the determinant variables and develop structural equation model using the Partial Least Square (PLS-SEM).

Materials and methods

Time and data collection

This study was conducted from July to October 2019 using a desk study approach to determine the latent variables (LV) and observed variables (indicators) for the development of ATP. Data collection was conducted using a survey method with an online questionnaire of Google forms. Respondents of this study were 143 people, consisted of researchers/academics (106 respondents), industry stakeholders (30 respondents), and government officials (7 respondents). The education level of the respondents consisted of Doctoral (49.29%), Masters (29.58%), Bachelors degree (18.31%), and the rest were senior high school and Diploma educations. Respondents were selected based on their activities related to ATP development and coffee agro-industry. Table 1 showed that this study used 38 ATP development strategies obtained from literature studies.

Table 1. Development strategy of coffee-based ATP in Kepahiang Regency

Latent variable		Observed variable
Resource Management	R_1	Construction of a resource circulation network between regions (Jung *et al.*, 2013; Hwang *et al.*, 2016)
	R_2	Analysis of material flow for supply chain management (Zhu and Cote, 2004)
	R_3	Development of infrastructure for resource circulation (Tian *et al.,* 2014; Hwang *et al.*, 2016)
	R_4	Application of production technology with high efficiency (Zhang *et al.*, 2015)
	R_5	Development of agriculture-based entertainment and technology promotion (Zhang *et al.*, 2015)
	R_6	Application of the ecological landscape related to spatial dimensions (Hwang *et al.*, 2016)
	R_7	Stimulation of the supply chain acceleration of raw materials to industry and strategic trade (FAO, 2017)
	R_8	Increase of technology transfer(Steruska *et al.*, 2019)
	R_9	Increase of regional productivity through innovation (Hu *et al.*, 2010)
Environmental Management	E_1	Improvement of the environmental quality (Hwang *et al.*, 2016)
	E_2	Reduction of the impact of chemical pesticides and fertilizers (Zhang *et al.*, 2015)
	E_3	Design of sustainable industries/green production (Boix *et al.*, 2014; Hwang *et al.*, 2016)
	E_4	Introduction of an environmental management system (Boix *et al.*, 2014; Hwang *et al.*, 2016)
	E_5	Maximizing the resources use (FAO, 2017)
	E_6	Implementation of a life cycle assessment (LCA) for industrial symbiosis (Hwang *et al.*, 2016)
Social Management	S_1	Providing employment for local workers who are less skilled (Chou, 2007; Hu, 2007; Bacon *et al.*, 2012)
	S_2	Increase wages for local labor (Boix *et al.*, 2014)
	S_3	Inhibiting the increase in regional inequality (Hu, 2007)
	S_4	Improvement of local labor skills (Chou, 2007)
	S_5	Reduction of resource conflicts (Chou, 2007; Noufal and Ramachandran, 2016)
Cooperation system development	C_1	Development of a professional management team (Kharabsheh, 2012)
	C_2	Selection of companies that have the potential to grow (Lalkaka, 1996)
	C_3	Development of risk-taking culture in entrepreneurship (Kharabsheh, 2012)
	C_4	Communication improvement among companies in the park (G. Hwang *et al.*, 2016)
	C_5	Increase of productivity and competitiveness through agglomeration (Albahari *et al.,* 2016)
	C_6	Providing finance and services to incubatee (Albahari *et al.*, 2016)
	C_7	Increase of government and legislative support (Hwang *et al.*, 2016)
	C_8	Establishment of a shared vision among stakeholders in technology parks (Kharabsheh, 2012)
	C_9	Facilitating technology transfer among companies in technology parks (Zhang *et al.*, 2015)
	C_{10}	Observation and application of the company success in the same line of business (Hwang *et al.*, 2016)

Table 2. (Con.)

Latent variable		Observed variable
ATP Development	P_1	Attraction to high quality companies (anchor tenants, champions) into the park (Kharabsheh, 2012; Muhammad *et al.,* 2017)
	P_2	Development of high technology-based start-ups/MSMEs (Tan, 2006)
	P_3	Growth and development of new entrepreneurship (Cheng *et al.,* 2014)
	P_4	Becoming the center of regional economic growth (Tan, 2006; Ratinho and Henriques, 2010)
	P_5	Becoming a liaison between industry-academics-government (Albahari *et al.,* 2018)
	P_6	Providing infrastructure and development facilities for technology-oriented industries (Bellini *et al.,* 2012)
	P_7	Becoming a knowledge partner for the development of government projects (Machado *et al.,* 2018; Faria *et al.,* 2019)
	P_8	Production of high quality products and services(Hsieh *et al.,* 2012; Anna Andreevna, 2013)

Research hypothesis

Considering the deepening of many previous results related to the establishment of various types of STPs (Kharabsheh, 2011; Albahari *et al.*, 2016; Díez-vial and Fernández-olmos, 2017), the following hypothesis was formulated.

1. Human and natural resources management strategies have a significant effect on ATP development
2. Environmental management strategies have a significant effect on ATP development
3. Social management strategies have a significant effect on ATP development
4. Human and natural resources management strategies have a significant effect on ATP development through the cooperation system development
5. Environmental management strategies have a significant effect on ATP development through the cooperation system development
6. Social management strategies have a significant effect on ATP development through the cooperation system development
7. Cooperation system strategies have a significant effect on ATP development

Data analysis method

The conceptual model for the Agrotechnology Parks development was tested based on empirical data by using the partial least square structural equation (PLS) with the support of Smart PLS 2.0 M3 software (Ringle *et al*., 2014). Pathway models are diagrams that display hypotheses and variables relationships to be estimated in SEM analysis (Bollen, 2002). SEM diagram consisted of Latent Variable (LV) as an element in the statistical model that represented conceptual variables. LV was visualized as a circle or oval in the pathway model, connected by a single-headed arrow that represented a predictive relationship. The indicator, manifest or observed variable was represented by a rectangle, which was directly measured data or observed variable that represented raw data.

Results

Model validity and reliability

Systematic modeling of the PLS-SEM pathway was performed through two measurement phases, such as the assessment of the outer model and inner model. The first measurement in the outer model was reflective using validity and reliability. The second measurement was formative, in which the analysis results that obtained value <10 means no collinearity between indicators in one formative block. Results of indicator reset generated a structural equation model as presented in Figure 1. Based on Table 2, the resulting model has convergent validity (AVE > 0.5) and excellent reliability (Cronbach's Alpha > 0.6).

Table 2. Value of SEM adjustment quality after reducing indicators with values below the criteria

Latent variable	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	R-Square
Agrotechnology Parks	0.761	0.847	0.582	0.507
Cooperation system	0.705	0.836	0.629	0.376
Environmental management	0.683	0.825	0.611	
Resource management	0.608	0.790	0.557	
Social management	0.642	0.808	0.583	

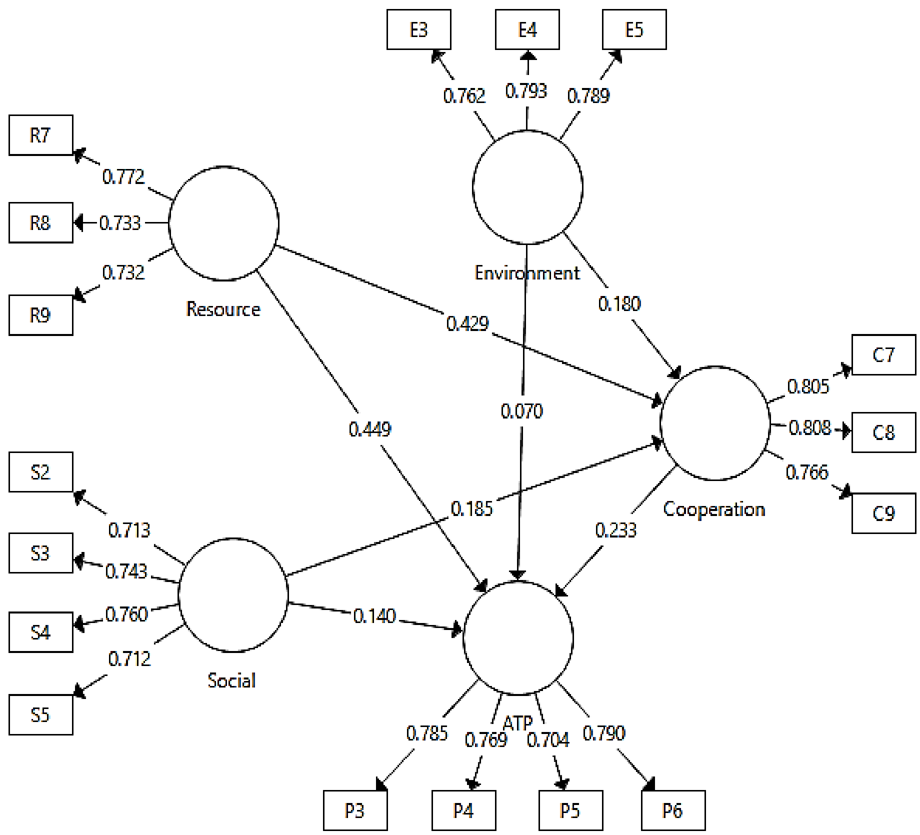

Figure 1. SEM of coffee-based ATP after reducing indicators with values below the criteria

Influence and strength of the model

Measurement of inner models aimed to test the predictive abilities of the model based on the determination coefficient (R^2), the path coefficient (F^2), and relevance prediction (Q^2). The latent variable of the cooperation system development and agrotechnology parks had a R^2 value of 0.376 and 0.507, respectively.

Based on Table 3, the variables of cooperation system development, resource management, and social management were significantly directly related to the development of ATP. Meanwhile, environmental management and resource management were directly related to the cooperation system development.

Table 3. Coefficient values and t- statistics of the ATP SEM pathways

Path	(O)	(M)	TDEV	|O/STDEV|	P
Cooperation system -> Agrotechnology Parks	0.237	0.243	0.076	3.115	0.002*
Environmental management -> Agrotechnology Parks	0.066	0.077	0.072	0.916	0.360
Environmental management -> Cooperation system	0.189	0.189	0.083	2.273	0.023*
Resource management -> Agrotechnology Parks	0.442	0.446	0.075	5.916	0.000*
Resource management -> Cooperation system	0.430	0.420	0.101	4.245	0.000*
Social management -> Agrotechnology Parks	0.152	0.144	0.073	2.078	0.038*
Social management -> Cooperation system	0.157	0.178	0.096	1.638	0.102

Remarks : 0 = original sample), M = sample mean, STDEV = Standard Deviation, T Statistics = |O/STDEV|)

Discussion

The analysis results showed the average value of the variant extracted (AVE) was less than 0.50, so the elimination of the indicator set that had an outer loading value of less than 0.7 was carried out (Sarstedt *et al.,* 2017). According to Henseler *et al.* (2009), the researchers agreed that postulating latent variables must describe at least 50% of each indicator variant.

Based on Table 2, the resulting model has convergent validity (AVE > 0.5) and excellent reliability (Cronbach's Alpha > 0.6) (Fornell and Larcker, 1981) and composite reliability > 0.7 (Hair *et al.*, 2017). Convergent validity showed that a set of indicators represented a latent variable and underlying this latent variable. The discriminant validity criteria showing the model was not unidimensional. The Fornell-Larcker postulate was also fulfilled with the AVE value for each latent variable must be greater than the highest value of R^2 with the value of other latent variables (Fornell and Larcker, 1981).

R^2 value which described the relationship of exogenous latent variables on endogenous latent variables was included in the moderate criteria. According to Henseler *et al.* (2009) and Hair *et al.* (2011), R^2 ranges from 0 to 1, in which R^2 values of 0.75, 0.50, and 0.25 can be considered strong, moderate, and weak. Criteria for value R^2 value can be different for a specific context. Raithel *et al.* (2011) in his research on the prediction of stock returns mentioned the R^2 value of 0.10 was included in satisfactory criteria.

The effect size value (F^2) of the ATP development strategy that was hypothesized obtained five pathways that showed a significant and robust relationship with t-statistics > 1.96 (Hair *et al.*, 2011) as shown in Table 3. Increasing added value and diversification of export-based agricultural products is still limited at the farmer level. This condition was reflected in the large volume of raw coffee exports which reached 99.11% of the total 279.96 thousand tons in 2018 (BPS, 2019).

Smallholder coffee plantations are faced with the problems of old plants age, pests and disease, and poor agricultural practices. Improvement of these conditions must be a long-term plan and carried out continuously to improve competitiveness and sustainability. Alternatives that can be taken include encouraging production and quality improvements of regional coffee that has a geographical indication (GI) certification (Neilson *et al.*, 2018), specialty coffee (Vellema *et al.*, 2015), rehabilitation of old plants (Randriani *et al.*, 2015), and applications of good agricultural practices. The technology transfer approach through the industrial sector in the ATP model will provide mutual benefits for the users and producers of technology. Farmers and industries will look for technology to meet the quantity and quality of the products, while technology producers will continue to develop technology to meet the dynamic user needs.

Social management variable with indicators of increasing local labor wages, inhibiting the increase in regional inequality, increasing the skills of the local labor became a set which also had a significant effect on the ATP development. Employment in the agricultural sector is associated with a high concentration of labor, low levels of education, and low participation of young workers. The existence of technology parks is one of the essential instruments of employment. The entrepreneurship development program through business incubators with various incentive systems and the infrastructure provision with the support of technological innovation will open up new jobs. According to (Hobbs *et al.*, 2017; Chen and Link, 2017), technology parks provide employment and absorb a higher workforce.

Environmental management variable with indicators of sustainable industrial design, environmental management systems, and maximization of resource use had a significant effect through the cooperation system development. Coffee agro-industry produces a large amount of liquid and solid waste, such as broken beans, coffee husks which make up about 60% of the wet weight, mucus and washing wastewater, and coffee grounds. According to Echeverria and Nuti (2017), the solid residues produced by the coffee agro-industry around the world every year are more than ten million tons. Utilization of this waste has been widely studied, such as fuel in livestock, animal feed, biodiesel production, briquettes, tannin extraction, etc.

The environmental problems of coffee agro-industry can be overcome by designing supply chain governance. Coffee processing carried out by farm households is transformed into a processing corporation so that the waste produced can be managed better. The waste can be processed into compost for use as fertilizer in coffee fields communally. The development of the center of change at the subdistrict level that is connected to the surrounding village will optimally integrate agricultural value chain actors. Other benefits of concentrating these activities are easy monitoring of processing, transportation, cost savings, and reducing the environmental impact of transportation.

The multivariate statistical valuation technique was used to examine the relationship among latent variables and manifests in the structural equation model of coffee-based ATP development. The most important construction that affected the strategy of a coffee-based agrotechnology parks development was the resource management with observed variables of accelerating the supply of raw materials to industry and strategic trade, increasing technology transfer, and increasing regional productivity through innovation. The latent variable of social management with indicators of increasing local labor wages, inhibiting the increase in regional inequality, increasing the skills of the local workforce became a set which also had a significant effect on the ATP development.

The two other latent variables, such as (1) resource management with indicators of accelerating the supply of raw materials to industry and strategic trade, increasing technology transfer, and increasing regional productivity through innovation; and (2) environmental management with indicators of sustainable industry designs, environmental management systems, and maximization of resource use had a significant effect through the cooperation system development

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