Cleaner Production for Small and Medium Enterprises: An Open Innovation Perspective

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***Abstract*—Small and medium enterprises (SMEs) in the industrial district have their own advantages because they can share information, knowledge, and facilities in a communal way. However, the implementation of cleaner production in SMEs requires a process of innovation that is environmentally friendly. Open innovation enables organizations like SMEs to innovate better by adopting knowledge from outside of the organization. Cleaner production is a major factor to attain sustainability because it is part of the steps for sustainability process. Innovation is required in the adoption process of cleaner production to reach sustainability; not to mention it has a role in cleaner production activity. This research model consists of two second-order variables, i.e., open innovation climate, and open innovation. Based on hypothesis testing on modern SMEs, open innovation has a positive influence on cleaner production; and open innovation climate has a positive influence on open innovation modern SMEs; environmental dynamism and environmental competitiveness do not have a positive effect in moderating open innovation climate and open innovation. On the other hand, all hypotheses on traditional SMEs are confirmed to have a positive influence or/and positive effect; open innovation has a positive influence on cleaner production; open innovation climate also has a positive influence on open innovation; environmental dynamism and environmental competitiveness have positive effects in moderating open innovation climate and open innovation.**

***Index Terms*—Cleaner production, open innovation, open innovation climate, small and medium enterprise (SME).**

I. Introduction

AN INDUSTRY needs to pay attention to a harmonious relationship with its supporting environment, including its natural environment [1]. When such premise occurs, there is a social interaction between humans and their natural environment. Organization's economic activities or sustainability cannot be separated from its ability to conserve its natural environment for it is part of the organization's asset [2]. The economic growth of small and medium enterprises (SMEs) is currently facing challenges pertaining to the balance between economic, social, and environmental factors [3]. SMEs' ability to continuously safeguard the environment needs to be enhanced to solve global issues which makes cleaner production an indispensable factor to sustain their competitiveness. Innovation is considered as a salient driver in implementing cleaner production in SMEs [4], [5]. Cleaner production is designed to reduce waste and emissions to improve environmental quality and economic performance of the organization [6]. Cleaner production is a novel form of innovation, which combines a significant elevation on the production process and the management methods in an organization. Thus, it can be implied that innovation becomes a supporting factor of environmental conservation [4], [5], [7], [8].

In general, similar to large-scale companies, SMEs also produce waste in their production activities. However, they have limited resources to treat waste in an environmentally friendly manner. With open innovation, cleaner production becomes an approach for SMEs to produce waste that is safer for the environment because in cleaner production, waste management activities are simplified yet still appropriate for the business. Cleaner production can be applied in small- and medium-scale business organizations through operational steps to prevent negative impacts on the environment. The activities for cleaner production include minimizing waste (liquid and air) and emissions (gas), minimizing the use of materials that have a negative impact on the environment, improving organizational policies, technological improvements, and selection of energy sources [9].

The implementation of the cleaner production can reduce the negative impact on the environment in the manufacturing industry. In addition to being applied in large-scale industries, cleaner production is also applied in small- and medium-scale industries [10], [11].

Innovation begins with the improvement carried out on an ongoing basis [12]; therefore, innovation in SMEs can be started by making improvements within organization's internal activities. The parties involved in open innovation are suppliers, consumers, competitors, and the public. Innovations that are carried out internally and involve external stakeholders are known as open innovations.

In open innovation, there is a flow of knowledge from and to both inside and outside the organization, so that the form of openness could materialize through alliances, joint ventures, or networks [13], [14]. In SMEs, the existence of the open innovation process may provide a better organizational system

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change, namely, to increase cooperation, increase the knowledge of organizational members, and the ability to understand market conditions [15], [16].

Open innovation has had strong links to resource-based view of the firm, as well as the related dynamic capabilities perspective. Open innovation may be studied or occur at different levels of analysis, i.e., individuals, groups/projects, business units, ecosystems/communities, firms, regions, or even national innovation systems [17]. There is a relationship between open innovation and SME diversification. Diversification of SMEs is closely related to the number of stakeholders or external parties related to these SMEs. SMEs rely on resources from business partners in open innovation, especially in their development strategies. The adoption and implementation of open innovation in SMEs will play an important role for SMEs to access external resources owned by their open innovation partners [18].

Open innovation is a contemporary paradigm in the implementation of innovation today. In open innovation, there is an element of collaboration, shared creativity, and the achievement of new knowledge and management in an organization [19]–[21]. Open innovation is one of the main supporting factors for achieving business success [22]–[24]. Open innovation is based on knowledge that flows from and into an organization (across organizational or interorganizational), so that the process involves all stakeholders [24]. Open innovation occurs only when companies work with other companies through active collaboration and contribution in market exploitation, market testing, or analysis of customer needs. Within their limited resources, SMEs must find ways to achieve some extent of economies of scale in production, market their products effectively, and provide support services that satisfy consumers. Valuable ideas can come from inside or outside the company and can go to the market from inside or outside the company too. Collaborating with other organizations is one of the methods used by SMEs in the concept of open innovation. SMEs are more flexible and more innovative in new fields, but in general, still have shortcomings in terms of the availability of resources [25]. Open innovation, which adopts environmental sustainability, has several driving factors, namely, the ability to use technology and knowledge, organizational management capabilities, both physical and nonphysical environmental factors, and market desires for both large-scale businesses and SMEs [26]–[28].

Innovation climate is required for innovation and increased innovation and creative capability among employees [29]. Open innovation climate is a condition under which open innovation in an organization is facilitated so that internal and external flows of innovation occur [30]. Open innovation is a part of environmental dynamism and environmental competitiveness [29]. Environmental dynamism is a dynamic environment that is based on up-to-date environment, and therefore, a company must quickly adapt to its environment [29]. Factors that influence environmental dynamism are government regulation, new technology, and the increase in product capacity as a result of consumer's need or demand. Environmental competitiveness is a factor suggesting that the current high level of competition demands firms to produce cost-efficient and low-price goods [29], [30].

In this article, open innovation climate is the initial condition that supports open innovation. The discussed context is open innovation, and therefore, the dimensions in open innovation climate represent the state of open innovation climate in an organization. The next discussion in this article is about open innovation.

Open innovation is one of the ways that organizations use to obtain an understanding of internal and external innovation capability. The concept of open innovation contributes in explaining the flow of knowledge that enters (inbound) and also the one that comes from outside (outbound), leveraged to accelerate internal innovation, expand the market, and produce external innovations for other organizations or perform an externalization on other organizations [29]–[32]. Based on the previous explanation, in this article, we will investigate the relation between open innovation and cleaner production, including its implementation in SMEs.

Based on the preliminary explanation in the previous study, this article provides contribution by first analyzing the effect of open innovation climate to support open innovation, and also the effect of open innovation on the cleaner production implementation. Second, this article makes a distinction between modern SMEs and traditional SMEs. This article is expected to help SMEs to continue to be able to produce the product with good quality while considering the environment.

II. Research Methodology

Several studies state that innovation can be perceived as a collective understanding by firms and stakeholders to facilitate cleaner production within the firms [4]. The presence of innovation is an initial step in selecting and leveraging the right technology for cleaner production. With regard to environmental factors, cleaner production is also influenced by the environmental condition, which refers to market needs that change rapidly, and also by the business competition among the SMEs [29].

Based on the previous explanation, therefore, in this article, the authors analyze the concept of open innovation climate, open innovation, and cleaner production in an organization. Innovation can be done internally and externally. This kind of innovation is called open innovation, i.e., an innovation that allows an organization to innovate by adopting technology from external organization while also contributing the innovation itself to the external organization.

Through the research framework, hypotheses are laid out as follows.

1) In an organization, innovation is an important initial step for open innovation process. Innovation climate would affect the success of open innovation [29]. Therefore, this article would test the hypothesis, i.e., open innovation climate influences the creation of open innovation in SMEs.
2) Nowadays, SMEs are required to increase their capacity to innovate, particularly in open innovation. Innovation is one of the ways to realize cleaner production [4], [5]. This claim becomes a basis for a research hypothesis, i.e., open innovation influences cleaner production.

3) The relationship between innovation climate and open innovation is moderated by the business environment represented by environmental dynamism and competitiveness [29]. This claim is adopted in this article, which becomes another hypothesis, i.e., the effect of environmental dynamism and environmental competitiveness moderates open innovation climate to open innovation.

The research objects in this article are several SMEs which are a combination of traditional and modern ones. These SMEs are divided into modern and traditional SMEs based on the conditions or the ability to implement waste treatment from batik production. SMEs that are included in the modern category are SMEs that implement production process and methods that are environmentally friendly, while traditional SMEs have not fully or only partially implemented efforts to produce environmentally friendly waste. The data are obtained through questionnaires distributed to the SME leaders, which then are passed to each respondent. Additionally, a series of direct interviews with the SME leader is also conducted to gain a clearer picture of the variables in this article. There are, in total, 100 traditional SMEs and 44 modern SMEs as respondents.

A. Model and Hypotheses

The model development is done through the influence between concepts that are previously explained in the research framework and is based on several theories and reference model. An empirical model is developed, which covers the following concepts—commitment-based resources, interdependence among departments, centralized decision-making, innovation climate, open innovation, and organization performance [29]. Based on the research model, the adopted concepts are innovation climate, open innovation, and the moderating factors, i.e., environmental dynamism and environmental competitiveness.

Cleaner production is defined as the implementation of a sustainable strategy involving process, product, and service in order to increase the overall efficiency and reduce the negative consequences on human beings and environment [8]. Cleaner production is a major factor to attain sustainability because it is part of the steps for sustainability process. Innovation is an important part in implementing technology within an industry. Innovation is required in the process of cleaner production adoption to reach sustainability. Innovation also has a role in cleaner production activity [4].

In this article, it is stated that firms and stakeholders collectively have an understanding about the importance of innovation to achieve cleaner production in a firm. The occurrence of innovation becomes an initial step in selecting and implementing the right technology for cleaner production. There is an effect of cleaner production on environmental sustainability and organizational performance [33]. Cleaner production entails actions that enable firms to fulfill the requirements as an efficient resources and energy user during the production process with the aim of increasing productivity, competitiveness, and organization performance. In this article, it is explained that cleaner production proves to be positively influencing organizational performance; thus, to achieve organizational performance, cleaner production is needed [34].

A continuous manufacturing process has a massive effect on the environment due to the significant energy consumption and waste—be it solid, liquid, or gas, undesired from the production process [34]. Therefore, the research framework can be transformed into a research model, referring to the previous model and theory [4], [5], [8], [29], [30], [32], [33]. The interdependence between the research and the reference model is presented in Fig. 1. The basis of determining the research variables is the concepts that have previously been built. The definition of the construct used in this article is presented in Table I.

Based on the definitions and indicators from the previous research highlighted above, the next step is the elaboration to determine the right indicator in measuring cleaner production in an organization. Referring to the explanation of open innovation and cleaner production, and to deepen the relation between the two concepts, the following hypotheses are constructed.

Hypothesis 1: Open innovation has a positive influence on cleaner production.

Open innovation illustrates the situation of an organization that enables the innovation process to receive external influences and cooperate with external parties [30]. Open innovation is a system of inflows and outflows of knowledge aiming to accelerate internal innovation and expand the market [31]. An organization can obtain valuable ideas from both internal and external sources and this could only happen if there is cooperation between organizations; this applies to all scales of organizations including SME [25].

Hypothesis 2: Open innovation climate has a positive influence on open innovation.

In this article, open innovation climate is the initial condition that supports open innovation because the context being discussed is open innovation. Thus, the dimensions in open innovation climate can be used to explain the condition of the climate for such open innovation within an organization. The dimensions in open innovation climate are innovation and flexibility, outward focus, and reflexivity [30].

In this article, each dimension of open innovation climate contributes to achieving open innovation. Based on observations and testing of research models, the dimension of innovation and flexibility is related to the ability of SMEs, that is, it is likely to be easier to carry out open innovation activities if there is an impetus to produce a new idea that is innovative and oriented toward the changes that occur. The outward focus dimension entails the extent to which the organization is able to respond to consumer and market needs, where open innovation can be achieved more optimally if SMEs are able to respond to consumer desires well and quickly. The reflexivity dimension is related to the organization's ability to review the goals, strategies, and work processes of the organization. When this dimension becomes more pervasive within the firm, open innovation can be carried out more optimally.

Innovation and flexibility here refer to the drive and support to create a novel idea that is innovative and oriented toward change, e.g., change in surrounding environment of an organization. Innovation and flexibility can be measured through the acceptance level of new ideas within an organization; the agility of reacting for change; the leader's ability to identify different needs in the organization; the ability to adjust the procedure to reflect

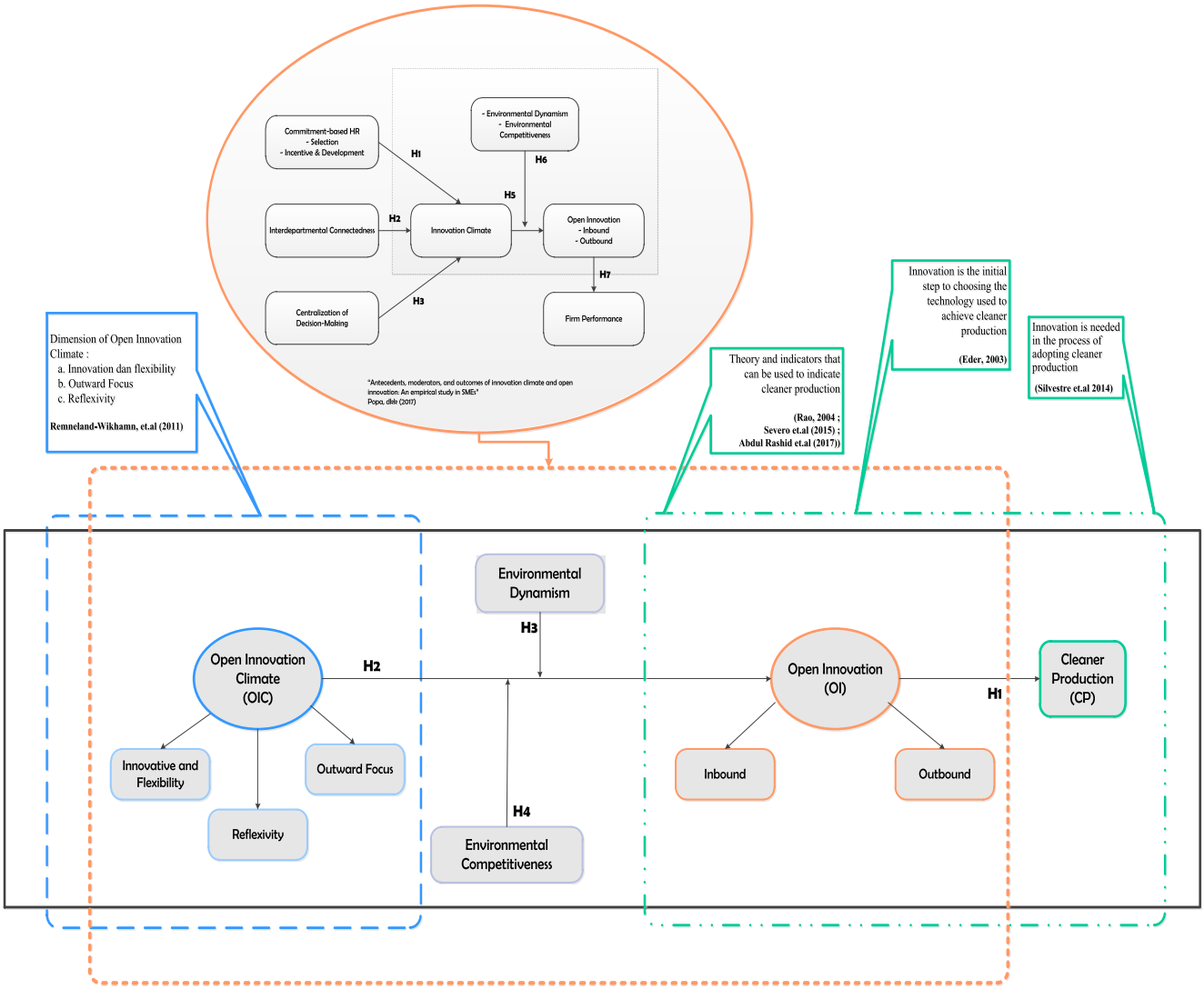

Fig. 1. Elaboration scheme for research model.

TABLE I
DEFINITION OF RESEARCH CONSTRUCT

Construct	Definition
Cleaner Production	The decline in the amount of waste by implementing a sustainable strategy involving process, product, and service in order to increase the overall efficiency and reduce the negative consequences on human beings and environment [30][33]
Open Innovation	The flow of knowledge in an organization, both that comes from within (inbound) and comes from outside organization (outbound), that is used to accelerate internal innovation, expand the market, and produce external innovation for other organization [29][30][31]
Open Innovation Climate	The requirement for innovation that initiate employees' innovative and creative capacity, as well as the environment that is builds upon values, trust, and assumption of the organization members to facilitate the innovation process [29][30]

the present challenge; the level of teamwork in developing new ideas; and the awareness from team members to find a solution with a new perspective.

Outward focus is the extent of organization in responding to the consumer and market needs [30]. Outward focus in an organization can be measured through several points, i.e., how organizations can reflect internally on how they satisfy the consumer need; ways in improving the level of consumer service; the priorities on consumer needs; the responses on the needs and the change in consumer needs; leveraging information to acquire a new business opportunity; and the ability to accept ideas from outside parties.

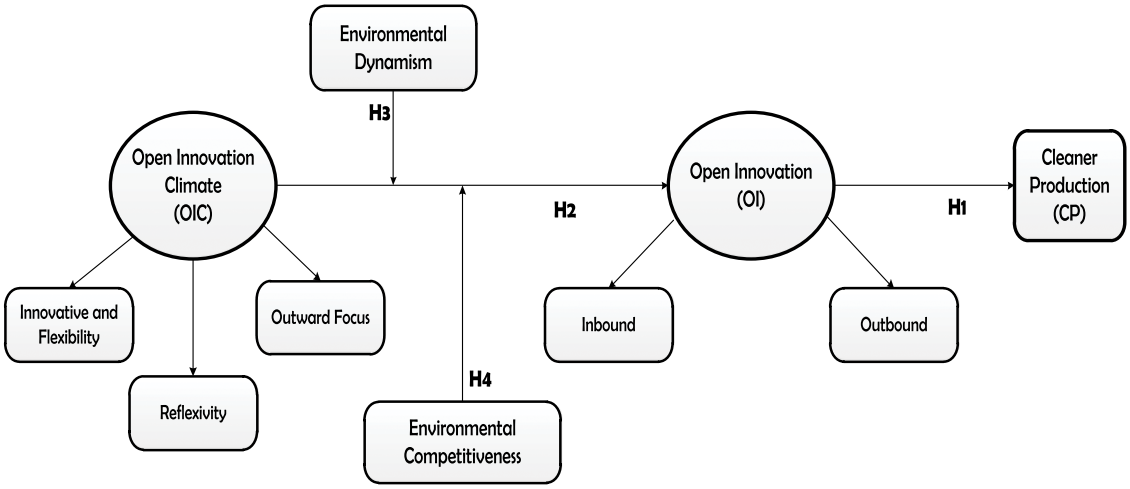

Fig. 2. Research model.

The other dimension for open innovation climate is reflexivity, which measures the extent of organizations' attention in reviewing their vision, strategy, and working process, to adapt with a wider environment. This dimension can be utilized to measure the performance improvement through an internal evaluation that involves all team members.

Hypothesis 3: Environmental dynamism strengthens the positive influence of open climate innovation to open innovation.

The effort to achieve open innovation is influenced by external factors, e.g., environment. Now, open innovation shows an openness to create innovation both internally and externally [35]. Organizations who implement open innovation will receive influences from external parties and inversely will give the effect of their internal innovation back to the external parties [29]. There are moderators that can strengthen the influence of open innovation climate on open innovation, i.e., environmental dynamism and environmental competitiveness. Environmental dynamism refers to the fact that in the dynamic environment that is based on knowledge, firms need to adapt quickly to the environment. The factors that influence environmental dynamism are government regulations, the existence of new technology, and the increase of product capacity due to consumer demand. The moderator's purpose is to show that there is an external factor that needs to be considered in strengthening the positive influence of open innovation climate on open innovation [29]. Therefore, to deepen the study regarding the positive influence of open innovation climate on open innovation, the third hypothesis is constructed.

Hypothesis 4: Environmental competitiveness strengthens the positive influence of open climate innovation to open innovation.

The next moderator is environmental competitiveness, which explains that in the midst of heightened competition, firms need to efficiently produce goods in low cost [29]. Environmental competitiveness moderates the positive influence of open innovation climate on open innovation [29]. Based on this, it is necessary to analyze the level of moderation given by environmental competitiveness, which is why the fourth hypothesis is constructed.

In Fig. 2, the design of the research model that represents cleaner production based on open innovation process is presented. This model encapsulates three concepts with two moderating variables. Cleaner production is represented by its indicators; open innovation has two dimensions; open innovation climate has three dimensions. For open innovation climate, there is an adjustment in measuring the concept.

In the reference model [29], the direction of the dimension or construct is formative because each construct is independent, so the omission of one construct will not affect the measured concept. Meanwhile, in this research model, the construct is reflective toward the concept, which means each construct is the effect of the analyzed concept. Therefore, a concept is reflected by all of the constructs or dimensions.

B. Research Strategy

In this section, the data collection required to test the research model is explained for both measurement model and structural model. The testing tool for the research model is partial least squares-structural equation modeling (PLS-SEM). PLS can simultaneously analyze constructions formed with reflective and formative indicators. In this research model, the following variables will be analyzed: AVE (average variance extracted), composite reliability, and T-value statistics. AVE is used to demonstrate the reliability of the questionnaire and illustrates the correct convergence validity, which means that a latent variable is able to explain more than half the variants of its indicators in the mean. AVE minimum value is 0.5. Composite reliability shows the level of consistency of respondents in filling out the questionnaire. Composite reliability reflects the reliability of all indicators in the model with a minimum value of 0.7. The T-statistic value is used to indicate the relationship of variables that is in line with the hypothesis with a minimum threshold whose value depends on the amount of data used. T-statistics shows whether each indicator significantly influences each construct.

Based on the ability to manage the business and waste, in this article, the observation objects are divided into two types,

TABLE II
COMPOSITE RELIABILITY VALUE AND AVE FOR MODERN SMES

Measuring Instrument	Alfa Cronbach	Composite Reliability	Average Variance Extracted (AVE)
Cleaner Production (CP)	0.869	0.894	0.632
Inbound Open Innovation (Inb)	0.980	0.987	0.962
Innovation and Flexibility (Inv_F)	0.861	0.906	0.707
Open Innovation (OI)	0.918	0.936	0.709
Open Innovation Climate (OIC)	0.904	0.920	0.512
Outbound Open Innovation (Outb)	0.937	0.960	0.889
Outwards Focus (Outw)	0.845	0.898	0.691
Reflexivity (Ref)	0.800	0.884	0.718

i.e., traditional SMEs and modern SMEs. The units of analysis in this article are SMEs that produce handmade batik in Indonesia. The location of the SMEs is in the center of batik in Indonesia, namely, in Kampung Batik Laweyan, Surakarta, Central Java Province, and Batik Centers on Madura Island, East Java Province. The respondent is the SME's leader because such individual possesses the information surrounding the business management of the respective SME that covers all business activities. Respondents were asked to give the information through a questionnaire. A description of the constructs and the associated indicators for the questionnaire in this article is provided in the appendix.

The questionnaire was distributed in September 2019 to 144 respondents with details of 44 respondents in Kampung Batik Laweyan (from 50 existing SMEs) and 100 respondents at batik SMEs in Madura (out of 113 existing SMEs). The data obtained are population data that represent each region that is a respondent in this article. Each received the same questionnaire for both traditional and modern SME. The number of respondents is 144, which consists of 44 modern SMEs located in Laweyan and 100 traditional SMEs located in Madura.

The 5:1 ratio is the ratio of data adequacy as a reference in this article. The number of samples in the PLS model based on a 5:1 ratio means that every five samples or data represent one variable [36]. With a total of 144 data, PLS-SEM can be used for testing the model in this article. PLS-SEM is not greatly influenced by a small number of samples as this technique analyzes one construct at a time by implementing an iterative order from ordinary least squares (OLS) and double linear regression [37].

In estimating the significance of relationship, PLS-SEM uses the bootstrapping approach that does not require parametric assumption. Thus, PLS-SEM is well-suited to analyze a small size of samples and those with nonnormal distribution [37].

In this article, the model testing consists of two steps, i.e., measurement model testing and structural model testing. Measurement model testing is aimed at ensuring that the research instrument is reliable and valid. Structural model testing is conducted to test the relationship between constructs. The testing is done through the software Smart-PLS. This research model consists of two second-order variables, i.e., open innovation climate and open innovation. Open innovation climate consists of three first-order variables, i.e., innovation and flexibility, outward focus, and reflexivity. Meanwhile, open innovation consists of two first-order variables, i.e., inbound open innovation and outbound open innovation; and one target variable, i.e., cleaner production.

The relationships between open innovation climate with all of its first-order variables is reflective, where the three first-order variables, i.e., innovation and flexibility, outward focus, and reflexivity, are able to describe open innovation climate in an organization. The relationship between first-order variables, i.e., inbound and outbound open innovation toward open innovation is also reflective. For models with reflective relationship, the measuring scale for second-order variables can be based on the repeated indicator approach, i.e., putting all indicators from first-order variable to its second-order variable [38]. Therefore, all indicators used to measure the first-order variable are now the indicators to measure each second-order variable.

III. RESULT AND DISCUSSION

In this article, SMEs need to be differentiated based on conditions or the ability to implement waste treatment in their batik production. SMEs are deemed modern if they have implemented environmentally friendly waste treatment for its production activities; meanwhile, traditional SMEs partially implement environmentally friendly waste for their production activities.

A. Model Testing for Modern SMEs

Modern SMEs are SMEs that have implemented a part of their business to produce environmentally safe waste. The result shows that all values of outer loading for all indicators are above 0.4. The composite reliability value and AVE for all constructs are above 0.5. The Fornell–Larcker value for the construct innovation and flexibility is smaller than the correlation between the construct open innovation climate and innovation and flexibility; the Fornell–Larcker value for the construct open innovation is smaller than the correlation between the construct open innovation and outbound open innovation; the Fornell–Larcker value for the construct open innovation climate is smaller than the correlation between the construct open innovation climate and reflexivity. Through the Fornell–Larcker value, the smaller correlation between construct against its latent variable can be ignored because the two variables represent the relationship between second-order variable with first-order variable. All of the cross-loading values for each indicator toward the construct are higher than the value with other construct. Based on the result, it can be inferred that the measurement model is reliable and valid from the perspective of convergence and discriminant. Table II presents the composite reliability value and AVE for modern SMEs.

TABLE III
SIGNIFICANCE OF STRUCTURE RELATIONSHIP FOR MODERN SMES

Hypothesis			Path Coefficient	T-Statistic	P Value	Conclusion
H_1	OI	→ CP	0.373	3.233	0.001	Accept ****
H_2	OIC	→ OI	0.240	1.525	0.064	Accept **
H_3	ED	→ OI	0.142	1.792	0.214	Reject
H_4	EC	→ OI	-0.249	1.460	0.072	Reject

Table information:
****: Significant at level 0.01.
***: Significant at level 0.05.
**: Significant at level 0.10.

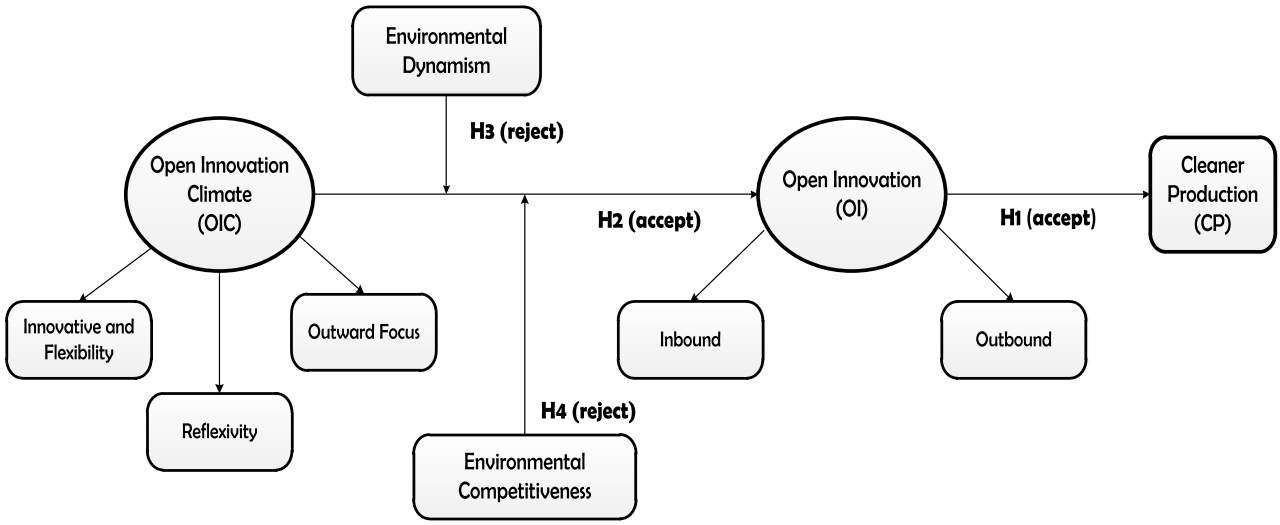

Fig. 3. Relationship significance in the structural model for modern SMEs.

TABLE IV
R^2 VALUE FOR MODERN SMES

	R Square	R Square Adjusted
CP	0.139	0.119
Inb	0.818	0.814
Inv_F	0.752	0.746
OI	0.256	0.158
Outb	0.711	0.704
Outw	0.700	0.693
Ref	0.739	0.733

The results of multicollinearity against the measurement model suggest that there is no issue in collinearity. Based on the testing presented in Table III, it is shown that the significant relationship occurs between the construct open innovation (OI) and cleaner production (CP) and between open innovation climate (OIC) and open innovation (OI). Meanwhile the relationship between the moderator environmental dynamism (ED) and moderator environmental competitiveness (EC) toward open innovation are not significant. Fig. 3 presents the structural relation in the research model.

The R^2 value in Table IV shows that variance of endogenous construct can be explained largely by the exogenous construct, except for cleaner production with the value less than 0.25, showing weak value, while the others showing moderate and substantial values. Aside from the significance of structural relationship, the model testing also shows the significance of the relationship between open innovation (OI) as a second-order construct and inbound open innovation (Inb) and outbound open innovation (Outb) as the first-order construct; also, the significance of the relationship between open innovation climate (OIC) and innovation and flexibility, outward focus, and reflexivity as first-order constructs is shown.

Tables V and VI present the significance result for the construct open innovation and open innovation climate. In Table V, it can be identified that each dimension for construct open innovation has a significant relationship with its construct, thus the dimensions can be considered to be able to measure the construct.

Table VI suggests that each dimension in the construct open innovation climate has a significance relationship with its construct, thus the dimensions are considered to be able to measure the construct. The results of structural model testing in modern SMEs show that the accepted hypothesis is H_1, which states that there is a positive relationship between the construct open innovation and cleaner production, and H_2, which states

TABLE V
RELATIONSHIP SIGNIFICANCE FOR OPEN INNOVATION WITH ITS DIMENSION FOR MODERN SMES

Relationship	Correlation Value	T- Statistic	P Value	Conclusion
Open Innovation → *Inbound open innovation*	0.905	44.863	0.000	Significant
Open Innovation → *Outbound open innovation*	0.843	19.818	0.000	Significant

TABLE VI
RELATIONSHIP SIGNIFICANCE FOR OPEN INNOVATION CLIMATE WITH ITS DIMENSION FOR MODERN SMES

Relationship	***Correlation Value***	***T Statistic***	***P Value***	***Conclusion***
Open Innovation Climate → *innovation and flexibility*	0.867	22.008	0.000	Significant
Open Innovation Climate → *outwards focus*	0.837	16.141	0.000	Significant
Open Innovation Climate → *reflexivity*	0.860	21.684	0.000	Significant

TABLE VII
COMPOSITE RELIABILITY VALUE AND AVE FOR TRADITIONAL SMES

Measurement Instrument	Alfa Cronbach	Composite Reliability	Average Variance Extracted (AVE)
Cleaner Production (CP)	0.491	0.797	0.662
Inbound Open Innovation (Inb)	0.896	0.920	0.659
Innovation and Flexibility (Inv_F)	0.810	0.887	0.724
Open Innovation (OI)	0.930	0.940	0.589
Open Innovation Climate (OIC)	0.885	0.907	0.501
Outbound Open Innovation (Outb)	0.860	0.900	0.644
Outwards Focus (Outw)	0.572	0.822	0.698
Reflexivity (Ref)	0.867	0.905	0.659

that there is a positive relationship between the construct open innovation climate and open innovation. Hypotheses H3 and H4 are rejected, which shows that they have no significant relationship as a moderator to strengthen the influence between open innovation climate and open innovation.

C. Model Testing for Traditional SMEs

Traditional SMEs are SMEs that have not fully or partially implemented the effort to produce environmentally safe waste. The result of model testing shows that the outer loading value for all indicators is above 0.4. The composite reliability value and AVE for all constructs are above 0.6 and 0.5, respectively. The Fornell–Larcker value for the construct inbound open innovation is smaller than the correlation between inbound open innovation and open innovation; the Fornell–Larcker value for the construct open innovation is smaller than the correlation between open innovation and outbound open innovation; the Fornell–Larcker value for the construct open innovation climate is smaller than the correlation between open innovation climate and reflexivity. Through the Fornell–Larcker value, the smaller correlation between a construct against its latent variable can be ignored because the two variables represent the relationship between a second-order variable with first-order variable.

All of the cross-loading values for each indicator toward the construct are higher than the value with other constructs. Based on the result, it can be inferred that the measurement model is reliable and valid from the perspective of convergence and discriminant. Table VII presents the composite reliability value and AVE for traditional SMEs. The indicator that can be used to check the criteria for internal consistency reliability is Cronbach's alpha which is based on the intercorrelation of indicator variables, assuming all indicators have the same outer loading to the construct.

Another criterion is composite reliability, which considers different outer loading for each indicator variable. Composite reliability values vary between 0 and 1, with higher values indicating a higher level of reliability. In exploratory research, composite reliability values between 0.6–0.7 can be accepted, while grades 0.7–0.9 are satisfactory. Although the rule-of-thumb value of the expected outer loading is at least 0.7–0.8, the 0.4–0.7 value can still be maintained. Indicators with a value of 0.4–0.7 can be considered not to be omitted from measurements if the value of the composite reliability or AVE increases above the specified limit value. The expected threshold value of AVE is 0.5, which indicates that the construct explains more than 50% of the variance of its indicators [39]. In this article, the *Alpha Cronbach* value for cleaner production and outward focus in traditional SMEs are 0.572 and 0.491; however, the AVE values are 0.662 and 0.698 (*above the threshold value 0.5*) and the composite reliability values are 0.797 and 0.882 (*above the threshold value 0.6–0.7)*, so that cleaner production and outward focus is reliable for the measurement model in this article.

The result of multicollinearity testing against the measurement model for traditional SMEs suggests that there is no issue related to collinearity. Based on the testing presented in Table VIII, it is suggested that the significance relationships are

TABLE VIII
SIGNIFICANCE OF STRUCTURAL RELATIONSHIP FOR TRADITIONAL SMES

Hypothesis			Path Coefficient	T-Statistic	P Value	Conclusion
H_1	OI	→ CP	0.493	7.216	0.000	Accept ***
H_2	OIC	→ OI	0.444	5.493	0.000	Accept ***
H_3	ED	→ OI	0.373	2.426	0.008	Accept ***
H_4	EC	→ OI	0.224	5.343	0.000	Accept ***

Table information:
***: Significant at level 0.05.

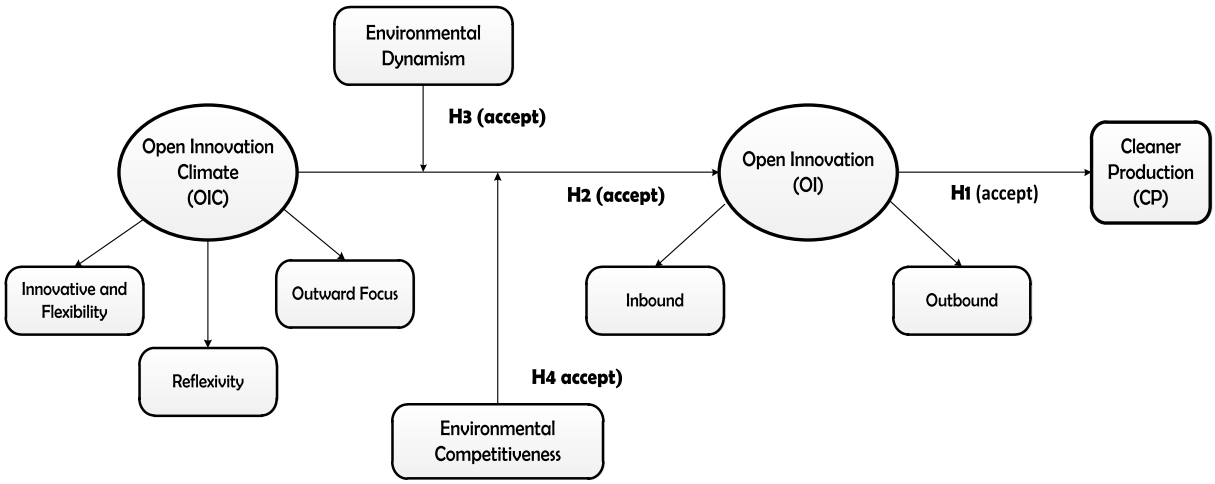

Fig. 4. Relationship significance in the structural model for traditional SMEs.

TABLE IX
R^2 VALUE FOR TRADITIONAL SMES

	R Square	R Square Adjusted
CP	0.243	0.236
Inb	0.921	0.921
Inv_F	0.661	0.657
OI	0.673	0.655
Outb	0.884	0.883
Outw	0.627	0.623
Ref	0.830	0.829

between OI and CP; OIC and OI; moderator ED and moderator EC on open innovation. Fig. 4 shows the information about the structural relationship in the research model for traditional SMEs. The R^2 value in Table IX shows that the variance of endogenous construct can be explained largely by the exogenous construct, except for cleaner production with the value less than 0.25, showing weak value, while the others showing moderate and substantial values. Aside from the significance of structural relationship, the model testing also shows the significance of the relationship between OI as a second-order construct and inbound open innovation (Inb) and outbound open innovation (Outb) as the first-order constructs; also, the significance of the relationship between OIC and innovation and flexibility, outward focus, and reflexivity as first-order constructs. Tables X and XI present the significance for construct open innovation and open innovation climate.

Through the result in Table X, it can be identified that each dimension for construct open innovation has a significant relationship with its construct, thus the dimensions can be considered to be able to measure the construct. Table XI shows that each dimension for the construct open innovation climate has a significant relationship toward its construct, thus the dimensions are considered to be able to measure the constrict. Based on the structural model testing in traditional SMEs, all hypotheses are accepted at 0.05 significances level. Based on the results of the research conducted, it can be seen that the accepted hypothesis in the SMEs batik with modern type are hypotheses H_1 and H_2. H_1 states that open innovation has a significant influence on cleaner production and H_2 states that open innovation climate has an influence on open innovation while moderators of environmental dynamism and environmental competitiveness do not influence open innovation. At SMEs batik with traditional type, statistically, all hypotheses are confirmed and acceptable. This shows that SMEs with traditional type still require a moderator, namely, environmental dynamism and environmental competitiveness to support open innovation within the organization.

The empirical results in this article are different for modern SME groups and traditional SMEs because of the differences in understanding the effort to achieve cleaner production through open innovation process. Modern SMEs are more independent in achieving the process of open innovation, so that environmental influences do not have a significant impact on the achievement

TABLE X
SIGNIFICANCE FOR OPEN INNOVATION WITH ITS DIMENSION FOR TRADITIONAL SMES

Relationship	Correlation Value	T- Statistic	P Value	Conclusion
Open Innovation → *Inbound open innovation*	0.960	160.026	0.000	Significant
Open Innovation → *Outbound open innovation*	0.940	90.366	0.000	Significant

TABLE XI
RELATIONSHIP SIGNIFICANCE FOR OPEN INNOVATION CLIMATE WITH ITS DIMENSION FOR TRADITIONAL SMES

Relationship	Correlation Value	T- Statistic	P Value	Conclusion
Open Innovation Climate → *innovation and flexibility*	0.813	22.652	0.000	Significant
Open Innovation Climate → *outwards focus*	0.792	19.912	0.000	Significant
Open Innovation Climate → *reflexivity*	0.911	54.858	0.000	Significant

of open innovation through open innovation climate. While on traditional SMEs, environmental influences (environmental dynamism and environmental competitiveness) provide support to achieve open innovation through open innovation climate.

IV. CONCLUSION

According to this article, the model synthesized in this research was the result from an elaboration that was based on a developed conceptual model that was adopted from a previous model. The objects of observation were two types of SMEs—traditional and modern. Such distinction was based on their ability to implement environmentally friendly waste treatment processes. SMEs that were able to apply environmentally friendly production processes were categorized as modern SMEs and vice versa were traditional SMEs.

In this article, the research model consisted of three main concepts, i.e., open innovation climate, open innovation, and cleaner production. Open innovation climate had three dimensions, i.e., innovative and flexibility, outward focus, and reflexivity. In modern SMEs, the dimension that gave a dominant influence on the concept of open innovation climate was innovation and flexibility with the correlation value of 0.867; and in traditional SMEs, the dimension that gave a dominant influence on the concept of open innovation climate was reflexivity with the correlation value of 0.911.

Open innovation had two dimensions, inbound and outbound open innovation. In modern SMEs, the dimension that gave a dominant influence on the concept of open innovation climate was inbound open innovation with the correlation value of 0.905. For traditional SMEs, dimension that gave a dominant influence on the concept of open innovation climate was inbound open innovation with the correlation value of 0.960.

Based on this result, it was revealed that in modern SMEs, open innovation was confirmed to positively influence cleaner production; open innovation climate also was confirmed to positively influence open innovation. But environmental dynamism and environmental competitiveness were confirmed not to moderate the open innovation climate and open innovation. In traditional SMEs, all hypotheses were confirmed. Open innovation was confirmed to positively influence cleaner production, and open innovation climate was confirmed to positively influence open innovation. Environmental dynamism and environmental competitiveness were confirmed to moderate open innovation climate and open innovation.

The relationship testing between open innovation and cleaner production in both modern and traditional SMEs considered that batik SMEs as respondents were expected to be able to carry out innovative activities optimally, both internally (outbound) and externally (inbound), as adequate ability in conducting open innovation will improve the ability of batik SMEs in achieving cleaner production. Optimal open innovation activities could be carried out by SMEs batik through several things, for instance, in collaboration with each stakeholder to support innovation activities in the internal organization as a basis to convey the results of internal innovation to the external parties of the organization. Based on the results of relationship testing between open innovation climate and open innovation both in modern SMEs and traditional SMEs, it could be concluded that the SMEs are expected to be able to foster a climate that supports innovation activities. This open innovation climate could improve the ability of batik SMEs in conducting open innovation activities, both in the form of inbound open innovation and outbound open innovation. Open innovation climate could be achieved by responding quickly and being flexible to changes through new ideas, responding well to market needs and evaluating internal capabilities.

In general, the results of this article had important implications, especially for the development of SMEs. In previous studies, the context of open innovation was discussed in large- and medium-scale manufacturing industries, and in part, discussed open innovation in small industries.

The contribution of this article was an empirical model that can be used by SMEs to implement the open innovation process in an effort to achieve cleaner production. So far, there was no research that addressed this. The results of this article provided guidance to the leaders of batik SMEs along with their workers to carry out an evaluation and development of the internal organization that had a significant impact on the creation of new ideas and to make improvements in the process of batik production through various ideas or new ideas. These ideas could also be obtained from interactions with consumers. In addition,

the leadership of SMEs batik was expected to have the ability to maintain stable internal conditions in responding to the needs and desires of consumers. Responding to market changes was an effort to get new opportunities based on the information obtained. In creating an open innovation climate, the leadership of SMEs batik could conduct periodic reviews of its organizational strategy in an effort to improve organizational performance. Improved performance in organizations showed that SMEs were able to adapt to changes that occurred in the SMEs environment. Changes that occur in the business environment will require the SMEs to make improvements and innovations so that they are able to survive in increasingly competitive competition.

As any other research, there were some limitations which can be addressed in future research. The first was the key informant method used for data collection. In this method, the data only reflected the opinion of one person. Future studies can consider research designs that allow the collection of data from many respondents in an organization. The second was the amount of data, which was not optimal. The data obtained can be added from several SMEs which at the time of conducting this article were not yet accessible for various reasons. Third, the type of SMEs that became respondents. In subsequent studies, it can be considered to include other types of SMEs as respondents. This article took cross-sectional static data for factors that affect all variables used in the research model, so there will be difficulties when overcoming the problem of changing interests that can change from time to time. A longitudinal study can enrich this research or finding. Future research could consider about circular economy. Circular economy aims to eliminate waste and use resources sustainably. This theory aims to maintain products, equipment, and infrastructure that can be used longer, thereby increasing resource productivity. The discussion on circular economy in the next research would help to facilitate resource utilization with very minimum waste or even without waste. These suggestions can be considered in future studies to improve the validity of the findings in this article.

Appendix (Questionnaire)

Cleaner Production (CP)

Reduction of waste by implementing a sustainable strategy to prevent environmental damage and improve efficiency and reduce negative impacts on humans and the environment.

- CP1 The organization applies batik production process by reducing waste emissions
- CP2 The organization applies batik production process by reducing the use of raw materials
- CP3 The organization applies batik production process in certain ways to reduce energy use
- CP4 The organization applies batik production process by reducing water use
- CP5 Organizations carry out batik production process by reducing the impact of waste on the environment
- CP6 Organizations apply certain procedures to reduce the use of raw materials (for example, reuse wax after processing again)
- CP7 Organizations apply certain procedures to reduce water used (for example, reusing wastewater that has been refilled)
- CP8 Organizations apply certain procedures to reduce energy used (for example, using electric canting that is more economical than kerosene stoves)
- CP9 The organization gets a positive view from stakeholders because it does batik production by applying the concept of clean products
- CP10 I need to motivate workers to be able to apply the concept of clean products to the batik production process
- CP11 The use of the cleaner production concept will produce high-quality products that can compete
- CP12 The concept of cleaner production supports the improvement of the production process in the organization

Open Innovation

Inbound Open Innovation (Inb): Innovation in organizations is carried out by exploring sources of innovation, such as knowledge and new technologies from external sources such as customers, suppliers, competitors, government, consultants, universities, or research organizations.

- Inb1 External parties are directly involved in innovation activities within the organization
- Inb2 The government provides assistance in innovation activities within the organization
- Inb3 Consumers contribute in innovation activities within the organization
- Inb4 Competitors contribute in innovation activities within the organization
- Inb5 Research institutions provide assistance in innovation activities within the organization
- Inb6 Universities or educational institutions contribute to innovation activities within the organization
- Inb7 The supplier contributes to the organization's internal innovation activities
- Inb8 There are consultants who provide assistance in innovation activities within the organization
- Inb9 Innovative activities carried out by the organization depend on the assistance of external parties
- Inb10 I use the latest equipment to improve innovation within the organization
- Inb11 I use the latest materials (fabrics, dyes, candles, etc.) to improve innovation within the organization
- Inb12 I bought patents for innovation activities within the organization
- Inb13 I bought copyright to be used for innovation activities within the organization
- Inb14 I bought a license to be used for innovation activities within the organization

Outbound Open Innovation (Outb): Innovations in organizations are carried out through the development of internal organizational innovation capabilities so that the results can be given to external organizations through certain licenses, patents, or contracts to obtain financial and nonfinancial benefits.

Outb1 I try to get other benefits from the internal innovations that have been made
Outb2 I offer new methods used by internal organizations in other organizations
Outb3 The organization sells batik product licenses to other organizations
Outb4 I sell batik product patents to other organizations
Outb5 I sell copyrighted batik motifs to other organizations
Outb6 I collaborated through the sale of new technology (for example, new batik tools, new batik ways, new waste processing methods) for the manufacture of batik in other organizations

Open Innovation Climate

Innovation and Fflexibility (Inv_F): Encouragement and support to produce new ideas that are innovative and oriented toward changes that occur.

Inv_F1 Workers in this organization can convey their ideas to me
Inv_F2 Many new ideas are obtained from internal organizations
Inv_F3 I give a quick response to technological changes (methods, tools, and processing of waste in batik production)
Inv_F4 I immediately responded if there was a change in batik motifs
Inv_F5 I immediately responded if there were changes to government regulations
Inv_F6 I determined needs for the batik production process, including developing new technologies
Inv_F7 I am looking for information about current consumer preference
Inv_F8 I am looking for information about changing consumer preference
Inv_F9 If a new problem arises, I immediately give instructions for changing procedures in the production process
Inv_F10 If there is a change in working conditions, I immediately provide instructions for changing procedures in the production process
Inv_F11 Another organization or outsiders can give help to the organization to develop the new ideas.
Inv_F12 Workers in this organization are always looking for new ways to solve problems

Outward Focus (Outw): Organizational focus in improving services according to consumer needs, while seeking new opportunities and ideas from the market.

Outw1 I prioritize solving problems that occur within the organization
Outw2 I prioritize solving problems that arise from external organizations
Outw3 I pay attention to how to improve service to consumers
Outw4 My priority is to meet consumer needs regarding the quality of batik products
Outw5 My priority is to fulfill the preference of consumers of batik products
Outw6 Organizations often cannot fulfill consumer preference for a type of product
Outw7 Consumers may directly order any of the products from this organization
Outw8 I am looking for information about consumer tastes for batik products
Outw9 I open opportunities for collaboration with external organizations to expand the market
Outw10 I accept new ideas from outside the organization with relative ease
Outw11 I have difficulties when implementing new ideas from outside the organization
Outw12 Workers may accept new ideas from outside the organization

Reflexivity (Ref): Collaboration is carried out to improve work performance and effectiveness, which can be done through reviewing or changing organizational goals if needed.

Ref1 Workers work together to produce batik
Ref2 Workers can replace each other's work
Ref3 Cooperation between workers can improve organizational performance
Ref4 Discussions took place between workers in the process of making batik
Ref5 I discussed with the workers in determining the batik products to be made
Ref6 Discussions were conducted to determine the quality of batik products to be made
Ref7 Discussions were conducted to determine the quantity of batik products to be made
Ref8 In organizations, discussions are held regularly, every time they make a batik product
Ref9 Every day I evaluate work results for each worker
Ref10 I evaluate the collaboration carried out by workers
Ref11 I evaluate work effectiveness for all workers
Ref12 I change the organization's goals to adjust the conditions that affect this SME.
Ref13 I review the organizational goals periodically

Environmental Dynamism (ED)

The organizational environment that is fast adjusting to its environment, for example, by government regulations, the emergence of new technologies, and increased product capacity due to consumer needs or demands.

ED1 Within the past one year (according to the accounting period) there was an increase in the number of consumers who visited
ED2 Within the past one year (according to the accounting period) there was a decrease in the number of consumers who visited
ED3 Within the past one year (according to the accounting period) there has been a change in the type of consumers who visit

ED4 Customers who visit ask for new design of batik that is produced by the organization
ED5 Consumers who visit ask about the delivery service of batik products to consumers
ED6 Consumers who visit ask information about batik training facilities
ED7 Every month there is a change in the number of product sales
ED8 Every month there is a change in the service type from organization
ED9 Changes in sales amount are influenced by general economic conditions
ED10 Changes in service types are affected by general economic conditions

Environmental Competitiveness (EC)

The current high level of competition requires companies to produce products or services that are cost efficient and at low prices.

EC1 This organization competes with others in one batik region
EC2 This organization has major competitors in one batik region
EC3 There is high competition between organizations in one batik region
EC4 There is high competition with other organizations that produce batik products outside the region
EC5 The competitive price of batik products is an advantage to the organization
EC6 The price of batik products is determined by market competition

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