ISSN 1816-6075 (Print), 1818-0523 (Online)
Journal of System and Management Sciences
Vol. 14 (2024) No. 5, pp. 97-112
DOI:10.33168/JSMS.2024.0506

Analysis of Key Constraint Factors in the Implementation of Regional Innovation Systems with Interpretive Structural Modeling Approaches

Amna Suresti, Firwan Tan, Endrizal Ridwan, Febrianda Prima Putra, Uyung,G.S.Dinata

Universitas Andalas, Padang, Indonesia

amnasuresti@ko2pi.org

Abstract. This study analyzed the constraint factors affecting the implementation of regional innovation systems in West Sumatra, Indonesia using the Interpretive Structural Modeling (ISM) approach. Data was collected from expert surveys using the Delphi technique. The ISM and Matrice d'Impacts multiplication application a classment (MICMAC) analyses identified several key obstacles related to leadership, policies, human resources, coordination, focus product and budgets. Leadership commitment was found to be the most critical constraint. The findings provide important practical insights on the priority actions needed to strengthen regional innovation systems by addressing key barrier factors. As one of the first ISM applications in analyzing innovation system constraints, this study enriches the limited literature. Further research with larger samples is recommended to validate the generalizability of findings

Keywords: Innovation System, MICMAC, Interpretive Structural Modeling

1. Introduction

Knowledge and innovation are key factors for driving people's economic growth in the current era of globalization(Rosda et al., 2023). The emergence of the industrial revolution 4.0 is proof that development in this era tends to lead to the exploitation of knowledge(Supardi et al., 2023). One of them is through the use of useful technology to increase productivity, competitiveness, flexibility, quality, and innovation (Mudin et al., 2018). This reiterates that currently innovation is needed for every development in the region, in order to achieve outputs that are creative-innovative and acceptable to the community, with the aim of increasing regional competitiveness.

With the presence of the era of globalization, the challenge to achieve prosperity is also getting bigger. Rapid technological advances, extensive information flows, intense market competition, and complex social dynamics demand integrated and coherent efforts in the context of development(Lisaria Putri, Chasan Amrulloh, et al., 2023; Muna et al., 2023). A country and a region will have a different reaction in responding to the impact of the globalization phenomenon. So that it will differentiate the position of each region in the increasingly fierce global competition. The current conditions must be interpreted as demands for each region in Indonesia to increase the competitiveness of each region, where high competitiveness between regions in Indonesia as a whole is a support for increasing national competitiveness(Huda & Santoso, 2014). Considering the trade phenomenon in this global situation, there is an increasing need for a separate strategy in a systematic, synergistic and integrated manner in an effort to optimize regional competitiveness.

Based on Law No. 17 of 2007 concerning the 2005-2025 National Long-Term Development Plan (RPJPN), it has been underlined that in order to strengthen the domestic economy with an orientation and competitiveness, it is necessary to support the strengthening of the innovation system, namely through the use of science and innovation in order to support competitiveness(Putera, 2012). This is also based on Law No. 18 of 2002 concerning the National System for Research, Development and Application of Science and Technology. Strengthening the national innovation system is the main vehicle for increasing competitiveness and social cohesion in realizing a society that is prosperous, just, advanced, independent and civilized. The development of regional innovation systems is one of the main strategies in the national innovation system which accommodates the process of interaction between the components of strengthening the innovation system(Handayani et al., 2012).

Therefore, to help accelerate development in the regions, the Government issued a national innovation policy stated in the Joint Regulation of the Minister of Home Affairs No. 36 and Minister of Research and Technology No. 3 of 2012 concerning Strengthening Regional Innovation Systems. This joint decision "instructs" each regional official to design the economic development of his region by developing a regional innovation system which is expected to unite all innovation actors to become the main component of the innovation system. Progressive development needs to make strengthening the innovation system a common agreement and priority in increasing competitiveness. Finally, the system innovation approach has considerable appeal for national/regional policy makers in order to achieve regional productivity so that it will increase people's welfare on a national/regional economic scale.

Therefore it is necessary for policy makers to seek appropriate recommendations on how to optimize the condition of an innovation system that is well-established, systematic, synergistic and comprehensively integrated, especially in an environment where resources for public investment are limited. Therefore, it is very important to identify the determinants of the innovation system by looking at the current constraints.

Although the development of a regional innovation system is one of the main strategies in the national innovation system as described in the Joint Regulation of the Minister of Home Affairs No. 36 and Minister of Research and Technology No. 3 of 2012 mandates the development of regional innovation systems, but regional innovation systems have not been proven to be implemented consistently and systematically by all provinces in Indonesia. As a result, the system works partially, not comprehensively integrated. The facts related to the current regional innovation system are; a) Regional Innovation Systems have not been proven to be implemented consistently and systematically, even joint regulations regarding regional innovation systems in Indonesia are still considered foreign by regional policy makers, government policy and regulatory support in innovation systems is highly expected to increase innovation capacity(Sanawiri & Wilopo, 2017), and governance in terms of coordination and interaction between actors in the innovation system in Indonesia is still weak (Putera, 2014).

This research is one part that is seen for the preparation of strategies to strengthen regional innovation systems, where the constraint factor is one of the inputs in developing strategies. Many studies discuss specifically related to the implementation of regional innovation systems, both from the aspects of policy, institutions, innovation resources and governance. innovation system. however, there has been no research that has developed a structural model based on contextual relations from the aspects of constraints and obstacles faced by the region and has not yet identified sub-factors that have a very strong influence on implementing regional innovation systems.

By looking at this phenomenon, the aim of this research is (a) to identify the factors that become obstacles in the implementation of regional innovation systems (b) to find out the sub-factors of obstacles that have a very strong influence in implementing regional innovation systems. This research is one part that looks at the preparation of strategies for strengthening regional innovation systems, where constraining factors are one of the inputs in developing strategies. Many studies discuss specifically the implementation of regional innovation systems, both from the aspects of policy, institutions, innovation resources and governance. innovation system. However, there has been no research that has developed a structural model based on contextual relationships from aspects of constraints and obstacles faced by regions and the sub-factors of obstacles that have a very strong influence on running regional innovation systems have not been identified. Many previous studies in formulating strategies used SWOT analysis (strengths, weaknesses, opportunities and threats). However, in this research the ISM method was used to formulate key elements in the constraint factors. Where, to identify and understand the dynamics of the relationship between constraint factors that influence the implementation of regional innovation systems and by referring to a relationship design model and grouping of strategic targets from several sub-elements of constraints encountered, it will be known which factors have a very strong influence on the implementation of the system regional innovation. By using the interpretive structural modeling (ISM) method, a relationship model and target grouping of obstacles can be designed in strengthening an implementable regional innovation system. After that, MICMAC (Matriced Impacts Croises Multiplication Appliqueaun Classement) analysis was carried out to classify the constraining factors into different categories and to reveal the direct and indirect influence of each factor on the regional innovation system. The findings provide important insights to help policymakers prioritize actions to strengthen regional innovation systems

2. Theory

According to Nelson and Rosenberg (1993), an innovation system is a set of actors who together play an important role in influencing innovative performance. Meanwhile, Metcalfe and Ramlogan (2005) explained that an innovation system is a system that brings together different institutions that contribute, both collectively and individually, to the development and diffusion of new technologies and provides a framework. The government forms and implements policies to influence the innovation process. Thus, the innovation system is a system of interrelated institutions to create, store and transfer knowledge and skills to develop new technology.

The regional innovation system is also a form of regional development perspective/approach that is implemented systematically, innovatively, holistically and sustainably with a focus on cooperation between regional development stakeholders. The regional innovation system can also be referred to as a set of development actors, institutions (including politicians), interactive relationships, and production processes that influence the direction of development, the rate of innovation and the diffusion of innovation (Taufik, 2010).

Although developing regional innovation systems is one of the main strategies in the national innovation system, regional innovation systems have not been proven to be implemented consistently and systematically by all provinces in Indonesia. As a result, the system works partially, not comprehensively integrated. Facts related to the current regional innovation system are; a) Regional innovation systems have not been proven to be implemented consistently and systematically, even joint regulations regarding regional innovation systems in Indonesia are still considered foreign by regional policy makers (Brillyanes & Wilopo (2018), and b) Governance in terms of coordination and interaction between actors in the innovation system in Indonesia is still weak (Putera, 2014).

Based on the literature that has been studied, it was found that there are several things that are the center of attention in the innovation system. The innovation system can be seen from several perspectives, at least from 2 sides, namely the institutional side as understood by Freeman (1987) and also by the OECD Institute (1997), from the coordination/interaction side between actors as understood by Lundval (1992) and Nelson (1993). This research looks at the aspects of the obstacles faced in implementing a regional innovation system based on the perspective above. Previous research that has analyzed regional innovation systems has mostly looked at it from an institutional perspective only (Seidel, 2013; Wimono, H. 2019; Kurniati, 2019), or from a policy perspective only (Lakitan, 2013; Martin and Triple, 2014; Coenen et al., 2017), Coordination in innovation systems (Putera, 2014; Nilsson, M., 2014). This research position will identify the main key obstacles in the regional innovation system. The method used to determine decisions is to use the interpretive structural modeling (ISM) method.

According to Mandal, A., & Deshmukh, S.G. (2014), interpretive structural modeling (ISM) is a way to identify and describe problems by connecting various predetermined factors, then according to Warfield J.N. & Staley S.M. (1996). ISM can help in identifying the sequence and magnitude of complex relationships between system elements. According to Darmawan, Dwi Putra. (2017). If ISM is well understood, ISM will help decision makers to simplify every process that will be carried out and synergize existing systems so that effectiveness and efficiency in the organization can be increased because decision makers can make decisions quickly and with a clearer understanding. Based on the explanations from the experts above, it can be concluded that ISM is a method used to structure complex problems into simple ones by creating cause and effect relationships from predetermined factors so that it can make it easier for decision makers to plan future actions. carried out in an organization.

Interpretive Structural Modeling (ISM) as applied by Bhattacharya and Momaya (2009), is a sophisticated interactive planning methodology that allows a group of people, working as a team, to develop structures that define the relationships among elements in a set. Structure is obtained by answering simple questions. The elements to be structured (such as goals, obstacles, problems, and so on) are determined by the group at the beginning of the ISM planning session. The ISM process starts from system modeling and ends with model validation. Through the ISM technique, unclear mental models are transformed into visible system models.

ISM is a method for making decisions from complex situations by connecting and organizing ideas in a visual map. ISM is a modeling that describes specific relationships between variables, a comprehensive structure and has output in the form of a graphical model in the form of quadrants and variable levels (Li & Yang, 2014). In terms of decision making, ISM has little in common with the Analytic Network Process (ANP) method developed by Thomas L. Saaty. For example, research conducted by Rusydiana & Devi (2013b). The basic idea is to use experienced experts and practical knowledge to decompose a complex system into several sub-systems (elements) and build a multi-level structural model. ISM is often used to provide a basic understanding of complex situations and develop actions to solve problems (Gorvett and Liu, 2007). The ISM method is widely applied in strategic management research in various fields.

3. Methodology

This study uses a qualitative approach with analytical tools using the Interpretative Structural Modeling (ISM) method. ISM is a descriptive modeling technique that is a structuring tool for a direct relationship (Saxena et al. 1992). The basis for decision making in the ISM technique is the group. Structural models are produced to describe the complex problems of a system, through carefully designed patterns using graphics and sentences. Interpretative Structural Modeling (ISM) is the development of modeling techniques for strategic policy planning (Marimin, 2004). Basically is to use experienced experts and practical knowledge to decompose a complex system into sub-systems (elements) and construct a multilevel structural model. ISM is often used to provide a basic understanding of complex situations, as well as formulate actions to solve problems (Gorvett & Liu, 2007). ISM modeling describes the contextual relationships between variables, the overall structure and has graphical model outputs in the form of quadrants and variable levels. The following is a flow chart of structural modeling using the ISM method (Eriyatno, 2012).

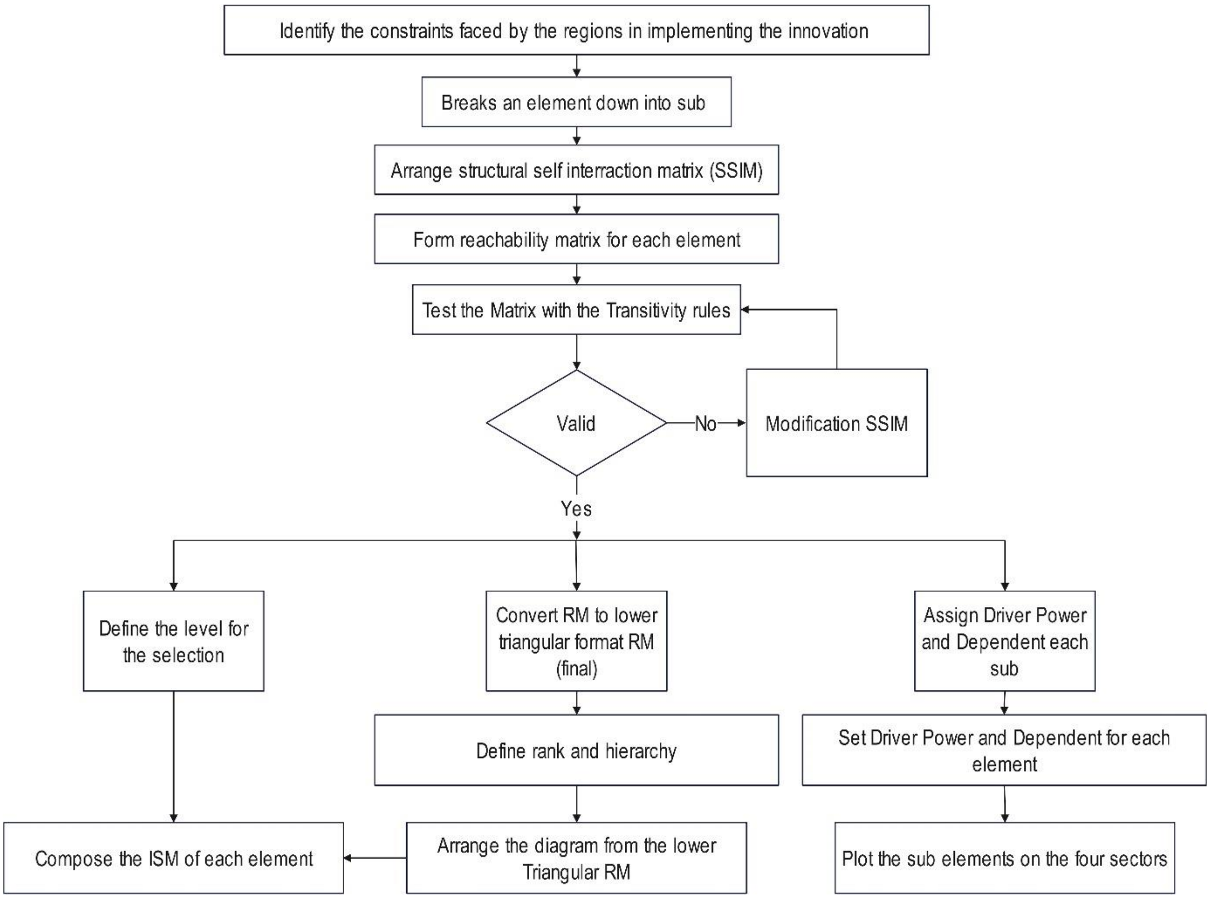

Fig.1: Structural Modeling Flowchart with the ISM method

Through focus group discussion with experts, results were obtained from questionnaires that had been filled in by selected regional stakeholders and were related to strengthening the regional innovation system. The data used as input for processing data was obtained from expert interviews. The experts in question are parties from related fields, namely West Sumatra Province government agencies such as the Regional Development Planning Agency (2 people), Regional Research and Development Agency (2 people), Academics (2 people), business actors (1 person). the number of experts is 7 people

The results will be processed and structured using the Interpretative Structural Modeling (ISM) method approach. In implementing the ISM method, discussions are first held with experts (brainstorming) to gather ideas for implementing a regional innovation system consisting of people who understand the ISM concept, understand the problem of developing a regional innovation system development model. From the discussion regarding the development strategy, several ideas or variables were obtained that will be processed using ISM. In this research, group decisions were made from several expert opinions and provided recommendations according to regional needs and interests so that the recommendations made could be implemented appropriately.

The steps taken in the ISM method in this study are as follows:

a. Identify the obstacles encountered in the implementation of the regional innovation system based on literature and expert opinion.
b. Making contextual relations based on a collection of expert opinions through questionnaires and interviews when answering the interrelationships between elements.
c. The results of the assessment are arranged in a Structural Self Interaction Matrix (SSIM) table which symbolizes the relational variables with the letters V, A, X and O.
d. The SSIM table is converted into a Reachability Matrix (RM) table by replacing V, A, X, O with the numbers 1 and 0 according to the letter symbols.
e. The RM table is corrected using the transitivity rule to obtain the final Reachability Matrix. The rule is that if variable 1 affects variable 2 and variable 2 affects variable 3, then variable 1 must affect variable 3.
f. From the final table, the RM is partitioned by iterations so that the level or level group of each variable is obtained.
g. Create a diagram or ISM model from the RM table by removing the transitivity and reviewing the consistency of the concept.

From the results of ISM then analyzed further by grouping variables based on the position of driver power and dependence with Matrice d'Impacts multipication application a classment (MICMAC) analysis (Godet, 1986), variable classification can be grouped into autonomous, dependent, linkage or interdependent so that known factors that have a strong influence on the element constraints.

MICMAC Quadrant Analysis

In this research, Godet (1986) has popularized the 'matrix of cross impact multiplications applied to classification' (MICMAC) to classify the system variables studied. The basis of this classification is 'driving power' and 'dependence power' which are calculated in the final reachability matrix. Additionally, MICMAC analysis can be used to examine direct and latent relationships among enablers obtained from ISM techniques. So, based on 'driving power' and 'dependence power', enablers in this study are classified into four groups, as shown and explained below:

a. Autonomous Variables: These variables do not have high influence or high dependence and are in quadrant I
b. Dependent Variable: Quadrant II is a dependent variable that has low influencing power and high dependence
c. Linkage Variables: These variables have high influence power as well as high dependency which are in quadrant III
d. Independent Variables: These variables have high influencing power and low dependence. They represent Quadrant IV

4. Results and Discussion

4.1. Identification of the obstacles encountered in the implementation of the regional innovation system

By understanding the constraints in the regional innovation system, we can identify existing problems and obstacles. This allows us to take concrete steps to address the problem and increase the effectiveness of the innovation system. In identifying the sub-element constraints in the regional innovation system in West Sumatra, it was carried out by collecting expert opinions with the Delphi technique, namely interviews using questionnaires and discussions so that the results of identifying the sub-element constraints in the regional innovation system were obtained, then analyzing the linkages of each sub-element and framework (framework) according to the ISM model.

Following are the results of the identification of the sub-element constraints that have been formulated by the author based on the technique above and it was found and agreed that there are 12 obstacles faced by the West Sumatra provincial government in running the regional innovation system. Following are the results of the identification of obstacles/obstacles in implementing regional innovation systems in West Sumatra, namely:

a. Leadership commitment to strengthening regional innovation systems.
b. Policies and regulations for strengthening regional innovation systems.
c. HR capacity regarding regional innovation systems.
d. There is no joint program and action plan in strengthening the regional innovation system.
e. Lack of Access to Information and Technology.
f. The system lacks product focus.
g. Weak Coordination.
h. Administrative barriers.
i. Budget constraints.
j. The current innovation support institutions are not yet in sync with the product focus in the system.
k. Culture.
l. The capacity of science and technology-based entrepreneurs is still low.

4.2. Develop and analyze the relationship of each of these scenarios with the ISM method

To develop and analyze the relationship between each of these scenarios using the ISM method, interviews were conducted by looking at the interrelationships between Factor i and Factor j. In this step of the ISM approach, 'leads to' type contextual relations have been taken to recognize the relationship between the identified factors (done in the previous step). Here, experts (the same group of experts used to identify factors) For this purpose, the following four symbols (used to show the relationship between two factors (i and j):

“V”: The presence of Indicator i triggers/reaches Indicator j. (Forward relationship)

“A”: The presence of Indicator i is triggered/accomplished by the presence of Indicator j. (Backward relationship)

“X”: Indicator i and Indicator j trigger/help each other (Cross relationship)

"O": Indicator i and Indicator j are not related (No relationship)

After obtaining the constraint sub-elements from the expert opinion, the next step is to develop and analyze the relationship of each of these sub-elements to do an expert assessment. This assessment is further illustrated in the Structural Self-Interaction Matrix (SSIM). in table 2.

Table 1. Structural self-Interaction Matrix

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]
[1,]		V	V	V	V	V	V	V	A	V	V	V
[2,]			V	V	V	V	V	A	V	A	A	V
[3,]				V	X	A	A	A	A	X	X	V
[4,]					X	A	A	V	V	V	V	V
[5,]						A	A	A	A	X	X	V

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]
[6,]							X	V	V	A	O	X
[7,]								V	V	X	X	A
[8,]									A	A	V	V
[9,]										V	O	V
[10,]											V	V
[11,]												A
[12,]												

4.3. Formation of Reachability Matrix Table

The next stage is to make the reachability matrix table. This table is obtained from the structural self-interaction matrix (SSIM) using a two-step process. In the first step, the alphabet used to show the relationship between variables in SSIM is replaced with "0" or "1". The value in the reachability matrix depends on the type of relationship in SSIM (Faisal, 2015) and is summarized in the following relationship:

a. If the relationship between the variable in one row and other variables in the column is "V", then in the initial Reachability matrix, the row entry will be "1" while the column entry between these two variables will be "0".
b. If the relationship between the variable in one row and other variables in the column is "A", then in the initial Reachability matrix, the row entry will be "0" while the column entry between these two variables will be "1".
c. If the relationship between the variables in one row and other variables in the column is "X", then in the initial Reachability matrix, the row entries will be "1" while the column entries between these two variables will be "1".
d. If the relationship between the variable in one row and other variables in the column is "O", then in the initial Reachability matrix, the row entry will be "0" while the column entry between these two variables will be "0".

Based on the rules above, an initial Reachability matrix for strategic input from the aspect of constraints in strengthening regional innovation systems was constructed. This matrix is formulated with the introduction of the concept of transitivity. Transitivity is a basic assumption of the ISM methodology. This stipulates that if factor A affects factor B and factor B affects other factor C, then factor A will also affect factor C. With the rules of relations (I,j) and (j,i) entered in the Reachable Table of the initial and final matrices The Reachability Matrix developed is presented in Table 2 and Table 3. As shown in the following table 2.

Table 2. Reachable Matrix

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]
[1,]		1	1	1	1	1	1	1	1	1	1	1
V			1	1	1	1	1	1	1	1	1	1
[3,]				1	1	0	0	0	0	1	1	1
[4,]					1	0	0	1	1	1	1	1
[5,]						0	0	0	0	1	1	1
[6,]							1	1	1	0	O	1
[7,]								1	1	1	1	0
[8,]									0	0	1	1
[9,]										1	0	1
[10,]											1	1
[11,]												0
[12,]												

Final Reachability Matrix:

The Final Achievement Matrix is used to determine the degree of relationship and dependency between elements in a hierarchy. This matrix reflects the extent to which an element can reach other elements through a series of relationships. In this matrix, each element is assigned a value based on its ability to achieve other elements in the hierarchy. These values reflect the level of achievement among the elements

Table 3. Final Reachability Matrix

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]	[,11]	[,12]
[1,]	1	1	1	1	1	1	1	1	1	1	1	1
V	0	1	1	1	1	1	1	1	1	1	1	1
[3,]	0	0	1	1	1	0	0	1	1	1	1	1
[4,]	0	0	0	1	1	0	0	1	1	1	1	1
[5,]	0	0	1	1	1	0	0	0	0	1	1	1
[6,]	0	0	1	1	1	1	1	1	1	1	1	1
[7,]	0	0	1	1	1	1	1	1	1	1	1	1
[8,]	0	1	1	0	1	0	0	1	0	0	1	1
[9,]	1	0	1	0	1	0	0	1	1	1	1	1
[10,]	0	1	1	0	1	1	1	1	0	1	1	1
[11,]	0	1	1	0	1	0	1	0	0	0	1	0
[12,]	0	0	0	0	0	1	1	0	0	0	1	1

4.4. Convergence Matrix

The Convergence Matrix is used to determine the degree of convergence between the elements in the hierarchy. This matrix reflects the extent to which the elements in the hierarchy influence each other and are interdependent on one another. In this matrix, each element is assigned a value based on the degree of influence it has on the other elements in the hierarchy. These values reflect the degree of convergence between the elements. Furthermore, to obtain the partition level, the Interpretative Structural Modeling (ISM) analysis process for the constraint elements is carried out in 7 iterations to determine the level and ranking of each constraint element.

4.5. Identify categories and determine the ranking of sub elements

Furthermore, there is table 4 which shows the results of the Interpretative Structural Modeling (ISM) analysis on the constraint elements. The results can be seen in the form of a canonical matrix. In the canonical matrix output table shows the rank, level of influence (driver power), level of dependence (dependence) of sub elements in a particular element.

Table 4. Canonical matrix of constraint elements

	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**DP**	**Driver Power**	**Rank**	**Dependence**	**Hirarchy**
A1	1	1	1	1	1	1	1	1	1	1	1	1	12	1	2	8
A2	0	1	1	1	1	1	1	1	1	1	1	1	11	2	5	7
A3	0	0	1	1	1	0	0	1	1	1	1	1	8	5	10	3
A4	0	0	0	1	1	0	0	1	1	1	1	1	7	6	7	5
A5	0	0	1	1	1	0	0	0	0	1	1	1	6	7	11	2
A6	0	0	1	1	1	1	1	1	1	1	1	1	10	3	6	6
A7	0	0	1	1	1	1	1	1	1	1	1	1	10	3	7	5
A8	0	1	1	0	1	0	0	1	0	0	1	1	6	7	9	4
A9	1	0	1	0	1	0	0	1	1	1	1	1	8	5	7	5
A10	0	1	1	0	1	1	1	1	0	1	1	1	9	4	9	4
A11	0	1	1	0	1	0	1	0	0	0	1	0	5	8	12	1
A12	0	0	0	0	0	1	1	0	0	0	1	1	4	9	11	2

4.6. Graphics development

In addition to the ISM quadrant graph, there is also an ISM rank chart which shows the key sub-elements in an element. The result can be seen in the picture.

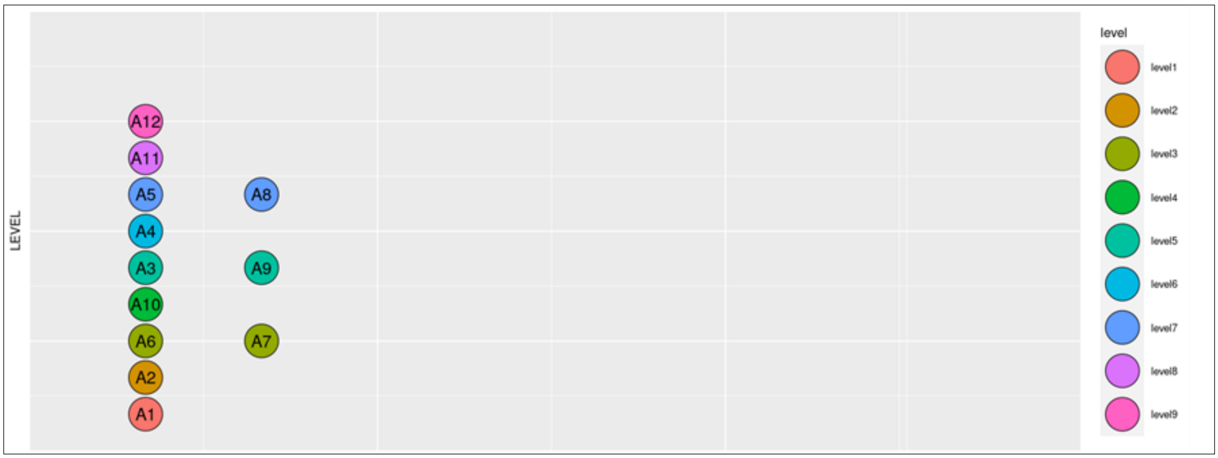

Fig.2: Graph of Constraint Element ISM Rank

From Figure 2 it can be seen that in the constraint element there is a sub-element A1 (leadership commitment) which occupies a rank 1 position. In other words, A1 (leadership commitment) is a key sub-element in the constraint element. The position of A1 as a key sub-element indicates that A1 must get maximum attention when faced with various choices of constraints because it has a very high influence on other sub-elements. The key element of the obstacle element is leadership commitment in strengthening the regional innovation system which is the main strategy in strengthening the regional innovation system in West Sumatra. There are three scenarios that are categorized as independent factors, namely data A1 (leadership commitment), A2 (policies and regulations strengthening regional innovation systems) and A6 (the system does not have a product focus to increase added value and production). Of the three scenarios, commitment is the most critical, where a strategy to build commitment must immediately take precedence to succeed in implementing regional innovation system strengthening before strategies for other scenarios.

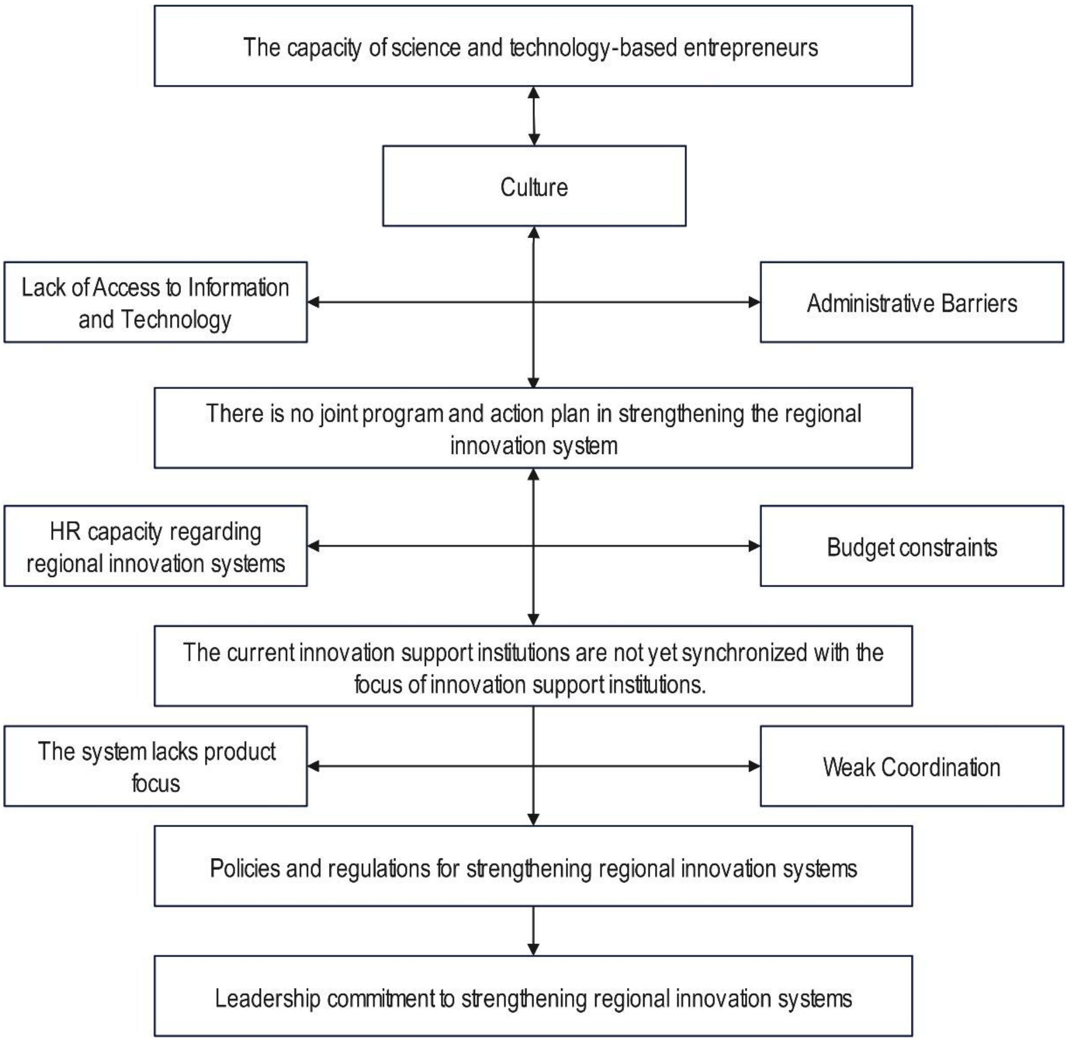

Fig.3: The structure of the ISM model with elements of constraints in regional innovation systems

4.7. MICMAC analysis

The MICMAC method was developed by Michel Godet and François Bourse (Chandramowli et al, 2011). MICMAC stands for Matrice d'Impacts croises-multipication application a classment. The main objective of the MICMAC analysis is to analyze the driving forces and factor dependencies. The next step is to group each factor from table 3. Final Reachability Matrix according to MICMAC. The grouping is as follows:

I. Autonomous variable which means as a weak driver and low dependency. This variable is located in quadrant I. There are no research variables that fall into this category.
II. Dependent variable which means as a weak driver and high dependency. This variable is located in quadrant II.
III. Linkage variable which means as a strong driver and strong dependency. This variable is located in quadrant III.
IV. Independent Variable which means as a strong driving force and low dependency. Variables in quadrant IV have a strong influence on the system and greatly determine the success of the program.

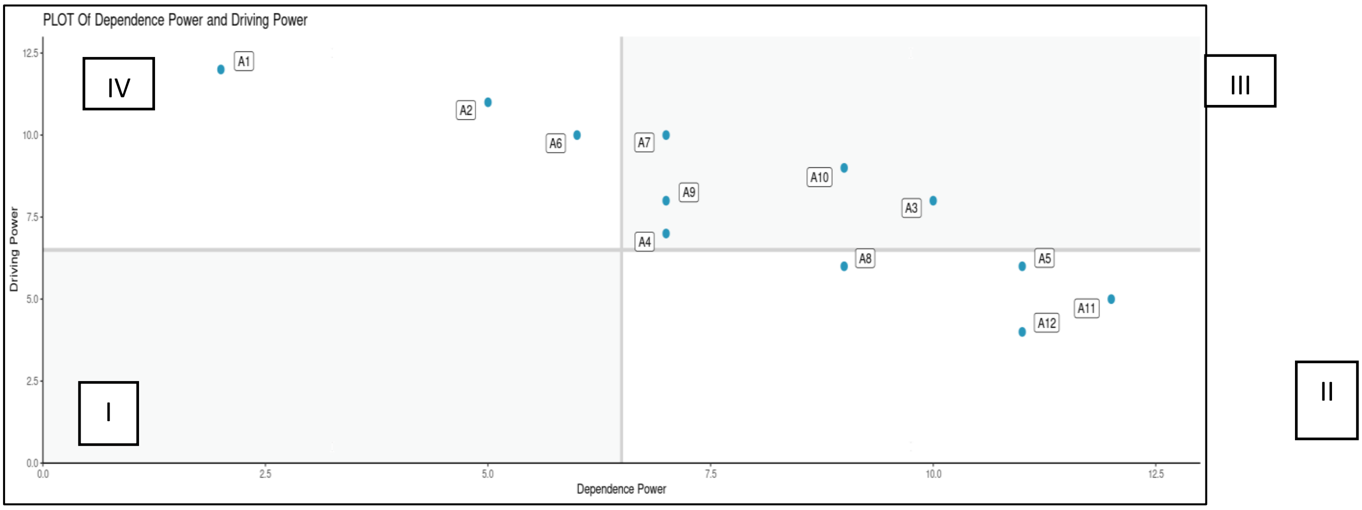

Fig.4: MICMAC analysis/Graph of ISM Quadrant element constraints

The results of the MICMAC analysis provide the position of several sub-element constraints in 4 quadrants. From the results of the position of the constraint sub-element in this quadrant, it is obtained that the sub-element has a very strong influence and this is used as an effort for strategy formulation(Jatmiko & Zulkarnain, 2019).

Figures 4 above show that the constraint sub-element is an Independent Variable which means it is a strong driver and has low dependency. This variable is in quadrant IV which has a strong influence on the system and really determines the success of the program. The variables are A1 (leadership commitment), A2 (policies and regulations for strengthening regional innovation systems in regional plan documents) and A6 (the system does not have a product focus to increase added value and production). Independent variables in this case mean variables that are treated as factors that underlie or influence other variables in the analysis. These are variables that are considered as parameters or basic elements in ISM modeling that are used to understand and describe the relationships between various factors or variables.

Based on the MICMAC results obtained in the form of the figure above, it shows that A1 (Leadership Commitment) is a very influential sub-element in the implementation of the innovation system. Strong leadership commitment from government, university and business world. The high level of influence indicates that leadership commitment is a key factor that will influence the success of the regional innovation system. However, the low level of dependency indicates that this sub-element is not too dependent on other factors in the regional innovation system. When local leaders demonstrate a strong commitment to innovation, this can influence the entire organization and society in supporting innovation efforts. This commitment can be reflected in the allocation of resources, institutional support, and the promotion of a culture of innovation.

This leadership commitment also determines whether a leader can make changes or not make any changes at all. A system in every organization, whatever its form and name, it allows everyone to develop their power to do something or not do something. Leadership commitment from the local government can be seen from the policy. In the innovation system, the role of policies and regulations in strengthening regional innovation systems is needed. Policies and regulations as a form of leadership commitment to support regional innovation systems are an important basis for directing and encouraging innovation activities. In the regional planning documents it is necessary to establish policies that recognize the importance of innovation as one of the regional development priorities.

This is relevant to the results of research conducted by Herwanto (2015) which states that leadership commitment is an aspect of leadership commitment that is the key to the challenges of developing innovation. Based on the research results of Risandewi (2017), Blora Regency has the potential for technological and innovation development. The development of regional innovation systems (2012-2015) is still experiencing obstacles because regional innovation system policy regulations have not yet been formed. These findings will help policy makers to develop strategies for developing regional innovation systems as a driver of increasing regional competitiveness. Leadership commitment in implementing regional innovation systems means that the government's role as a policy maker is very necessary.

In addition to leadership commitment, another factor that is reflected in the MICMAC results is that an unclear product focus can be an obstacle in achieving added value and increased production in regional innovation systems. This factor is a factor that enters the quadrant which is called the Independent Variable which means it is a strong driver and has low dependency. The variables are leadership commitment, policy and product focus in the system.

Setting goals by increasing product competitiveness as a system focus is very important to have a clear strategy regarding priority products to be developed and added value added. By concentrating efforts on these products, regions can achieve competitive differentiation and better economic growth.

The development of a product focus (both potential and superior) should be based on the elements contained in the regional innovation system so that it can provide optimal results for increasing regional competitiveness and people's welfare on an ongoing basis because economic development utilizes science and technology that seeks to provide added value of the product (Yufit et al., 2017).

Furthermore, from the MICMAC results, several obstacles that have a high level of driving power and a high level of dependence in quadrant III are A3 (HR Capacity), A4 (There are no joint programs and activities, regular meetings between actors Regional innovation systems in discussing product innovation system-based focus), A7 (weak coordination), A9 (budget limitations) and A10 (the current innovation support institutions are not yet in sync with the product focus in the system). We call these five variables Linkage which means as a strong driver and strong dependency. This variable is located in quadrant III This is in accordance with the results of research by Nissa (2022) which states that there are obstacles or problems for the city of Samarinda in implementing the regional innovation system, including that the city of Samarinda has research and development institutions spread across government agencies and also in universities, but its human resources still very limited

Overall, the sub-elements that are in quadrant III indicate significant constraints and challenges in the development and success of regional innovation systems. The high level of influence shows the importance of serious attention and handling of these problems. The high degree of dependability also emphasizes that problem solving and improvement must involve multiple stakeholders and a collaborative effort.

In overcoming these obstacles, it is important to develop appropriate strategies and actions. Improving HR capacity, encouraging collaboration and regular meetings between actors, strengthening coordination between stakeholders, allocating adequate budgets, and synchronizing innovation support institutions with product focus are important steps that can be taken.

From the results of previous research that the interaction between actors in strengthening regional innovation systems in West Sumatra is weak. Therefore, to increase the effectiveness of the regional innovation system, it is necessary to have good coordination between this sub-element and other elements in the system. In addition, it is also important to involve various stakeholders in the development and implementation of regional innovation systems. Collaboration between the government, the private sector, educational institutions and the general public can generate synergies and strengthen innovation systems. By paying attention to these sub-elements with high levels of influence and low dependency, it is hoped that the regions will be able to increase their innovation capabilities, generate greater added value, and promote sustainable economic growth.

The next quadrant is a sub-element of the constraint element that has a low level of influence (driving power) and a high level of dependence which is in quadrant II, namely A5 (access to information technology and information), A8 (administrative barriers), A11 (Culture innovation), A12 (Science-based entrepreneurial capacity is still low). This constraint is a factor that is highly dependent on the innovation environment in the region. This follow-up requires cooperation between the government, the private sector, educational institutions, and the community. Through coordinated and synergistic efforts, it is hoped that this sub-element can be overcome and encourage the development of a stronger and more sustainable innovation system in the region.

5. Conclusion

This study makes important theoretical and practical contributions by using ISM methodology to analyze constraints faced in implementing regional innovation systems in the Indonesian context. The results of identifying the obstacles encountered in the regional innovation system in West Sumatra through brainstorming and gathering expert opinions using the Delphi technique, there are 12 obstacles found. This research studies the relational relationship of twelve constraints that are very likely to affect the implementation of regional innovation system strengthening. By using the ISM approach, the position of each constraint in a framework can be identified so that a clear description and recommendation of the strategy will be obtained according to the priority level.

The findings provide empirical evidence on the relative priority and interdependencies between key barriers related to leadership, policies, resources, and coordination. Leadership commitment emerged as the most critical factor requiring urgent attention. These results have crucial implications for policymakers in formulating targeted strategies to strengthen innovation systems by addressing priority constraint areas first. However, the limitations of a small localized expert sample affect the generalizability of the findings. Further research with more diverse and larger samples covering multiple regions would be valuable. Overall, this study represents an early empirical application of ISM analysis to prioritize innovation system constraints, providing a useful foundation to build on using larger scale quantitative and qualitative studies. The insights generated have strong practical utility for developing strategies to foster stronger and more sustainable regional innovation systems.

References

Almeida, A., Figueiredo, A., & Silva, M. R. (2011). From Concept to Policy: Building Regional Innovation Systems in Follower Regions. *European Planning Studies*, *19*(7), 1331–1356. https://doi.org/DOI: 10.1080/09654313.2011.573,

Doloreux, D., & Parto, S. (2005). Regional Innovation Systems: Current Discourse and Unresolved Issues. *Technology in Society - TECHNOL SOC*, *27*, 133–153. https://doi.org/10.1016/j.techsoc.2005.01.002

Eriyatno. (2012). *Ilmu sistem: meningkatkan mutu dan efektifitas manajemen* (L. Larasati (ed.); 4th ed.).

Faisal, M. N. (2015). A study of inhibitors to transparency in red meat supply chains in Gulf cooperation council (GCC) countries. *Business Process Management Journal*, *21*, 1299–1318. https://doi.org/10.1108/BPMJ-11-2014-0107

Fiore, A., Grisorio, M. J., & Prota, F. (2011). Regional Innovation Systems: Which Role for Public Policies and Innovation Agencies? Some Insights from the Experience of an Italian Region. *European Planning Studies*, *19*(8), 1399–1422. https://doi.org/10.1080/09654313.2011.586173

Gorvett, R., & Liu, N. (2007). Using Interpretive Structural Modeling to Identify and Quantify Interactive Risks. *Program*, 1–11.

Handayani, W., Setyono, J. S., Sophianingrum, M., & Kusharsanto, Z. S. (2012). Kajian Pengembangan Sistem Inovasi Daerah (SIDa) Kota Semarang. *Jurnal Riptek*, *6*(2), 1–16.

Höglund, L., & Linton, G. (2018). Smart specialization in regional innovation systems: a quadruple helix perspective. *R and D Management*, *48*(1), 60–72. https://doi.org/10.1111/radm.12306

Huda, M., & Santoso, E. B. (2014). Pengembangan Daya Saing Daerah Kabupaten / Kota di Propinsi Jawa Timur. *Jurnal Teknik Pomits*, *3*(2), 81–86.

Jatmiko, S. W., & Zulkarnain. (2019). Rekomendasi Strategi untuk Implementasi Industri 4 . 0 pada Pemeliharaan di Industri Proses Menggunakan Metode ISM. *Seminar Dan Konferensi Nasional IDEC 2019*, *2017*, F13-3 s.d F13-8.

Kawilarang, J., Adolfina, P., & H.C, M. (2019). PENGARUH BUDAYA INOVATIF DAN GAYA KEPEMIMPINAN TERHADAP KINERJA KARYAWAN DI RUMAH KOPI TRADISIONAL DI KOTA MANADO. *JURNAL RISET EKONOMI, MANAJEMEN, BISNIS DAN AKUNTANSI*.

Kusharsanto, Z. S., Handayani, W., & Artiningsih, A. (2017). Regional Innovation System Performance in Indonesia: Case of Semarang and Balikpapan. *The Asian Journal of Technology Management (AJTM)*, *10*(2), 58–73. https://doi.org/10.12695/ajtm.2017.10.2.2

Lisaria Putri, R., Chasan Amrulloh, M., Sutrisno, J., Saptana, S., & Dani, N. L. (2023). Government Policy Strategy towards Empowering MSMEs in the Covid-19 Pandemic at the Bulak Fish Market Center, Surabaya City. *Athena: Journal of Social, Culture and Society*, *1*(3), 93–101. https://doi.org/10.58905/ATHENA.V1I3.43

Lisaria Putri, R., Nyoman Sri Werastuti, D., Dwi Astuti, E., Fatimah Khairunnisa, A., Wahyono, E., & Luh Apriani, N. (2023). Integrated Reporting: Corporate Strategy Towards Achieving Sustainable Development SDGs. *Apollo: Journal of Tourism and Business*, *1*(2), 64–71. https://doi.org/10.58905/APOLLO.V1I2.39

Marimin. (2004). Teknik dan Aplikasi Pengambilan Keputusan Kriteria Majemuk. In *Manjemen*. PT.Grasindo.

Mudin, D. K. D., How, S. E., Rahman, M. M., Ibrahim, P., & Jopony, M. (2018). Industrial revolution 4.0: Universiti Malaysia Sabah perspective. *E3S Web of Conferences*, *48*, 3–6. https://doi.org/10.1051/e3sconf/20184803005

Muna, A., Ausat, A., Al Bana, T., & Gadzali, S. S. (2023). Basic Capital of Creative Economy: The Role of Intellectual, Social, Cultural, and Institutional Capital. *Apollo: Journal of Tourism and Business*, *1*(2), 42–54. https://doi.org/10.58905/APOLLO.V1I2.21

Putera, P. B. (2012). … 2000-2011 (The Perspective of Innovation Systems on Regional Policy Content of East Java in the Field of Science-Technology and Innovation Period from 2000 …. *Journal of S&T Policy And R&D Management*.

Putera, P. B. (2014). *Tata Kelola Sistem Inovasi Nasional di Indonesia*.

Richard R. Nelson. (1993). National Innovation Systems: A Comparative Analysis. *Columbia University - School of International & Public Affairs (SIPA)*.

Rosda, R., Wali, M., & Imilda, I. (2023). Evaluation of the Successful Implementation of the SIMARDI Using the Technology Acceptance Model (TAM). *SAGA: Journal of Technology and Information System*, *1*(2), 56–63. https://doi.org/10.58905/SAGA.V1I2.67

Sanawiri, B., & Wilopo, W. (2017). REGIONAL INNOVATION SYSTEM IN RURAL AREAS AND THE ROLE OF SMES AS COUNTERMEASURE FOR POVERTY: A CASE IN EAST JAVA, INDONESIA. *Russian Journal of Agricultural and Socio-Economic Sciences*, *66*, 215–223.

https://doi.org/10.18551/rjoas.2017-06.25

Supardi, S., Eko Agustinova, D., Tri, S., Putro, J., & Septiantoko, R. (2023). E-Services: Implementation of Digital-Based Public Services in The 4.0 Era. *Athena: Journal of Social, Culture and Society*, *1*(3), 87–92. https://doi.org/10.58905/ATHENA.V1I3.40

Taufik, T. (2005). *Pengembangan Sistem Inovasi Daerah: Perspektif Kebijakan*.

Wright, T. A., Cropanzano, R., & Bonett, D. G. (2007). The moderating role of employee positive well being on the relation between job satisfaction and job performance. *Journal of Occupational Health Psychology*, *12*(2), 93–104. https://doi.org/10.1037/1076-8998.12.2.93

Yufit, H., Herry, B., Abdurrahman, A., & Dwi, T. (2017). Strategi Pengembangan Produk Unggulan Lintas Wilayah untuk Mendukung Sistem Inovasi Daerah di Kabupaten Magetan, Ponorogo, dan Pacitan. *Cakrawala*, *11*(1), 113–129.