Identifying Unwanted Conditions using Lower Boundaries on Individual Control Charts in the Context of Urban Economic Resilience in Indonesia as an Information Supply Chain for Government Policy

Titi Purwandari[1*], Sukono[2], Yuyun Hidayat[3], Wan Muhamad Amir W Ahmad[4]

[1]*Doctoral Program in Mathematics,*
Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Indonesia
[2]*Department of Mathematics,*
Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Indonesia
[3,]*Department of Statistics,*
Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran, Indonesia
[4]*School of Dental Sciences, Health Campus,*
Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

*Corresponding author: *titipurwandari@yahoo.com*

***Abstract*—This study presents the unwanted conditions determination. The economic resilience model without taking into account the level of disruption and unwanted conditions is unrealistic model. The Objective is to determine unwanted conditions as a key criterion in determining the economic resilience status of a city. This study used data on Concern variables group and Control variables groups from website of Central Bureau of Statistics Indonesia. These data covered all 514 cities in Indonesia and are observed for a 5-year period from 2014 to 2018. The data is useful to develop a statistical model that can explain well the pattern of relationships between concern variables and control variables. Piecewise linear regression is applied to identify statistics model between Pc and Z, Lower Control Limit (LCL) for variable Z using Individual control Chart is applied to determine the unwanted conditions. We obtained that the control variable, Z is the ratio between the original income of the region (PAD) with the number of poor people in a city and the concern variable is income per capita, Pc of a city. Piecewise linear regression with breakpoint 126,255,066 can explain well the pattern of relationships between Z and Pc variables. The equation is: Pc = 26,660,263+0.28Z, R-square = 70.48%. LCL value is.1.884.059.5 so all cities that have a Z value below 1.884.059.5 fall into the unwanted condition area and after careful examination is obtained percentage of cities classified as do not have economic resilience , PER =28%. Cities that fall into unwanted conditions are defined as cities that cannot bear receiving economic shocks. Based on the results of this analysis, it can be used as a supply chain of information in economic policy making.**

***Keywords*—** *Economic resilience, Unwanted Conditions, Lower Control Limit, Control Variable, Concern Variable*

1. Introduction

Strengthening economic resilience for quality and equitable growth is included in National Priority One (PN-1) in the Government of Indonesia Work Plan (RKP) 2021. The plan carries the theme "Accelerating Economic Recovery and Social Reform". Economic resilience is a strategic issue of the Indonesian State. This is reflected in the statement: Bank of Indonesia-BI policy synergy, government and related authorities are strengthened to maintain economic resilience and encourage economic growth. National economic resilience is currently in a fragile state. Strengthening economic resilience is also a key recommendation in the Policy Brief: Strengthening Macroeconomic Resilience & Competitiveness for the Acceleration of Inclusive & Quality Economic Growth [1].

The research problem of this study, currently economic resilience in Indonesia is measured using the index approach. The national resilience index measured by Labkurtannas is economic resilience. The socialization of the National Resilience Index (IKN) measurement, including the economic resilience index, is continuing. Economic resilience according to the findings is in a pretty strong position.

The strategic research question is how strong a city to withstand the effect of an economic shock and at what intensity? An index cannot answer that question, but a model that shows the interrelation between the disturbance variable and the unwanted condition.

National Resilience according to the National Resilience Institute (Lemhannas) is "The dynamic condition of the Indonesian people which contains tenacity and resilience which contains the ability to develop national strength in facing and overcoming all challenges, threats, obstacles and disturbances both from within and outside that can endanger the integrity, survival nation and state".

Based on the explanation given in the background section, it can be formulated that the determination of the level of economic resilience of a city must exist in the context of disturbances and economic variables that are of concern to the city government. Therefore the approach to measuring economic resilience by simply setting an index as carried out by the National Resilience Measurement Laboratory of the National Resilience Institute (Lemhannas) is not enough. This fact shows that a new approach is needed in assessing the level of economic resilience of a city that takes into account the interrelation between three groups of variables: disturbance variable, control variable and concern variable

The motivation of researchers is to formulate a new model of measurement of economic resilience that contributes to economic development for a country. This new model of economic security is very important and urgent for the economic development of a country. In an effort to control the stability of a city's economic resilience, comprehensive and in-depth research is needed on the level of economic resilience of a city. This is because the condition of a city's economic resilience is dynamic in the context of responding to and reducing economic disruption to the concerns of the city's economic development, based on the supply chain of information on existing economic conditions.

2. Methodology

The data used in this research are historical data of yearly variables. This study used data on Concern variables group and Control variables groups from website of Central Bureau of Statistics Indonesia. These data covered all 514 cities in Indonesia and are observed for a 5-year period from 2014 to 2018. The modifier variable studied is Z, the ratio between PAD and the number of poor people. The concern variable studied is Pc, the ratio between gross regional domestic product (PDRB) and Population for every 514 cities. 2570 observation units on each variables PAD, number of poor people, PDRB, and Population are collected to analyze model of the relationship between modifier variables Z and concern variables Pc. The methods that will be involved in this research are Piecewise Linear Regression, Individual Control Chart, Non Linear Estimation, Simple Linear regressions and acceptance sampling plan

2.1 Economic Resilience

In ref [2], economic resilience as the ability of individuals, communities or countries to reduce vulnerability, to withstand shocks and to recover quickly. In ref [3], defines economic resilience as the ability of cities to minimize potential losses due to disasters. In ref [4], defines economic resilience as the ability of an area to anticipate, prepare to respond, and recover from disturbances. Hill et al. (2008) defines economic resilience as the ability of a region to recover successfully from economic shocks [5]. In ref [6], defines regional resilience as the ability of an area to anticipate, prepare, respond to, and recover from disturbances. In ref [7], defines economic resilience as a systematic approach to reducing economic vulnerability and loss and improving critical disaster situations.

The definition of regional economic resilience refers to the idea of the ability of the local economic system to recover from an elastic shock. Rose and Krausmann, developed an economic resilience index using microeconomic, mesoeconomic, and macroeconomic variables, the results of the study obtained a framework for obtaining an economic resilience index [8].

Bakhtiari and Sajjadieh, have conducted research under the title Theoretical and Empirical Analysis of Economic Resilience Index on economic resilience indexes applied to developing countries the definition of regional economic resilience refers to the idea of the ability of the local economic system to recover from an elastic shock [9]. Research on economic resilience was also carried out in ref [10], in this study discussing regional economic resilience in the face of natural disasters by establishing a resistance and recovery index for Japan which was hit by a major earthquake, while the factors studied were regional demographics, economic aspects , labor, innovation and social, using the resistance index and sensitivity index, with the following formula [10]:

$$\textit{Resistance index} = \beta_{res} = \frac{(E_{p,t} / E_{p,t-1})}{(E_{w,t} / E_{w,t-1})} \quad (1)$$

$$\textit{Recovery index} = \beta_{rec} = \frac{\Delta E_p}{\Delta E_{p,t}} \quad (2)$$

2.2 Individual Full Control Chart

Average individual scores are calculated as follows [11].

$$\textit{Center line} = \overline{X} \quad (3)$$

Which corresponds to the process average (the mean of the normal distribution). This line is usually plotted as a horizontal solid line. Above and below this are the upper control limit (UCL) and lower control limit (LCL) lines which represent L standard deviations above and L standard deviations below the process mean. L is the "distance" of the control limits from the centre line, expressed in standard deviation units.

$$\overline{X} \pm L\sigma, \quad (4)$$

The estimate of the process standard deviation is S, In the United Kingdom and parts of Western Europe, probability limits are used, with the standard probability level in each direction being 0.001, then the appropriate multiple of the standard deviation would be 3.09 then

$$\text{LCL} = \overline{X} - 3.09S \quad (6)$$

$$\text{UCL} = \overline{X} + 3.09S \quad (7)$$

Where S is a sample standard deviation,

$$S^2 = \sum_{i=1}^{n} \frac{(x_i - \bar{X})^2}{n-1} \quad (8)$$

$$S = \sqrt{S^2}, \bar{X} = \sum_{i=1}^{n} \frac{x_i}{n}, \quad (9)$$

Once the averages and limits are calculated, all of the individual data are plotted serially, in the order in which they were recorded. To this plot is added a line at the average value, x and lines at the UCL and LCL values. Data accuracy is checked using 30% acceptance sampling plan [12]. A methodology that is designed specifically to perform the precedence analysis is developed. The methodology is modified I-Chart [13].

2.3 Piecewise linear regression

Ryan, Porth , in some studies the independent variable consists of several segments based on certain values called X-knots denoted by X*, in this case used piecewise linear regression analysis. Piecewise linear regression analysis is a form of regression which includes various linear regression models that match the data for each X interval [14]. Piecewise linear regression from the Nonlinear Estimation Startup Panel - Quick tab, STATISTICA estimates, using least squares, the model:

$$y = (b01 + b11 * x1 + ... + bm1 * xm) * (y \leq bn) +$$

$$(b02 + b12 * x1 + ... + bm2 * xm) * (y > bn) \quad (10)$$

STATISTICA estimates two separate linear regression equations; one for the y values that are less than or equal to the breakpoint (b0) and one for the y values that are greater than the breakpoint. Nonlinear Estimation uses one very efficient general algorithm (quasi-Newton) that approximates the second-order derivatives of the loss function to guide the search for the minimum (i.e., for the best parameter estimates, given the respective loss function). Levenberg , for nonlinear least-squares regression (i.e., nonlinear regression functions, and the least-squares loss function), Nonlinear Estimation includes a dedicated algorithm that is very efficient and robust, and is the recommended estimation method when analysing large data sets and using the least-squares loss function): The Levenberg-Marquardt algorithm [15], Marquardt, developed a maximum neighborhood method which perform an optimum interpolation between the Taylor Series method and the gradient method [16].

2.4 Rosenbrock Pattern Search.

Where all other methods fail, the Rosenbrock pattern search method often succeeds. This method rotates the parameter space and aligns one axis with a ridge (this method is also called the method of rotating coordinates); all other axes remain orthogonal to this axis. If the loss function is unimodal and has detectable ridges pointing towards the minimum of the function, then this method will proceed with sure-footed accuracy towards the minimum of the function. However, note that this search algorithm may terminate early when there are several constraint boundaries (resulting in the penalty value; see above) that intersect, leading to a discontinuity in the ridges. The Rosenbrock pattern search method as follows:

We start with a diagonally method

$$k_i^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n + \alpha_{ii}k_i), i = 1,2,\dots s \qquad (11)$$
$$y^{n+1} = y^n + \sum_{j=1}^{s} b_j k_j$$

Applied to autonomous differential equation

$$y^{'} = f(y)$$

Linearizing the first formula yields

$$k_1^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n) + hf'(y^n + \sum_{j=1}^{n}\alpha_{ij}k_j^n)\alpha_{ii}k_i^n, \qquad (12)$$
$$i = 1,2,\dots,s$$

Replacing the Jacobians with $J = f'(y^n)$ for the computational cost

$$k_1^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n) + hJ\alpha_{ii}k_i^n, \qquad (13)$$
$$i = 1,2,\dots,s$$

And introducing additional linear combinations of terms to gain further freedom:

$$k_1^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n) + hJ\sum_{j-1}^{i}\gamma_{ii}k_j^n, \qquad (14)$$
$$i = 1,2,\dots,s$$

Definition:

An s-stage Rosenbrock method is given by the formulas:

$$k_i^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n) + hJ\gamma_{ij}k_j^n, i = 1,2,\dots,s \qquad (15)$$
$$y^{n+1} = y^n + \sum_{j=1}^{s} b_j k_j$$

Where α_{ij}, γ_{ij} are the determining coefficients and $J = f'(y)$.

Non Autonomous problem

The equation $y' = f(x, y)$ can be converted to autonomous form by adding $x' = 1$.So the s-stage Rosenbrock method for non autonomous case could be written a

$$k_1^n = hf(x^n + \alpha_i h, y^n + \sum_{j-1}^{i-1}\alpha_{ij}k_j^n + \qquad (16)$$
$$\gamma_i h^2 \frac{\partial f}{\partial x}(x^n, y^n) + h\frac{\partial f}{\partial x}(x^n, y^n)\sum_{j-1}^{i}\gamma_{ij}k_j^n$$
$$y^{n+1} = y^n + \sum_{j-1}^{s} b_j k_j$$

where the additional coefficients are given by

$$\alpha_i \sum_{j=1}^{i-1}\alpha_{ij} \;, \gamma_i = \sum_{j=1}^{i}\gamma_{ij}$$

Implicit differential equation:

Suppose the problem is of the form

$M y^{'} = f(x, y)$ where M is a constant, nonsingular matrix. The applying an s-stage Rosenbrock method, we can get

$$Mk_i^n = hf(y^n + \sum_{j=1}^{i-1}\alpha_{ij}k_j^n) + hJ\sum_{j=1}^{i}\gamma_{ij}k_j^n, i = 1,2,\dots s \qquad (17)$$
$$y^{n+1} = y^n + \sum_{j=1}^{s} b_j k_j$$

Then the inversion of M is adviced.

2.5 Hooke-Jeeves Pattern Moves.

Convergence is a pattern search method, who proved that it converges using the theory of positive bases [17]. In a sense this is the simplest of all algorithms. The Hooke-Jeeves method comprises of an iterative application of an exploratory move in the locality of the current point and a subsequent jump using the pattern move. If the pattern move does not take the solution to a better region, the pattern move is not accepted and the extent of the exploratory search is reduced. The step sizes in this process are constantly adjusted to "zero in" on the respective optimum. The positive-basis techniques to prove the convergence of another pattern-search method on specific classes of functions [18]-[19]. Outside of such classes, pattern search is not an iterative method that converges to a solution; indeed, pattern-search methods can converge to non-stationary points on some relatively tame problems [20]-[21].

In the Hooke-Jeeves method, a combination of exploratory moves and heuristic pattern moves is made iteratively. An exploratory move is performed in the vicinity of the current point systematically to find the best point around the current point [22]. In the exploratory move, the current point is perturbed in positive and negative directions along each variable one at a time and the best point is recorded. If the point found at the end of all variable perturbations is different than the original point, the exploratory move is a success; otherwise the exploratory move is a failure. In any case, the best point is considered to be the outcome of the exploratory move [23]-[25]. Finally the pattern search method consists of a sequence of exploratory moves about a base point which, if successful, are followed by pattern moves [26]. Unwanted there is great interest in the literature in discovering unwanted conditions using chaotic systems with closed curves of equilibrium points [27].

3. Results and Discussion

The findings of this study based upon the information gathered as a result of applying the new method explains above are arranged in a following sequence.

3.1 Model of the relationship between modifier variables Z and concern variables Pc

The mechanism to find out good model is as follows: Data for modifier variables and concerns are collected from website of Central Bureau of Statistics Indonesia (BPS) and presented in a 5-year time series (2014-2018) for 514 cities throughout Indonesia. The modifier variable studied is Z, the ratio between PAD and the number of poor people. The concern variable studied is Pc, the ratio between gross regional domestic product (PDRB) and Population for every 514 cities. 2570 observation units on each variables PAD, number of poor people, PDRB, and Population are collected to analyse model of the relationship between modifier variables Z and concern variables Pc. The mean of Pc are IDR 35,559,642.42 per year and the mean for Z are IDR 7,919,249.12.Table 1 shows that the relationship between the independent Z variable and the Pc response variable cannot be explained by a simple linear regression model.

The best model that can explain the behavior of Pc as concern variables by variable modifier Z is to use advanced models that are related to non-linear estimation techniques. Specifically the piecewise linear regression analysis method has been chosen. Utilizing the help of STATISTICA software the results obtained are presented in Table 2. Specifically the piecewise linear regression analysis method has been chosen. Utilizing the help of STATISTICA software the results obtained are presented in Table 2. Based on the summary in Table 2 it appears that the best results are shown by Rosenbrock pattern search estimation. The estimation results using Rosenbrock pattern search estimation are presented in Table 3.

The regression coefficients are obtained using the Rosenbrock Pattern Search estimation method. Piecewise linear regression with breakpoint 126,255,066 can explain well the pattern of relationships between Z and Pc variables. The equation is

$$Pc = 26,660,263+0.28Z, \text{R-square} = 70.48\%.$$

The R-square means that there is a 29.52% variation in Pc that cannot be explained by changes in Z.

Table 1 ANOVA[a] non significance linear relationship between Pc and Z

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	11130721131151750.000	1	11130721131151750.000	4.876	.027[b]
Residual	5862236805334794200.000	2568	2282802494289250.000		
Total	5873367526465945600.000	2569			

a. Dependent Variable: Pc
b. Predictors: (Constant), Z

Table 2 Summary of piecewise regression coefficients estimation using 7 methods of estimation

Relationship	Estimation Method		
Z to Pc	Quasi_Newton	R-Square	Does not converges
		B_0	
		B_1	
	Simplex	R-Square	2.40%
		B_0	
		B_1	
	Simplex and QuasiNewton	R-Square	2.40%
		B_0	
		B_1	
	Hooke Jeeves pattern moves	R-Square	70.41%
		B_0	26,338,137.60
		B_1	0.244223217
	Hooke Jeeves and Quasi Newton	R-Square	70.41%
		B_0	26,338,137.60
		B_1	0.244223217
	Rosenbrock pattern search	R-Square	70.48%
		B_0	26,660,263
		B_1	0.280338075
	Rosenbrock and Quasi Newton	R-Square	70.42%
		B_0	26,660,263
		B_1	0.280338075

Table 3 Model of Piecewise Linear Regression between Pc and Z using Rosenbrock pattern search estimation

N=2570	Model is: Piecewise linear regression with breakpoint Dependent variable: Pc Loss: Least squares Final loss:140580968E10 R=0 .83954 Variance explained: 70,48%				
	Const.B0	Z	Const.B0	Z	Breakpt. 126255066
Estimate	26,660,263	0.28	223761475	-0.34	

3.2 The unwanted Limits

Lower Control Limit (LCL) for variable Z using Individual control Chart is computed by running SPSS software (IBM SPSS Statistics 21, 2020). The results are presented in Figure 1. Figure 1 shows that the LCL is constructed using some portion of Z data set. Z data selection as LCL input refers to the results of piecewise regression. The process is found out Pc1 which is the smallest Pc value above the intercept (B0). B0 =26,650,106 is obtained from the model in Table 1. Then we filter and separate the origin of data pairs (Pc, Z) and get all pairs of (Pc, Z) for each Pc < Pc1. Based on Figure 1, it can be seen that the LCL value is 1,884,059.5 so all cities that have a Z value below 1,884,059.5 fall into the unwanted condition area. Those cities will be declared as cities that do not have economic resilience and after careful examination is obtained percentage of cities classified as do not have economic resilience , PER =28%. 2 sigma limits are indicators of the accuracy of the measurement method used in control charts. Two sigma limits indicate data chosen randomly from a set of normally distributed data that has a 95% of probability of being within the acceptable standard deviation. so if there are cities that have a Z value under the LCL, this shows that the cities are OUT of control. In this context, out of control means that it has a significantly small z value compared to other cities in Indonesia. So that the Z values under LCL reflect the unwanted Z values.

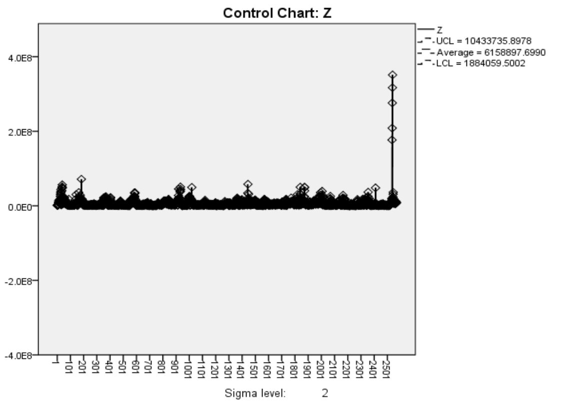

Figure 1 The Individual Control Chart using 2 Sigma level

No study covers all aspect of the research problem. This study limits economic resilience at the city, not provincial or even country level. Furthermore, this study does not discuss the model of economic disturbances in determining the economic resilience status of a city. Disturbance models and unwanted condition models are two important things that must be present as determinants in establishing the economic resilience status of a city. So this study cannot stand alone. Therefore, the disturbances model Study is our future plan of research. We cannot determine the economic resilience status of a city just by having an unwanted conditions model or a disruption model. Both models must be present.

Urban Economic Resilience is the dynamic condition of urban economic life which contains creativity and resilience which contains the ability to develop national strength in facing and overcoming all threats, obstacles, disturbances, obstacles and challenges originating from abroad and from within the country directly or indirectly. to ensure the economic survival of urban communities in Indonesia. One of the efforts to increase economic resilience by moving the economy through the creative economy is an economic concept in the new economic era by considering the supply chain of information and creativity by creating ideas that can be developed to improve the urban economy.

The resilience of the urban economy depends on the regional development planning itself. Meanwhile, the success of development planning is strongly supported by development planning policies that must be based on the conditions and potential of the region. Furthermore, to ensure that economic development policies can achieve optimal results, the policies taken need to be based on the supply chain of information on economic resilience, as well as in-depth and comprehensive research. The supply chain for information on economic resilience includes identification of basic economic sectors, economic growth, sectoral contributions to the formation of Gross Regional Domestic Product (GRDP), transformation of economic structures, multiplier effects of basic sectors in the urban economy.

4 Conclusions

Based on the critical review of earlier researchers and existing theories, there is not a single paper that explicitly stipulates unwanted conditions as a criterion for determining the economic resilience status of a city. This research disagree to work of earlier researchers with the approach that determines economic resilience based only on the index, as carried out by the National Resilience Measurement Laboratory of the National Resilience Institute (Lemhannas), and many researchers as mentioned in Introductions. Index is not enough because index is not able to identify specifically which disturbance factors significantly influence the economic resilience of the city. Index also unable to identify at what level of disturbances a city will fall to unwanted conditions such that it's classified as not resilience economically. This research also disagrees to the existing theories that determine economic resilience based only on disturbance model. The uniqueness of this research is the firmness in determining the economic resilience status of a city, only if the control variable Z falls into unwanted conditions, a city is claimed as not resilient. Lower Control Limit is established as cut off for determining unwanted conditions, because in this area high uncertainty occurs. LCL value is 1,884,059.5 and it means all cities that have a Z value below 1,884,059.5 fall into the unwanted condition area and after careful examination are obtained percentage of cities in Indonesia classified as do not have economic resilience , PER = 28%. Identifying these undesirable conditions can be used as a supply chain of information for urban economic resilience development policies.

Acknowledgement

The author would like to thank the Dean of the Faculty of Mathematics and Natural Sciences, Padjadjaran University and the Directorate of Research and Community Service (DRPM), who have provided funding via the Unpad Doctoral Dissertation Research Grant (RDDU), with a contract number: 5893/UN6.D/LT/2019.

References

[1] Tambunan, T. "*Recent evidence of the development of micro, small and medium enterprises in Indonesia*." Journal of Global Entrepreneurship Research, vol. 9, no. 1, 18, 2019.

[2] Sánchez, A. C., de Serres, A., Gori, F., Hermansen, M., and Röhn, O. "*Strengthening economic resilience: Insights from the post-1970 record of severe recessions and financial crises*."OECD Economic Policy Paper, vol. 20, pp. 1-30, 2016.

[3] Rose, A., and Krausmann, E. "*An economic framework for the development of a resilience index for business recovery*." International Journal of Disaster Risk Reduction, vol. 5, pp. 73-83, 2013.

[4] Simmie, J., and Martin, R. "*The economic resilience of regions: towards an evolutionary approach*." Cambridge journal of regions, economy and society, vol. 3, no. 1, pp. 27-43.

[5] Hill, E., Wial, H., and Wolman, H.. Exploring regional economic resilience (No. 2008, 04). Working paper, University of California, Institute of Urban and Regional Development (IURD), Berkeley, 2008.

[6] Foster, K. A. "*A case study approachto understanding regional resilience*." Annual Conference of the Association of Collegiate Schools of Planning, Fort Worth, Texas, November 9-12, 2006

[7] Bastaminia, A., Rezaei, M. R., and Saraei, M. H. "*Evaluating the components of social and economic resilience: After two large earthquake disasters Rudbar 1990 and Bam 2003*." Jàmbá: Journal of Disaster Risk Studies, vo. 9, no. 1, pp. 1-12, 2017.

[8] Rose, A. "*Defining and measuring economic resilience to disasters*." Disaster Prevention and Management: An International Journal, vo. 13, no. 4, pp. 307-314.

[9] Bakhtiari, S., and Sajjadieh, F. "*Theoretical and Empirical Analysis of Economic Resilience Index*." Iranian Journal of Economic Studies, vol. 7, no. 1, pp. 41-53, 2018.

[10] Oliva, S., and Lazzeretti, L. "*Measuring the economic resilience of natural disasters: An analysis of major earthquakes in Japan*." City, culture and society, vol. 15, pp. 53-59, 2018.

[11] Montgomery, D. *Statistical Quality Control: A Modern Introduction*, New York: John Wiley & Sons,Inc, 2009.

[12] Squeglia, N. L. *Zero acceptance number sampling plans.* New York: ASQ Quality Press, 1994.

[13] Hidayat, Y., Purwandari, T., Sukono, S., Supian, S., Juahir, H., Kamarudin, M. K. A., and Yusra, A. I. "*Improving unprecedented restlessness as the new strong indicator of rice crisis at national level*." Journal of Fundamental and Applied Sciences, vol. 10, no. 1, pp. 128-138, 2018.

[14] Ryan, S. E. *A tutorial on the piecewise regression approach applied to bedload transport data*. US: Department of Agriculture, Forest Service, Rocky Mountain Research Station, 2007.

[15] Li, S., Wang, P., and Goel, L. "*Short-term load forecasting by wavelet transform and evolutionary extreme learning machine*." Electric Power Systems Research, vol. 122, pp. 96-103, 2015.

[16] Levenberg, K. "*A method for the solution of certain non-linear problems in least squares*." Quarterly of applied mathematics, vol. 2, no. 2, pp. 164-168, 1994.

[17] Marquardt, D. W. "*An algorithm for least-squares estimation of nonlinear parameters.*" Journal of the society for Industrial and Applied Mathematics, vol. 11, no. 2, pp. 431-441, 1963.

[18] Verwer, J. G., Spee, E. J., Blom, J. G., and Hundsdorfer, W. "*A second-order Rosenbrock method applied to photochemical dispersion problems*." SIAM Journal on Scientific Computing, vol. 20, no. 4, pp. 1456-1480, 1999.

[19] Yu, W. C. "*Positive basis and a class of direct search techniques*." Scientia Sinica (in Chinese), vol. 9, no. S1, pp. 53-67, 1979.

[20] Torczon, V. "*On the convergence of pattern search algorithms*." SIAM Journal on optimization, vo. 7, no. 1, pp. 1-25, 1997.

[21] Dolan, E. D., Lewis, R. M., and Torczon, V. "*On the local convergence of pattern search*." SIAM Journal on Optimization, vol. 14, no. 2, pp. 567-583, 2003.
[22] Lewis, C. D. *Industrial and Business Forecasting Methods*. London: Butterworth-Heinemann, 1982.
[23] Powell, M. J. "*On search directions for minimization algorithms*." Mathematical programming, vol. 4, no. 1, pp. 193-201, 1973.
[24] McKinnon, K. I. "*Convergence of the Nelder--Mead Simplex Method to a Nonstationary Point*." SIAM Journal on optimization, vo. 9, no. 1, pp. 148-158, 1998.
[25] Kirgat, G. S., and Surde, A. N. "*Review of Hooke and Jeeves direct search solution method analysis applicable to mechanical design engineering*." Int. J. Innov. Eng. Res. Technol, vo. 1, pp. 1-14, 2014.
[26] Deb, K. *Optimization for engineering design: Algorithms and examples*. New Dehi: PHI Learning Pvt. Ltd, 2012.
[27] Mukherjee, I., and Ray, P. K. "*A review of optimization techniques in metal cutting processes*." Computers & Industrial Engineering, vol. 50, no. 2, pp. 15-34, 2006.