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A regression-based model of MSME strategy effectiveness during and beyond the COVID-19 crisis

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ABSTRACT

The COVID-19 pandemic has triggered a profound global economic crisis, disproportionately affecting Micro, Small, and Medium-Sized Enterprises (MSMEs) in developing countries such as Indonesia. Unlike previous economic shocks—such as the 1998 Asian Financial Crisis and the 2008 Global Recession—where MSMEs served as economic buffers, the pandemic exposed structural vulnerabilities in digital readiness, innovation capacity, and operational resilience. This study aims to empirically model the effectiveness of MSMEs' strategic responses during crisis conditions using a multiple linear regression framework. Data were collected from 300 MSMEs across Indonesia through structured questionnaires, followed by classical assumption testing and regression analysis. The model includes six strategic variables: production activities, innovation, rebate strategies, business planning, e-commerce utilization, and product reliability. The results indicate that innovation, e-commerce, and product reliability significantly contribute to MSME effectiveness during disruption. The adjusted R^2 value of 0.147 suggests moderate explanatory power, with potential for future research to examine broader environmental and policy-related variables. This study extends the existing literature by quantitatively identifying key strategic factors that foster MSME resilience—offering not only pandemic-era insights but also long-term guidance for post-crisis adaptation and preparedness. The findings provide a foundation for evidence-based policymaking aimed at enhancing MSME agility, sustainability, and crisis resistance in both current and future contexts.

1. Introduction

The COVID-19 pandemic has triggered a global economic disruption of unprecedented scale, affecting all sectors and segments of society. In Indonesia, the economy officially entered a recession in the third quarter of 2020, with the national GDP contracting for two consecutive quarters, 5.32% in Q2 and between 1% to 2.9% in Q3. Unlike previous economic shocks, such as the 1998 Asian Financial Crisis or the 2008 Global Recession, the COVID-19 crisis simultaneously affected both supply and demand, disrupting production capacities and suppressing consumption [1].

The collapse of global supply chains, mobility restrictions, and mandated lockdowns further deteriorated economic stability in emerging economies. Indonesia's Micro, Small, and Medium-Sized Enterprises (MSMEs), which contribute over 55% to the national GDP and employ more than 97% of the workforce, were disproportionately affected [2, 3]. National surveys revealed that 96% of MSMEs experienced operational disruptions, with 75% reporting a drastic decline in revenue [4].

More critically, this crisis exposed long-standing structural vulnerabilities among MSMEs, including limited digital infrastructure, low financial buffers, and minimal integration into online marketplaces. Unlike previous crises, COVID-19 demanded rapid organizational agility and technological adaptation, which many MSMEs were unprepared for [5, 6]. Consequently, widespread layoffs occurred, with over 6 million workers affected, further weakening aggregate demand for MSME products and services [7].

The magnitude of the COVID-19 impact on MSMEs also unveiled significant behavioral shifts and digital divides that further complicated their recovery. Studies revealed that the rate of digital platform adoption among Indonesian MSMEs lagged behind other

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Southeast Asian countries, primarily due to digital literacy gaps and infrastructure deficiencies [8, 9]. Moreover, socio-cultural resistance to technology adoption and limited access to affordable financial instruments have exacerbated these structural barriers [10, 11]. Meanwhile, international analyses emphasized the importance of agile leadership and proactive crisis communication strategies to sustain business continuity in uncertain environments [12, 13]. As such, MSMEs that lacked strategic foresight or were overly reliant on traditional models were found to be more vulnerable to prolonged downturns.

To overcome these challenges, recent literature proposes integrated frameworks combining crisis management, digital transformation, and resilience engineering as foundational elements for MSME recovery [14-16]. Specific recommendations include expanding microfinance accessibility, investing in inclusive digital upskilling programs, and fostering public-private innovation ecosystems [17, 18]. Empirical evidence from Thailand and Vietnam suggests that MSMEs which adopted platform-based sales and automated logistics experienced faster revenue rebounds and customer retention [19, 20]. Furthermore, policy-oriented research has highlighted the critical role of regulatory flexibility and adaptive fiscal support in enhancing MSME adaptability under crisis conditions [21-23]. These multidimensional insights offer a timely foundation for understanding how Indonesian MSMEs can realign their strategies toward digital integration and long-term resilience.

While a growing number of studies have examined the qualitative consequences of COVID-19 on small businesses, there remains a lack of empirical models that quantify the strategic factors influencing MSME resilience, particularly in the Indonesian context. More importantly, there is a gap in understanding how these strategies can remain effective beyond the immediate crisis and be integrated into long-term business continuity planning [24].

This study seeks to fill this gap by developing a regression-based model that identifies the most influential internal strategies contributing to MSME effectiveness during and after the COVID-19 crisis. The analysis includes key strategic dimensions such as production flexibility, innovation capability, rebate strategies, business planning, e-commerce adoption, and product reliability. These factors were selected based on established frameworks of crisis response and digital transformation [25, 26].

The primary objective is to construct an evidence-based regression equation that not only explains MSME performance during the pandemic but also serves as a decision-making tool for future resilience. Data were collected from 300 MSMEs across various Indonesian provinces and sectors. This study offers significant implications for practitioners and policymakers aiming to build sustainable MSME models in the face of future disruptions. It also demonstrates the methodological value of regression analysis as a rigorous, quantitative tool to assess and predict enterprise effectiveness across multidimensional strategies [27].

2. Material and method

2.1. Research design

This study employed a quantitative research design using multiple linear regression analysis to identify the factors influencing the effectiveness of MSMEs' survival strategies during the COVID-19 pandemic. Multiple regression was selected as it enables the evaluation of the simultaneous impact of several independent variables on a single dependent variable [28]. The model includes six independent variables, production activity, innovation, rebate strategy, business planning, e-commerce utilization, and product reliability, on MSME effectiveness as the dependent variable.

In the use of multiple regression analysis, the classical assumption test and test between variables. The explanation regarding the classical assumption test and testing between variables will be explained in more detail as conducted by [29].

2.2. Population, sample, and data collection

The target population for this study consisted of MSMEs across various regions in Indonesia. A purposive sampling technique was used to select 300 MSME respondents. Data were collected through a structured questionnaire, with all variables measured on a 7-point Likert scale, where respondents indicated their level of agreement or extent of implementation for each statement. Data analysis was conducted using SPSS 20.0. To ensure the validity of the regression model, classical assumption tests (e.g., normality and multicollinearity) were performed before the regression analysis [30].

2.3. Classical assumptions tests

A classical assumption test is conducted to determine whether the regression model is good or not. The classical assumption test in this study consists of the normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test. To ensure that the regression model met the necessary conditions, the following statistical assumption tests were performed [31].

(a) Normality test. The Kolmogorov–Smirnov test was used to check if the residuals were normally distributed. If the *p*-value is greater than 0.05, the data is considered normally distributed.
(b) Multicollinearity sest. Multicollinearity was assessed using the Variance Inflation Factor (VIF) and Tolerance values. A VIF value less than 10 and a Tolerance value greater than 0.1 indicate that there is no multicollinearity among the independent variables [28]. VIF is calculated as the

inverse of Tolerance, where Tolerance represents the proportion of a variable's variance not explained by other independent variables. A low Tolerance (and thus a high VIF) suggests that the variable is highly correlated with others, indicating multicollinearity.

(c) Heteroscedasticity test. Heteroscedasticity test is conducted through scatterplot analysis of standardized residuals. A random distribution pattern and a significance level > 0.05 indicated homoscedasticity.

(d) Autocorrelation test: The Durbin–Watson (DW) statistic was used to test for serial correlation. Values within the range of 1.5 to 2.5 were considered acceptable [32].

2.4. Variables, measurement, and model specification

This study employs multiple linear regression analysis to examine the factors influencing the effectiveness of Micro, Small, and Medium Enterprises (MSMEs) during a crisis period. The variables and their respective measurements, as well as the regression model specification, are described below.

The dependent variable in this study is MSME effectiveness (Y), which represents the overall performance and resilience of Micro, Small, and Medium Enterprises (MSMEs) during the crisis period. It reflects key indicators such as business continuity, adaptability, and financial performance. Meanwhile, the independent variables consist of several strategic and operational factors. The first is production activities (X_1), referring to the operational adjustments MSMEs make, including aligning production with fluctuating demand and managing inventory levels. The second is innovation (X_2), which captures the ability of MSMEs to introduce new products, services, or processes, as well as rebranding efforts in response to changing market conditions. The third variable is rebate strategies (X_3), encompassing promotional initiatives such as discounts, bonuses, and voucher programs aimed at retaining customers and boosting sales. The fourth, business planning (X_4), involves strategic actions like networking, managing customer data, and establishing collaborations to support business continuity. The fifth variable, e-commerce utilization (X_5), measures the extent to which MSMEs adopt digital platforms for conducting sales, managing deliveries, and processing payments. Lastly, product reliability (X_6) reflects the implementation of product certification, hygiene practices, and service guarantees that help build consumer trust and ensure consistent quality.

The relationship between the dependent and independent variables is modeled using the following multiple linear regression equation as in Eq. (1)

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon \quad (1)$$

where:

- Y = MSME effectiveness (dependent variable)
- X_1 = Production activities
- X_2 = Innovation
- X_3 = Rebate strategies
- X_4 = Business planning
- X_5 = E-commerce utilization
- X_6 = Product reliability
- β_0 = Intercept
- β_1-β_6 = Regression coefficients
- ε = Error term (assumed normally distributed)

2.5. Hypothesis testing

Testing between variables in multiple linear regression analysis is to test the effect of all independent variables on the dependent variable, and which independent variables affect the dependent variable. To determine the strength and significance of the relationships, coefficient of determination, F-test and t-test were conducted [34, 35]. All tests were conducted at a 95% confidence level. The analytical approach adopted in this study aligns with best practices in empirical research for economic behavior and business resilience [35].

3. Results and discussions

This study uses data from questionnaires that have been conducted previously. The data from the questionnaire results in the survey on the effectiveness of the survival strategy for Indonesian MSMEs affected by the COVID-19 pandemic are shown in Table A1 (see Appendices).

Table 1
Descriptive statistics (valid N (listwise) = 300)

Variable	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Effectiveness (Y)	300	5	7	2032	6.77	.499
Production ($X1$)	300	2	7	1627	5.42	1.173
Innovation ($X2$)	300	3	7	1887	6.29	.865
Rebates ($X3$)	300	1	7	1760	5.87	1.197
Business Plan ($X4$)	300	3	7	1885	6.28	.966
E-Commerce ($X5$)	300	4	7	2036	6.79	.492
Reliability ($X6$)	300	4	7	2015	6.72	.662

Table 2
Reliability test.

Variable	Calculated R	Cronbach Alpha	Description
Production Activities ($X1$)	0.321	0.60	Sufficiently
Mastery of Innovation ($X2$)	0.781	0.60	Reliable
Rebate ($X3$)	0.900	0.60	Reliable
Business Plan ($X4$)	0.822	0.60	Reliable
E-Commerce ($X5$)	0.809	0.60	Reliable
Product Reliability ($X6$)	0.797	0.60	Reliable

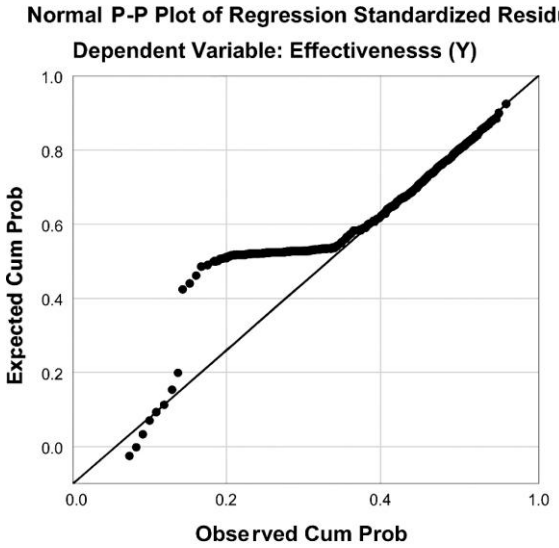

Fig. 1. Normality test results.

Based on Table A1, the results of the MSME effectiveness questionnaire are presented. This questionnaire uses a 7-point rating scale and includes one dependent variable (Y) and six independent variables (X), each represented by several statement items. The data were collected from 300 respondents.

3.1. Descriptive statistics

Descriptive statistics were conducted on data collected from 300 Indonesian MSMEs. Each item was rated on a 7-point Likert scale, capturing respondent perceptions of six independent variables and one dependent variable. The results (Table 1) show that E-commerce (Mean = 6.79, SD = 0.49) and Product Reliability (Mean = 6.72, SD = 0.66) were rated the highest, suggesting MSMEs place strong emphasis on digital accessibility and quality assurance during crises. Conversely, Production Activities (Mean = 5.42, SD = 1.17) had the lowest score, indicating operational constraints under pandemic conditions. This supports previous findings that digital platforms and customer trust mechanisms are crucial in MSME survival strategies [6, 26]. From Table 1, it is known that the results of descriptive statistics for each variable in the study this. Descriptive statistics are intended to determine the minimum, maximum, total value, average value, and standard deviation of the assessment results obtained from the MSME effectiveness questionnaire data that has been carried out.

3.2. Data processing and assumptions testing

In this study, data processing was carried out by using multiple regression analysis. Before this multiple regression, several tests were carried out such as data adequacy test, data validity test, data reliability test, classical assumption test, and finally, the inter-variable influence test was carried out [36]. To determine whether the data to be processed is sufficient, a data adequacy test was conducted using the Slovin formula. This formula is used to determine the required sample size based on the population size (N) and the margin of error (e), or significance level, as shown in [36]. Based on the calculation, with a population size (N) of 300 respondents and a margin of error of 5% (or 0.05), the resulting sample size (n) is 171.43. Since $N \geq n$ (300 ≥ 171.43), it can be concluded that the data is sufficient to be used as a sample.

The data validity test is used to determine whether the questionnaire data used in the study is valid and reliable. In this test, a calculated r-value is obtained and compared to the critical r-value from the r-table. With a degree of freedom (df) of 298 and a significance level (α) of 0.05, the critical r-value is 0.113 [37]. Table A2 (see Appendices) presents the results of the data validity test for the questionnaire data.

Table 3
Multicollinearity test results.

Model	Statisticscollinearity	
	Tolerance	VIF
(Constant)		
Production (X1)	.683	1.465
Innovation (X2)	.648	1.544
Rabat (X3)	.528	1.893
Business Plan (X4)	.575	1739
E-Commerce (X5)	.786	1273
Reliability (X6)	.557	1,794

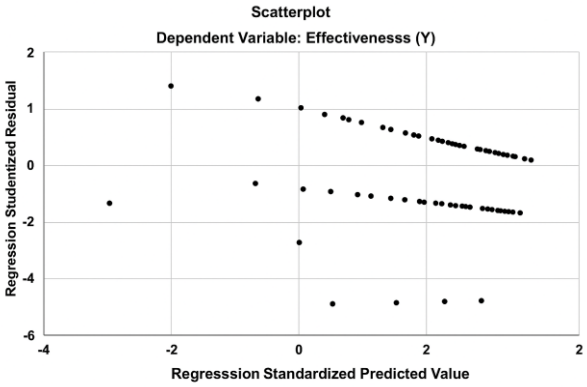

Fig. 2. Scatter plot of heteroscedasticity test.

A data item is considered valid if the calculated r-value is greater than the critical r-value. The results show that all questionnaire items for each variable have r-values greater than 0.113, indicating that the data is valid for use in this study.

The data reliability test is used to determine whether the available data can be trusted and remains consistent or stable over time, such as the respondents' answers to questionnaire statements [37]. The results of the reliability test for the questionnaire data are as shown in Table 2. It can be seen that the reliability test results for each variable in this study are provided. Data that has been tested for reliability can be considered reliable if the calculated r-value is greater than the Cronbach's Alpha value.

Test classical assumption test is a test that is carried out before the regression test is carried out to determine whether the data tested has met the assumptions so that a proper regression model will be obtained. Prior to regression modeling, classical assumption were test [31, 34]. A normality test is conducted to determine whether the data being tested, specifically the dependent and independent variables, follow a normal distribution. This test is performed using a graphical method.

As shown in Fig. 1, the results of the normality test for the questionnaire data are presented in graphical form. A Kolmogorov-Smirnov test and a Normal P-P Plot indicate that the residuals are approximately normally distributed. The graph uses a Normal P-P Plot, where the spread of data (points) is observed along the diagonal axis of the chart. The questionnaire data is considered normally distributed if the data points are spread around the diagonal line and follow its direction. Based on the graph above, the data points are spread along the diagonal line and align with its direction, indicating that the data used is normally distributed.

A multicollinearity test is used to determine whether there is a correlation between independent variables in the regression model. A good regression model should show no significant correlation among the independent variables. The results of the multicollinearity test for this research data are presented in Table 3. Based on the test results, the multicollinearity status of each independent variable in this study was evaluated. A regression model is considered good if there are no signs of multicollinearity, which can be observed from Tolerance values close to 1 and Variance Inflation Factor (VIF) values below 10. All VIF values in this study ranged from 1.2 to 1.9, indicating no serious multicollinearity.

The heteroscedasticity test is used to examine whether the data used to construct the regression model exhibits constant variance in its residuals. In this study, the test was conducted by analyzing the data distribution in a scatter plot. Fig. 2 presents the results of the heteroscedasticity test, using a scatter plot to display the spread of data points along the diagonal axis of the chart. A good regression model is indicated when there is no pattern or similarity in the variance of the residuals, known as homoscedasticity. As shown in Fig. 2, the scatter plot of residuals demonstrates a random distribution, suggesting the presence of homoscedasticity.

Table 4
Model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.406[a]	.165	.147	.461	1.188

a. Predictors: (Constant), Reliability (X6), E-Commerce (X5), Innovation (X2), Production (X1), Promotion (X3), Business Plan (X4)
b. Dependent Variable: Effectiveness (Y)

Table 5
Results of multiple regression.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.292	.412		10.416	.000
	Produksi (X1)	.004	.028	.009	.136	.892
	Inovasi (X2)	.094	.038	.163	2.449	.015
	Rabat (X3)	.023	.031	.055	.745	.457
	Bussiness Plan (X4)	-.055	.036	-.107	-1.518	.130
	E-Commerce (X5)	.143	.061	.141	2.343	.020
	Reliability (X6)	.165	.054	.219	3.064	.002

a. Dependent Variable: Effectiveness (Y)

An autocorrelation test was conducted to determine whether there is a correlation between time-ordered research data variables. The test was performed using the Durbin-Watson statistic. The results are presented in Table 4. The Durbin-Watson value for this test is 1.188, which falls within the indecisive range of 1.10–1.54. Consequently, it cannot be conclusively determined whether autocorrelation is present. However, since the Durbin-Watson value of 1.188 is relatively close to 2, it suggests that there is no significant autocorrelation issue [33].

3.3. Multiple regression analysis

The research data has been collected and meets the classical assumptions, allowing multiple regression analysis to be conducted. This analysis was performed to obtain a regression model from the research data and to determine the significant influence between the dependent and independent variables. The results of the multiple regression analysis in this study are shown in Table 5. Table 5 presents the results of the multiple regression analysis based on the study data, using unstandardized coefficients to formulate the regression model equation. Based on the table of regression results, the regression equation model is expressed in Eq. (2).

$$Y = 4.292 + 0.04\,X_1 + 0.94\,X_2 + 0.023\,X_3 - 0.55\,X_4 + 0.143\,X_5 + 0.165\,X_6 \quad (2)$$

The regression equation model above shows that the dependent variable (Y) is the effectiveness of MSMEs, and the independent variables (X) consist of production activities (X_1), mastery of innovation (X_2), rebates (X_3), business plan (X_4), e-commerce (X_5), and product reliability (X_6). The following is a description of the coefficient values for each variable:

(a) The constant value in the regression equation model is 4.292. This value is positive, indicating that the independent variables collectively have a positive effect on the effectiveness of MSMEs.
(b) The coefficient value of the production activity variable (X_1) is 0.94, indicating a positive relationship with the effectiveness of MSMEs (Y). This means that an increase in production activity is associated with an increase in the effectiveness of MSMEs.
(c) The coefficient value of the innovation mastery variable (X_2) is 0.04, indicating a positive relationship with the effectiveness of MSMEs (Y). This means that greater mastery of innovation leads to increased effectiveness of MSMEs.
(d) The coefficient value of the rebate variable (X_3) is 0.23, indicating a positive relationship with the effectiveness of MSMEs (Y). This suggests that higher rebate values contribute to increased MSME effectiveness.
(e) The coefficient value of the business plan variable (X_4) is -0.55, indicating a negative relationship with the effectiveness of MSMEs (Y). This means that an increase in the business plan variable is associated with a decrease in effectiveness, although the effect is relatively small.
(f) The coefficient value of the e-commerce variable (X_5) is 0.143, indicating a positive relationship with the effectiveness of MSMEs (Y). This suggests that greater engagement with e-commerce is associated with improved MSME effectiveness.
(g) The coefficient value of the product reliability variable (X_6) is 0.165, also indicating a positive relationship with the effectiveness of MSMEs (Y). This means that increased product reliability contributes to greater MSME effectiveness.

Table 6
The value of the multiple determination coefficient.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.406[a]	.147	.461	.165

a. Predictors: (Constant), Reliability (X6), E-Commerce (X5), Innovation (X2), Production (X1), Promotion (X3), Business Plan (X4)

Table 7
ANOVA.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12,277	6	2,046	9,622	.000[b]
	Residual	62,310	293	.213		
	Total	74,587	299			

a. Dependent Variable: Effectiveness (Y)
b. Predictors: (Constant), Reliability (X6), E-Commerce (X5), Innovation (X2), Production (X1), Promotion (X3), Business Plan (X4)

The multiple regression model showed that three variables significantly influenced MSME effectiveness, as shown in Eq. (3)

$$Y = 4.292 + 0.094X_2 + 0.143X_5 + 0.165X_6 \quad (3)$$

where X_2 denotes Innovation, X_5 denotes E-commerce, and X_6 denotes Product Reliability.

Variables such as Production Activities (X_1), Rebates (X_3), and Business Plan (X_4) did not show statistically significant contributions ($p > 0.05$). The model's adjusted R^2 was 0.147, indicating that 14.7% of the variance in MSME effectiveness was explained by the model. This moderate value aligns with behavioral research models, which often involve unmeasured environmental or structural variables [28].

3.4. Hypothesis testing

The coefficient of determination, commonly referred to as Adjusted R-Square (Adj. R^2), is a simple and frequently used measure to assess the quality of a regression line equation. This coefficient is used to determine the correlation and relationship between variables in the regression model, as well as to evaluate the accuracy of the regression predictions based on the sample data.

Table 6 are the results of the multiple determination coefficient calculation in this study. As shown in Table 6, the value of the multiple determination coefficient obtained is based on the adjusted R^2 value. The Adjusted R^2 in this study was 0.147, indicating that the independent variables (production, innovation, promotion, business plan, e-commerce, and product reliability) collectively explain 14.7% of the variance in the dependent variable (the effectiveness of MSMEs). The F-test in this study was conducted to determine whether the independent variables collectively have a significant effect on the dependent variable. The results of the F-test are shown in Table 7. Based on Table 7, the F-test revealed that the model is statistically significant ($F = 9.622$; $p < 0.001$), confirming that the independent variables jointly influence the effectiveness of MSMEs.

To determine the significance of the influence between variables, the calculated F value is compared with the F table value. The critical F value is obtained using a significance level (α) of 0.05, with degrees of freedom for regression (df_1) = 6 and degrees of freedom for residual (df_2) = 293, resulting in an critical F value of 2.128. Since the calculated F value (9.622) is greater than the critical F value (2.128), it can be concluded that the independent variables have a significant simultaneous effect on the dependent variable—the effectiveness of MSMEs.

This conclusion is in line with the criterion that a significant effect is indicated when the calculated F value exceeds the critical F value. Additionally, the obtained significance value ($p = 0.000$) is less than the significance threshold of 0.05, further confirming that the independent variables jointly have a significant influence on the dependent variable.

The t-test is conducted to determine whether the independent variable has a significant partial effect on the dependent variable in the regression equation model. The results of the t-test in this study are shown in Table 8. The t-test results are based on the calculated t-value and its significance value. The calculated t-value is compared with the critical t-value, and the significance value is compared with the standard significance level. If the calculated t-value is greater than the critical t-value and the significance value is less than 0.05, it indicates that the independent variable has a significant partial effect on the dependent variable.

The critical t-value is determined based on the number of variables ($n = 7$), the number of data points ($k = 300$), degrees of freedom ($n - k = 293$), and a confidence level of $\alpha = 0.05$, resulting in a critical t-value of 1.968. Based on the comparison between the calculated t-value and the critical t-value, the following results are obtained.

Table 8
Results of the *t*-test.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.292	.412		10.416	.000
	Production(X1)	.004	.028	.009	.136	.892
	Innovation (X2)	.094	.038	.163	2.449	.015
	Rebate (X3)	.023	.031	.055	.745	.457
	Business Plan (X4)	-.055	.036	-.107	-1.518	.130
	E-Commerce (X5)	.143	.061	.141	2.343	.020
	Reliability (X6)	.165	.054	.219	3.064	.002

a. Dependent Variable: Effectiveness (Y)

Table 9
Beta coefficient

Model	Standardized Coefficients Beta
(Constant)	
Production(X1)	.009
Innovation (X2)	.163
Rebate (X3)	.055
Business Plan (X4)	-.107
E-Commerce (X5)	.141
Reliability (X6)	.219

(a) The production variable (X1) has a t-value of 0.136, which is smaller than the t-table value of 1.968, and a significance value of 0.892, which is greater than the threshold of 0.05. This indicates that the production variable does not have a significant effect on the effectiveness of MSMEs.
(b) The innovation variable (X2) has a t-value of 2.449, which is greater than the t-table value of 1.968, and a significance value of 0.015, which is smaller than 0.05. This indicates that the innovation variable has a significant effect on the effectiveness of MSMEs.
(c) The rebate variable (X3) has a t-value of 0.745, which is smaller than the t-table value of 1.968, and a significance value of 0.457, which is greater than 0.05. This indicates that the rebate variable does not have a significant effect on the effectiveness of MSMEs.
(d) The business plan variable (X4) has a t-value of -1.518, which is smaller than the t-table value of 1.968, and a significance value of 0.130, which is greater than 0.05. This indicates that the business plan variable does not have a significant effect on the effectiveness of MSMEs.
(e) The e-commerce variable (X5) has a t-value of 2.343, which is greater than the t-table value of 1.968, and a significance value of 0.020, which is smaller than 0.05. This indicates that the e-commerce variable has a significant effect on the effectiveness of MSMEs.
(f) The product reliability variable (X6) has a t-value of 3.064, which is greater than the t-table value of 1.968, and a significance value of 0.002, which is smaller than 0.05. This indicates that the product reliability variable has a significant effect on the effectiveness of MSMEs.

Based on the *t*-test analysis above, three independent variables are found to significantly affect the effectiveness of MSMEs: innovation, e-commerce, and product reliability. These results reinforce the idea that MSMEs which pivoted toward innovation, expanded digital access, and enhanced product reliability experienced significantly higher survival effectiveness during the pandemic [1, 24].

In the *t*-test that was conducted, some independent variables were found to have a significant influence on the dependent variable. To determine which independent variable has the greatest influence, the standardized beta values were examined. The beta values for each variable in this study are presented in Table 9. Based on the table, the standardized beta coefficients indicate that Product Reliability (β = 0.219) is the most influential predictor of MSME effectiveness, followed by Innovation (β = 0.163) and E-Commerce (β = 0.141). These findings are consistent with previous research emphasizing the role of consumer confidence and digital enablement in business continuity [25, 38].

3.5. Comparison with other studies

Our findings support prior empirical studies [6, 26] that document how innovation and digital tools were crucial for MSMEs' survival during the COVID-19 pandemic. However, this study advances existing knowledge by providing a quantified regression model specific to the Indonesian MSME context, an empirical contribution not yet explored in prior qualitative research. Importantly, the model offers insights that extend beyond the immediate crisis. The identification of innovation, e-commerce, and product reliability as key determinants of MSME effectiveness can serve as a strategic foundation for resilience planning in future disruptions, whether they are health-related, economic, or environmental in nature. Thus, the model holds enduring relevance not only during the pandemic but also throughout the recovery period and in preparation for potential future outbreaks or systemic shocks.

3.6. Managerial implications

Although this study was conducted during the acute phase of the COVID-19 pandemic, its findings hold

lasting relevance beyond the crisis period. The significant roles of continuous innovation, digital commerce, and product reliability highlight strategic dimensions that are not only vital in times of disruption but also foundational for long-term competitiveness in increasingly uncertain markets.

As the global economy transitions into a recovery phase, MSMEs that have embedded innovation and digital infrastructure into their operations are more likely to adapt to post-pandemic shifts in consumer behavior, digital expectations, and global trade dynamics. Moreover, these insights can serve as a proactive guide for policymakers and MSME actors in developing crisis-resilient business models, ones that are prepared for future pandemics or external shocks that may emerge.

Hence, the regression model developed in this study is not merely a reactive tool, but a strategic framework that contributes to both immediate recovery and sustainable transformation in the MSME sector.

4. Conclusions

This study developed a multiple linear regression model to evaluate the effectiveness of MSMEs' strategic responses during and beyond the COVID-19 crisis. The model incorporated six independent variables—production activities, innovation, rebates, business planning, e-commerce, and product reliability—to explain MSME effectiveness as the dependent variable. Among the variables tested, three were found to significantly influence MSME effectiveness: (1) Product reliability ($\beta = 0.219$), (2)Innovation ($\beta = 0.163$), and (3) E-commerce ($\beta = 0.141$).

These findings suggest that MSMEs that prioritize product quality, innovate rapidly in response to market shifts, and adopt digital platforms are better positioned not only to withstand pandemic-related shocks but also to sustain growth in the post-pandemic economy. The model provides valuable empirical insights for MSME owners, policymakers, and support institutions aiming to build resilient, adaptive business ecosystems. It serves as a data-driven guide for designing strategic interventions that enhance MSME sustainability in volatile environments. Moreover, the model has broader relevance beyond the COVID-19 context, offering a framework for navigating future systemic disruptions and transforming crisis experiences into long-term competitive advantage.

Future research may refine this model by incorporating external variables (such as market structure or access to capital) and applying longitudinal data to assess strategic effectiveness over time.

Declaration statement

Dyah Lintang Trenggonowati: Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision. **Putiri Bhuana Katili**: Data Curation, Formal Analysis, Resources and Investigation. **Moses Laksono Singgih:** Questionnaire Design, Data Collection, Visualization, Validation and Software, Asep **Ridwan:** Writing – review and editing, Literature Review, Project administration, and Funding Acquisition

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Disclosure statement

The authors declare that this manuscript is free from any conflict of interest, including financial, personal, or institutional affiliations that could have influenced the conduct or outcomes of the research. This study complies fully with ethical standards and journal publication policies.

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Data availability statement

The data that support the findings of this study were collected from 300 Indonesian MSME respondents through structured questionnaires. All relevant data are included within this article. Additional data and materials (such as raw response sets or statistical outputs) are available from the corresponding author upon reasonable request. Data are not publicly archived to ensure respondent confidentiality.

AI Usage Statement

This manuscript utilizes generative AI and AI-assisted tools, specifically ChatGPT developed by OpenAI, to enhance the readability and academic expression during the manuscript revision process. All AI-generated content has been carefully reviewed and edited by the authors to ensure accuracy, consistency, and scientific integrity. The authors take full responsibility for the intellectual content, data interpretation, and conclusions of this work. The use of AI is disclosed in compliance with the transparency policy of the Journal of Industrial Services (JISS), and no AI tool was involved in drawing scientific conclusions, formulating hypotheses, or performing data analysis.

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Appendices

Tabel A1
Questionnaire results

Variable	Statement of	Level of Interest							Total
		1	2	3	4	5	6	7	
Effectiveness (Y)		0	0	0	0	11	46	243	300
Production activities (X1)	Products/services are prepared according to order / agreement (Make by Order)	0	6	2	20	49	48	175	300
	Products or services are always ready stock	5	10	11	16	57	85	116	300
	Products / Services are prepared using a mixed-method between Make by Order and Ready Stock	0	0	14	19	43	108	116	300
Innovation (X2)	Quick Response Replacing Products / Services (Products / Services that are more needed by the Community at a certain time)	0	1	9	21	35	65	169	300
	Quick Response Rebranding / Changing Current Logo and Product / Service Packaging	8	11	36	75	68	71	31	300
	Quick Response Changing Current Product / Service Label	10	25	50	48	66	73	28	300
Rebates (return of part of the payment) (X3)	Buying Products / Using Services by Giving Discounts (%)	4	1	9	11	45	119	111	300
	Buying Products / Using Services by Giving N Get N Free Bonuses	4	1	13	42	61	85	94	300
	Buying Products / Using Services by Giving Vouchers (Discount Voucher for next transaction)	11	8	7	36	48	96	94	300
	Buying Products / Using Services by Giving Away (Direct Gifts)	12	6	25	34	52	76	95	300
Business Plan (X4)	Creating Networking (reseller/distributor)	4	0	0	16	65	68	147	300
	Creating a Consumer Data Base (large category consumers and small category consumers/individuals)	10	1	5	29	37	100	118	300
	Collaborating with other MSMEs	2	0	7	25	51	95	120	300
	Creating a Business Community	6	0	4	28	44	87	131	300
E-Commerce (X5)	Ordering Products / Services Can Be Online (Shopping Website Application, WhatsApp, Call / SMS)	0	0	0	2	7	56	235	300
	Product / Service Delivery Can Be Online (Online Transportation / Delivered by Product Seller / Taken Service Provider)	0	0	2	8	18	74	198	300
	Bus Payment Online (Electronic Money, Transfer, Pay on the spot)	0	0	0	1	26	21	252	300
Product Reliability (X6)	Products / Services are Certified (Halal, SNI, ISO, etc.)	4	2	10	16	25	27	216	300
	Product Services / Services are carried out hygienistically / in accordance with Health Protocols	0	0	0	11	14	30	245	300
	Listed product expiration date/service period is listed	2	5	0	3	16	35	239	300
	Customer testimonials	0	0	3	7	37	96	157	300
	Providing guarantees purchased	4	0	4	16	27	72	177	300

Tabel A2
Validity Test Results

Variable	Statement	Calculated R	Critical R	Description
Production Activities (X1)	Products / Services are prepared according to order/agreement (Make by Order)	0.461	0.113	Valid
	Products or Services always ready stock	0.763	0.113	Valid
	Products/services prepared with a mixed-method between Make by Order and Ready Stock	0.722	0.113	Valid
Mastery of Innovation (X2)	Quick Response Changing Products / Services (Products / Services that are more needed by the Community at a certain time)	0.679	0.113	Valid
	Quick Response Rebranding / ChangingLogo and Product / Service Packaging	0.902	0.113	Valid
	Quick Response ChangingProduct / Service Label	0.902	0.113	Valid
Rebates (return of part of the payment) (X3)	Buying products / using services by giving a discount (%)	0.864	0.113	Valid
	Buying Products / Using Services by Giving N Get N Free Bonuses	0.868	0.113	Valid
	Buying Products / Using Services with Me Giving Vouchers (Discount Vouchers for the next transaction)	0.898	0.113	Valid
	Buying Products / Using Services by Giving Away (Direct Gifts)	0.901	0.113	Valid
Business Plan (X4)	Creating Networking (resellers/distributors))	0.746	0.113	Valid
	Creating Customer (ConsumerData Base Large category and Small category/individual)	0.846	0.113	Valid
	Collaborating with other MSMEs	0.816	0.113	Valid
	Creating Business Communities	0.823	0.113	Valid
E-Commerce (X5)	Ordering Products / Services Can Be Online (Website shopping applications, WhatsApp, Call / SMS)	0.867	0.113	Valid
	Product Delivery / Services Can Be Online (Online Transportation / Delivered by Product Seller / Service Provider Taken)	0.885	0.113	Valid
	Online Payment (Electronic Money, Transfer, Pay On)	0.830	0.113	Valid
Product Reliability (X6)	Products / Services are Certified (Halal, SNI, ISO, etc.)	0.827	0.113	Valid
	Product / Service services are carried out hygienistically / according to Health Protocols	0.731	0.113	Valid
	Listed Product Expiration Date / Service Period of Service	0.786	0.113	Valid
	Customer Testimonials	0.640	0.113	Valid
	Providing Guarantee for Products / Services purchased	0.761	0.113	Valid