



DIGITAL CAPACITY, TRAINING, EDUCATION, HALAL CERTIFICATION, AND REVENUE OF YOUNG INDONESIAN MSE ENTREPRENEURS

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ARTICLE INFO

Article history

Received : 3 August 2026
Revised : 4 October 2026
Accepted : 6 October 2026

Keywords

business revenue; digital
capacity; halal certification;
micro and small industries;
young entrepreneurs

JEL classification

L25, L26, O33

ABSTRACT

The increasing adoption of digital technology in Indonesia's food and beverage micro and small enterprises (MSEs) creates opportunities for business development. However, limited evidence jointly examines digital capacity, training, education, and halal certification in relation to revenue among young entrepreneurs in this sector. This study examines these associations using cross-sectional data from the 2022 Indonesian Micro and Small Industry (IMK) Survey conducted by Statistics Indonesia, covering 28,984 enterprises managed by entrepreneurs aged 15–40 years. Multiple linear regression is employed using the natural logarithm of annual nominal business revenue as the dependent variable and heteroskedasticity-robust standard errors. The results show positive and statistically significant associations for digital capacity, training, education, and halal certification, with coefficients of 0.1301, 0.1284, 0.0679, and 0.7097, respectively. The model reports an R^2 of 0.0422, indicating relatively limited explanatory power. Quantile regression shows that these positive associations persist across the 25th, 50th, and 75th conditional revenue quantiles, although their magnitudes vary. The findings suggest that policies supporting digital capacity, business training, and access to halal certification should consider differences across enterprises. However, the cross-sectional design limits causal interpretation, while incomplete survey-design variables prevent full adjustment for the complex sampling design.

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1. INTRODUCTION

Micro and Small Enterprises (MSEs) play an important role in Indonesia's economy by creating employment, generating household income, and supporting economic activity across regions. Their importance is particularly evident in food and beverage manufacturing. Based on Statistics Indonesia (BPS), the total number of MSEs declined from 4,500,584 businesses in 2023 to 4,413,443 in 2024, or 1.94%. In contrast, food and beverage MSEs increased from 1,916,094 to 2,062,163 businesses, representing 7.62% growth and increasing their share from 42.57% to 46.73% (BPS, 2024). Business revenue also increased from Rp274.52 trillion to Rp306.68 trillion,

while employment rose from 3,963,979 to 4,558,610 workers. These developments indicate continued expansion of the food and beverage sector despite the overall decline in MSE numbers. These 2023–2024 statistics provide recent contextual evidence on the development of food and beverage MSEs, while the empirical analysis in this study is based exclusively on the 2022 IMK Survey data.

The expansion of food and beverage MSEs has occurred alongside increasing digital technology adoption. BPS data show that food and beverage MSEs using the internet increased from 763,108 businesses in 2023 (39.82%) to 956,584 in 2024 (46.39%) (BPS, 2024). Digital technologies can support promotional activities, online sales, and the digital procurement of raw materials. Trinugroho et al. (2022) document increasing digital technology adoption among Indonesian micro and small businesses, while Prakasa & Juman (2024) find positive associations between digital capabilities and SME performance. Soman et al. (2024) similarly examine ICT uptake and MSE performance. Cirera et al. (2022) emphasize that technology access alone is insufficient and that productive adoption depends on firms' capabilities. Karadağ et al. (2024) further demonstrate relationships among digital capability, digital transformation, and organizational performance.

Digital resources may generate business outcomes partly through entrepreneurs' knowledge and skills. Human capital theory conceptualizes education and training as investments that enhance productivity and economic returns (Becker, 1964). In entrepreneurship, these capabilities may improve resource allocation, decision-making, opportunity recognition, and business management. Training represents an acquired dimension of human capital, particularly through business planning, marketing, financial management, and operational skills. Idris et al. (2023) find a positive relationship between training and SME performance, while Nor (2026) highlights entrepreneurship education and training alongside digital transformation. Sakib et al. (2022) similarly associate entrepreneurial competencies with SME performance. Formal education represents another dimension of human capital. Iqbal et al. (2023) report associations between human capital and SME performance.

Although training may strengthen entrepreneurial capabilities, participation is not randomly distributed across enterprises. Entrepreneurs who participate in training may differ from non-participants in managerial capabilities, resources, motivation, access to information, or growth orientation. McKenzie & Woodruff (2014) emphasize methodological challenges in evaluating business training in developing countries, particularly when differences in enterprise performance may reflect pre-existing differences between participants and non-participants. Therefore, a positive statistical association between training and business revenue should not automatically be interpreted as a causal effect of training. This consideration is particularly relevant to the present study because the objective is to examine conditional associations rather than treatment effects. The training variable is consequently interpreted as an observable characteristic associated with business revenue, while potential selection and omitted-variable bias remain important limitations of the empirical specification.

Halal certification can be understood through the signaling perspective. In markets characterized by information asymmetry, consumers may not directly observe product quality, production processes, or compliance characteristics. Akerlof (1970) demonstrates how such information asymmetry can generate uncertainty in market transactions, while certification can provide observable information about otherwise difficult-to-verify characteristics. In food and beverage businesses, halal certification may therefore function as a signal of product compliance and legitimacy. Amer (2024) finds a positive association between halal certification and SME financial and operational performance, while Azizah et al. (2025) report positive associations between halal certification and operational and financial performance among Indonesian MSMEs. However, certification may also be subject to selection because certified enterprises may differ systematically from non-certified firms. Akbar & Rohman (2023) address observable differences between certified and non-certified SMEs using propensity score matching, highlighting the importance of selection when interpreting certification-performance relationships.

Taken together, digital capacity, training, education, and halal certification represent complementary but theoretically distinct resources associated with business revenue. Digital capacity reflects productive technology use, training and education represent acquired and formal human capital, while halal certification represents product legitimacy and market signaling. Existing studies have generally examined these dimensions separately or across different sectors and populations. Indonesian research has examined digital technology adoption (Trinugroho et al., 2022), human capital and SME performance (Iqbal et al., 2023), and halal certification and MSME performance (Azizah et al., 2025). International studies similarly examine digital capability, training, human capital, and halal certification (Kim & Jin, 2024). Limited evidence jointly examines these four dimensions in relation to annual business revenue among young food and beverage MSE entrepreneurs in Indonesia.

This study contributes descriptive and associational evidence on the relationship between digital capacity, business training, educational attainment, halal certification, and annual business revenue among young food and beverage MSE entrepreneurs. Using 28,984 observations from the 2022 Indonesian Micro and Small Industry (IMK) Survey, it jointly considers technological capability, human capital, and product certification within a national empirical framework. The study does not seek to identify causal effects. Accordingly, ordinary least squares (OLS) is employed as a parsimonious multivariate framework for estimating conditional associations among the variables. This approach does not eliminate potential selection or omitted-variable bias, particularly for training and halal certification. The empirical strategy therefore differs from propensity score matching, as applied by Akbar & Rohman (2023), which is designed to address observable differences between treatment and comparison groups when estimating treatment effects.

Accordingly, this study examines the relationship between digital capacity, business training, educational attainment, halal certification, and annual business revenue among young entrepreneurs operating food and beverage MSEs in Indonesia. The empirical analysis uses cross-sectional microdata from the 2022 Indonesian Micro and Small Industry (IMK) Survey and focuses on entrepreneurs aged 15–40 years. The inclusion of entrepreneurs aged 15 years reflects the age range recorded in the IMK dataset and the study's operational definition of young entrepreneurs as individuals aged 15–40 years. This inclusion does not imply that younger entrepreneurs are expected to have different or stronger relationships between the explanatory variables and business revenue, as the study does not include an older-entrepreneur comparison group. Based on the conceptual framework and previous evidence, the study proposes four hypotheses. H1: Digital capacity is positively associated with business revenue. H2: Business training is positively associated with business revenue. H3: Educational attainment is positively associated with business revenue. H4: Halal certification is positively associated with business revenue. All hypotheses are formulated as associational expectations rather than causal claims, consistent with the cross-sectional observational design and the empirical objective of estimating conditional relationships between the explanatory variables and annual business revenue.

2. RESEARCH METHODS

This study uses secondary cross-sectional data from the 2022 Micro and Small Industry Survey (Survei Industri Mikro dan Kecil/IMK) conducted by Statistics Indonesia (BPS, 2022). The analysis focuses on micro and small manufacturing enterprises operating in the food sector (KBLI 10) and beverage sector (KBLI 11) in Indonesia. The analytical sample is restricted to business units managed by entrepreneurs aged 15–40 years who were recorded as actively operating during the survey period. After applying the sample selection criteria and excluding observations with missing values in the variables used in the regression analysis, the final analytical sample consists of 28,984 business units.

The restriction to entrepreneurs aged 15–40 years is based on the substantive focus of the study on young entrepreneurs, rather than on an assumption that young entrepreneurs necessarily benefit more from digital capacity, training, education, or halal certification than older entrepreneurs. The inclusion of entrepreneurs aged 15 years reflects the age range recorded in the IMK dataset and

the study's operational definition of young entrepreneurs as individuals aged 15–40 years. Because the empirical analysis does not include an older-entrepreneur comparison group, the study does not estimate whether the relationships observed among young entrepreneurs are stronger or weaker than those among older entrepreneurs. The findings should therefore be interpreted as evidence concerning the correlates of business revenue within the young-entrepreneur group.

The variables extracted from the IMK Survey include annual business revenue, digital technology use, participation in business training, educational attainment of the business owner, and halal certification status. The operational definitions of the variables are presented in Table 1.

Table 1. Operational Definition of Variables

Variable	Operational Variable	Scale
lnREV	Natural logarithm of the total annual business revenue of micro and small industrial enterprises (Rp).	Natural Logarithm (Rp)
Digital Capacity	Use of information technology, encompassing promotional activities, online sales, and digital procurement of raw materials.	Index Score (0-3)
Training	Number of training sessions attended regarding management, skills, marketing, and environmental impact assessment (AMDAL).	Index Score (0-4)
Educ	Level of the manager's intellectual capacity, measured by the highest level of formal education completed by the business owner.	Ordinal Score (1-8)
Certif Halal	Dummy variable indicating whether the enterprise possesses halal certification: 1 = certified, 0 = not certified.	Dummy (0/1)

Source: Processed BPS data (2026)

The study employs a multiple linear regression model to estimate the conditional association between the explanatory variables and annual business revenue. Because the dependent variable is expressed in natural logarithmic form, the specification allows the analysis to examine differences in annual revenue in proportional rather than absolute terms.

The empirical model is specified as follows:

$$\ln REV_i = \beta_0 + \beta_1 DC_i + \beta_2 TR_i + \beta_3 ED_i + \beta_4 CH_i + e_i \dots \dots \dots (1)$$

The variables in the regression model are defined as follows. $\ln REV_i$ represents the natural logarithm of the annual business revenue of enterprise i . β_0 denotes the constant term, while β_1 , β_2 , β_3 , and β_4 represent the regression coefficients of the independent variables. DC_i refers to the digital capacity score of enterprise i , TR_i represents the number of business training sessions attended by enterprise i , and ED_i denotes the highest formal education level completed by the owner of enterprise i . CH_i is a halal certification dummy variable, taking a value of 1 if the enterprise is halal-certified and 0 otherwise. Finally, e_i represents the error term of the model.

The IMK Survey employs a complex sampling design involving sampling weights, strata, and clustering. However, the analytical dataset used in this study does not provide the corresponding survey-design variables required to explicitly incorporate these features into the regression estimation. Therefore, the complex survey design could not be fully implemented in the empirical analysis. To account for potential heteroskedasticity in business revenue, the regression estimates are obtained using heteroskedasticity-robust standard errors.

In addition to the ordinary least squares model, quantile regression is employed to examine whether the conditional associations between the explanatory variables and annual business revenue vary across the revenue distribution. The quantile regression model is specified as follows:

$$Q_\tau(\ln REV_i | X_i) = \beta_{0,\tau} + \beta_{1,\tau} DC_i + \beta_{2,\tau} TR_i + \beta_{3,\tau} ED_i + \beta_{4,\tau} CH_i \dots \dots \dots (2)$$

Where τ denotes the conditional quantile, with $\tau = 0.25, 0.50$, and 0.75 , representing the 25th, 50th, and 75th conditional revenue quantiles, respectively. $\ln REV_i$ represents the natural logarithm of annual nominal business revenue of enterprise i . DC_i , TR_i , ED_i , and CH_i represent digital capacity, training, educational attainment, and halal certification of enterprise i , respectively. The coefficients $\beta_{0,\tau}$ to $\beta_{4,\tau}$ represent the conditional associations between the explanatory variables and business revenue at quantile τ .

The coefficients are interpreted as conditional associations rather than causal effects because the cross-sectional observational design does not establish temporal ordering or eliminate selection and omitted-variable bias. The statistical significance of individual regression coefficients is assessed using the t-test, while the joint significance of the explanatory variables is evaluated using the F-test. The coefficient of determination (R^2) describes the variation in logged annual revenue explained by the explanatory variables included in the model (Wooldridge et al., 2016). Statistical significance is assessed at the 5% level, with a probability value below 0.05 indicating statistical evidence of an association conditional on the other variables (Gujarati & Porter, 2009).

Because the dependent variable is expressed in logarithmic form, coefficients of continuous explanatory variables are interpreted as proportional changes in annual revenue associated with a one-unit difference in the corresponding variable. For the halal certification dummy, the coefficient represents the proportional difference in predicted revenue between certified and non-certified enterprises. Multicollinearity is assessed using the variance inflation factor (VIF) as a diagnostic check. The logarithmic transformation of annual revenue is used to reduce the influence of substantial differences in enterprise revenue levels and improve the suitability of the regression specification (Wooldridge et al., 2016).

In addition to ordinary least squares regression, quantile regression is employed to examine whether the associations between the explanatory variables and business revenue vary across the conditional revenue distribution. The analysis considers the 25th, 50th, and 75th conditional quantiles, providing complementary evidence on whether the estimated associations differ across enterprises located at different points of the revenue distribution.

3. RESULTS AND DISCUSSION

3.1. RESULTS

The descriptive statistics indicate substantial variation in annual business revenue across the sampled food and beverage MSEs, as reflected in the standard deviation of logged revenue (1.305). Digital capacity has a relatively low mean of 0.213 on a 0–3 scale, indicating that the use of the three measured digital business activities remains limited. Training also has a low mean of 0.081 on a 0–4 scale, suggesting limited participation across the sample. Halal certification is similarly uncommon, with a mean of 0.055, indicating that approximately 5.5% of enterprises in the sample possess halal certification. Educational attainment has a mean score of 3.271, with observed values ranging from 1 to 8. These descriptive patterns indicate substantial heterogeneity in the resources and capabilities represented by the explanatory variables.

Table 2. Summary of Descriptive Statistics for Research Variables

Variable	Mean	Std. Dev.	Min
lnREV	15.3793	1.3051	8.7144
DigitalCapacity	0.2127	0.5669	0
Training	0.0807	0.3886	0
Educ	3.2709	1.5340	1
Certifhalal	0.0552	0.2284	0

Source: Processed data (2026)

Outlier diagnostics identified 218 observations (0.75% of the sample) with studentized residuals exceeding ± 3 . However, the maximum Cook's distance was 0.0072, suggesting that no single observation exhibited substantial influence on the regression estimates. Therefore, no observations were excluded solely on the basis of the outlier diagnostics. The minimum value of

lnREV is 8.714, corresponding to approximately Rp6,000 in annual nominal business revenue after back-transformation. This relatively low minimum value indicates substantial heterogeneity in annual revenue across the sampled enterprises.

Table 3. VIF Estimation

Variable	VIF	Conclusion
DigitalCapacity	1.10	No Multicollinearity Detected
Training	1.08	No Multicollinearity Detected
Educ	1.06	No Multicollinearity Detected
Certifhalal	1.06	No Multicollinearity Detected

Source: Processed data (2026)

The multicollinearity diagnostic results indicate no evidence of problematic multicollinearity among the explanatory variables. The VIF values range from 1.06 to 1.10, with Digital Capacity showing the highest VIF (1.10), followed by Training (1.08), Education (1.06), and Halal Certification (1.06). These values indicate that the explanatory variables are not strongly correlated with one another and that multicollinearity is unlikely to materially affect the estimated regression coefficients.

Table 4. Linear Regression Estimation Results (Robust)

Variable	Coefficient	Std. Err.	t-stat	p-value
DigitalCapacity	0.1301	0.0101	12.76	0.000
Training	0.1284	0.0209	6.13	0.000
Educ	0.0679	0.0052	12.87	0.000
Certifhalal	0.7097	0.0374	18.95	0.000
Constant	15.0410	0.0178	844.74	0.000
F-statistic				288.78
Prob > F				0.0000
R-squared				0.0422

Source: Processed data (2026)

The regression results, estimated using heteroskedasticity-robust standard errors, show that all four explanatory variables are individually statistically significant at the 5% level. The model reports an F-statistic of 288.78 with a probability value below 0.001. The R^2 is 0.0422, indicating that approximately 4.22% of the variation in logged annual business revenue is explained by the explanatory variables included in the model. This relatively low explanatory power suggests that substantial variation in business revenue is associated with other characteristics not included in the specification. Given the cross-sectional observational design, the estimated coefficients are interpreted as conditional associations rather than causal effects.

In the log-linear specification, Digital Capacity has a coefficient of 0.1301, Training has a coefficient of 0.1284, Education has a coefficient of 0.0679, and Halal Certification has a coefficient of 0.7097. All four coefficients are positive and statistically significant at the 5% level, indicating positive conditional associations with annual business revenue. Because the explanatory variables are measured on different scales, including index scores, an education score, and a binary certification measure, their coefficient magnitudes are not directly comparable. Therefore, the explanatory variables are not ranked based on coefficient magnitude.

Table 5. Quantile Regression Estimation Results

Variable	Q25	Q50	Q75
Digital Capacity	0.1388*	0.1310*	0.1225*
Training	0.1127*	0.1366*	0.1399*
Educ	0.0698*	0.0591*	0.0607*
CertifHalal	0.5280*	0.6267*	0.8788*
Constant	14.2317*	15.0109*	15.7696*
Pseudo R2	0.0195	0.0204	0.0231

Note: The * symbol indicates significance at alpha 0.05.

Source: Processed data (2026)

The quantile regression results indicate that all four explanatory variables have positive and statistically significant associations with business revenue across the 25th, 50th, and 75th conditional quantiles. Digital Capacity shows a slightly stronger association at Q25 (0.139) than at Q50 (0.131) and Q75 (0.123), while Education remains relatively stable across the three quantiles, with coefficients ranging from 0.059 to 0.070. These results suggest that digital capacity and education are consistently associated with business revenue across different points of the conditional revenue distribution.

Training and halal certification display larger coefficient magnitudes toward the upper revenue quantiles. The coefficient for Training increases from 0.113 at Q25 to 0.140 at Q75, while the coefficient for halal certification increases from 0.528 to 0.879. This pattern suggests that the conditional associations of training and halal certification with business revenue may be stronger among enterprises located at higher points of the revenue distribution. However, differences in coefficient magnitudes across quantiles should be interpreted descriptively, as formal cross-quantile equality tests would be required to establish whether these differences are statistically significant.

3.2. DISCUSSION

The positive and statistically significant association between digital capacity and annual business revenue is consistent with previous evidence on digital capabilities and SME performance. The coefficient of 0.1301 indicates that a one-unit increase in the 0–3 digital capacity index is positively associated with annual business revenue, conditional on the other variables. This finding is consistent with Kim & Jin (2024), who identify a positive relationship between digital capabilities and entrepreneurial performance, and Prakasa & Jumaní (2024), who show that digital capability is associated with small business performance through digital business transformation. Elkhoudary et al. (2026) likewise identify digital marketing capabilities as an important dimension associated with SME innovation and performance. However, the present study does not directly test whether digital capacity increases market reach, customer interaction, or operational efficiency. These mechanisms should therefore be regarded as plausible explanations rather than empirically demonstrated channels. The relatively low mean digital capacity (0.213) also indicates that digital adoption remains limited among the observed enterprises.

Training is positively associated with annual business revenue, with a coefficient of 0.1284, indicating a positive conditional association between the training score and annual business revenue, holding the other variables constant. This result is consistent with Idris et al. (2023), who find a positive relationship between training and SME performance. Sakib et al. (2022) similarly associate entrepreneurial competencies with SME performance. However, the mean training score is only 0.081 on a 0–4 scale, indicating that participation in the measured training activities is relatively limited. Therefore, the estimated association should not be interpreted as evidence that training participation necessarily causes higher revenue. Entrepreneurs who participate in training may differ systematically from those who do not in managerial capability, resources, motivation, or business orientation. This selection concern is particularly relevant when interpreting the estimated association and is consistent with the methodological concerns regarding business training evaluations discussed by (McKenzie & Woodruff, 2014).

Educational attainment is positively associated with annual business revenue. The coefficient of 0.0679 indicates a positive conditional association between the education score and annual business revenue, holding the other variables constant. This finding is consistent with the human capital perspective of (Becker, 1964; Mincer, 1974), under which education represents an investment in productive knowledge and skills. It is also broadly consistent with (Dinku et al., 2024; Iqbal et al., 2023), who report associations between human capital and SME performance. Nevertheless, the education variable is ordinal, meaning that the estimated coefficient reflects differences in the coded education level rather than a precisely equal economic return for each additional educational qualification. The result should therefore be interpreted as an association with educational attainment as measured in the survey, rather than as evidence that each additional educational qualification generates an identical increase in revenue.

Halal certification is positively associated with annual business revenue. The coefficient of 0.7097 indicates a positive conditional association between halal certification and annual business revenue, holding the other variables constant. This finding is consistent with Azizah et al. (2025), who report positive associations between halal certification and SME/MSME performance. However, only 5.5% of enterprises in the present sample are certified. The relatively large conditional difference may therefore reflect systematic differences between certified and non-certified enterprises, such as firm size, capital, formalization, market orientation, or managerial capability, rather than certification itself. Akbar & Rohman (2023) address observable differences between certified and non-certified SMEs using propensity score matching, illustrating the importance of selection when interpreting certification-performance relationships. The present OLS estimates should therefore be understood as associational evidence rather than a causal estimate of the return to halal certification. Because the explanatory variables are measured on different scales, the coefficient magnitudes are not directly comparable and are not used to rank the relative importance of the explanatory variables.

Taken together, the results indicate statistically significant conditional associations between digital capacity, training, education, halal certification, and annual business revenue among young food and beverage MSE entrepreneurs. The R^2 of 0.0422 indicates relatively limited explanatory power for the number of predictors, suggesting that substantial variation in business revenue is associated with factors not included in the specification, such as firm size, capital, firm age, location, subsector, labor, and other owner characteristics. The findings should therefore not be interpreted as identifying which entrepreneurs “benefit most” from digitalization, training, education, or certification.

The quantile regression results provide complementary evidence across the conditional revenue distribution. The positive associations persist at the 25th, 50th, and 75th conditional quantiles, although their magnitudes vary. Digital capacity shows a slightly larger coefficient at Q25 (0.1388) than at Q50 (0.1310) and Q75 (0.1225), while the coefficients for training increase from 0.1127 at Q25 to 0.1366 at Q75. Halal certification also shows a larger coefficient toward the upper end of the conditional revenue distribution, increasing from 0.5280 at Q25 to 0.8788 at Q75. These patterns suggest that the associations of training and halal certification may be more pronounced among enterprises with higher conditional revenue. However, differences in coefficients across quantiles should be interpreted descriptively unless formal cross-quantile equality tests are conducted. Overall, the findings provide evidence of conditional associations within the observed group rather than causal effects or definitive evidence of heterogeneous treatment effects.

4. CONCLUSION

This study finds statistically significant positive conditional associations between digital capacity, business training, educational attainment, halal certification, and annual business revenue among young entrepreneurs operating food and beverage MSEs in Indonesia. The regression estimates use heteroskedasticity-robust standard errors. The R^2 of 0.0422 indicates relatively limited explanatory power, suggesting that substantial variation in business revenue is associated with factors outside the model. Quantile regression shows that these positive associations remain statistically significant across the 25th, 50th, and 75th conditional revenue quantiles, although their magnitudes vary. Because the explanatory variables use different measurement scales, their coefficients are not directly comparable or ranked. Given the cross-sectional design, the findings represent conditional associations rather than causal effects. Policy implications should therefore consider enterprise differences, targeting, and implementation costs.

This study has several limitations. First, the cross-sectional 2022 IMK Survey limits the ability to establish temporal ordering and causal relationships. Second, selection and endogeneity concerns may arise because training participation and halal certification may be systematically related to unobserved enterprise characteristics. Third, survey measures and constructed indices may contain measurement error. Fourth, the relatively low R^2 indicates that important determinants of business revenue are not captured by the model. Fifth, survey-design variables for sampling weights,

strata, and clustering were unavailable, preventing full incorporation of the complex survey design; heteroskedasticity-robust standard errors were therefore used. Finally, the sample covers entrepreneurs aged 15–40 years and food and beverage MSEs, limiting generalization. Future research should employ panel or quasi-experimental designs and examine heterogeneity across enterprise characteristics.

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