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Internet Use and Turnover among Indonesian Micro and Small Manufacturing Industries during the COVID-19 Pandemic

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Abstract

Micro and Small Manufacturing Industries (MSMIs) play an important role in Indonesia's economy but faced operational and market disruptions during the COVID-19 pandemic. Internet adoption offered opportunities to maintain business activities, although its relationship with turnover may differ across digital functions. This study examines the association between internet use and MSMI turnover, distinguishing advertising, product sales, raw-material purchasing, business-development information seeking, and fintech lending. Using data from the 2020 Annual Survey of Micro and Small Manufacturing Industries conducted by Statistics Indonesia, this quantitative study analyzes 88,888 MSMIs through Propensity Score Matching (PSM). The results indicate a positive and statistically significant association between overall internet use and turnover across all matching specifications. Activity-specific estimates are also positive, with raw-material purchasing and fintech lending showing relatively large estimated effects, followed by information seeking and product sales. Advertising produces the smallest estimate and is not statistically significant under one alternative specification. These findings suggest that the relationship between digital adoption and turnover varies according to business activity. Internet use may support MSMI performance, particularly when digital tools facilitate procurement, financing, and market access. However, the results represent conditional associations rather than definitive causal effects.

Keywords

Digital Adoption, Internet Use, MSMIs, Propensity Score Matching, Turnover.

1. Introduction

Micro and Small Manufacturing Industries (MSMIs) play an important role in Indonesia's manufacturing sector by supporting local production, employment, and regional economic activity. However, the COVID-19 pandemic disrupted production, distribution, customer interactions, and sales, creating substantial challenges for small businesses with limited financial and technological resources. These disruptions highlighted the need for alternative business practices that could maintain market access and operational continuity under restricted physical interactions (Heckman et al., 1997; Wahidah, 2024). Digital technologies provided potential solutions by enabling businesses to communicate with customers, promote products, conduct transactions, procure raw materials, obtain business information, and access financial services. BPS (2022) reported that product sales accounted for 42.2% of reported internet-based business activities among MSMIs in 2020, followed by advertising (25.9%), raw-material purchasing (17.1%), business-development information seeking (14.5%), and fintech lending (0.3%). These figures show that internet use spans several business functions, each with different implications for firm performance. Nevertheless, the prevalence of digital activities does not necessarily indicate that all forms of internet use generate equivalent economic benefits.

The relationship between internet use and turnover can be explained through several business mechanisms. Online advertising may increase product visibility and attract potential customers, while online sales can expand market reach and facilitate transactions beyond conventional sales channels. These mechanisms may generate additional revenue opportunities, as digital marketing and e-commerce have been associated with MSME performance during the COVID-19 pandemic (Gao et al., 2023). Similarly, Noviaristanti et al. (2023) linked social media adoption to SME performance in West Java, while Yacob et al. (2023) in Indonesia found that social media and e-commerce adoption are associated with MSME business performance. Digital transformation may also improve operational efficiency and competitive advantage when firms develop appropriate technological and adaptive capabilities (Wang et al., 2024; Kahveci et al., 2026).

Other internet-based activities may influence turnover through different pathways (Dwiputri et al., 2022; Trinugroho et al., 2022). Online raw-material purchasing can help manufacturers identify suppliers, compare input prices, and maintain production continuity. Searching for business-development information may improve knowledge of markets, technologies, and business opportunities, potentially supporting better operational decisions. Fintech lending may ease financial constraints by providing access to external funding, although additional financing does not automatically translate into higher sales. Evidence concerning technology adoption and SME performance during the pandemic further emphasizes the importance of organizational conditions and how digital tools are implemented (Mishrif & Khan, 2023; Hussain et al., 2026). Moreover, research on ICT adoption and productivity suggests that performance outcomes may vary by the specific technology adopted (Amador & Silva, 2025). Thus, the relationship between internet use and turnover should be examined separately for each business activity rather than assumed to be uniform.

Despite growing evidence linking digital adoption to business performance, an important research gap remains. Previous studies have examined social media, e-commerce, digital marketing, industrial internet, and broader digital transformation, often using general performance indicators or survey-based assessments (Bertschek et al., 2013; World Bank, 2016). Other studies by Lechner (2002) and Gao et al. (2023) have explored technology-mediated performance during COVID-19. However, evidence remains limited on how distinct internet-based activities relate

specifically to turnover among Indonesian micro and small manufacturing industries using nationally representative survey data. Differences in research contexts, technology measures, and performance outcomes also limit direct comparisons across existing findings.

This study addresses these gaps by examining the association between internet use and MSMI turnover during the COVID-19 pandemic, distinguishing five activities: advertising, product sales, raw-material purchasing, business-development information seeking, and fintech lending. Using data from the 2020 Annual Survey of Micro and Small Manufacturing Industries, it applies Propensity Score Matching (PSM) to construct comparison groups with similar observed characteristics. Accordingly, the study asks: (1) Is internet use associated with higher turnover among MSMIs? (2) Does this association differ across the five internet-based business activities? By providing activity-specific evidence at the national level, this study contributes to understanding digital adoption in small manufacturing firms. It offers insights for designing digitalization policies that better address their operational and market needs.

2. Literature Review and Hypothesis Development

2.1. The Effect of Internet Use on MSMI Turnover

The internet supports economic development through inclusion, efficiency, and innovation by expanding market access, reducing information and transaction costs, and enabling new business processes (World Bank, 2016). For MSMIs, these mechanisms may improve customer reach, supplier discovery, access to business information, and financing opportunities. Previous studies by Bertschek et al. (2013) and Tarutė and Gatautis (2014) have linked digital technologies and information and communication technology adoption to firm performance. However, the magnitude of these relationships varies across business contexts. During the COVID-19 pandemic, internet use may have helped firms maintain customer interactions and access markets despite mobility restrictions. Digital adoption has also been examined as a strategy for sustaining MSME performance during the pandemic (Utomo et al., 2021).

Turnover represents business activity through the gross sales generated during a specified period. Internet use may be associated with higher turnover by enabling firms to reach customers beyond their immediate locations, obtain market information, and identify business opportunities. However, research by Dwiputri et al. (2022) shows that internet adoption is not randomly distributed: firms may differ in owner education, business age, capital structure, pandemic exposure, and industry. These differences may influence both adoption decisions and business performance. Therefore, examining the relationship between internet use and turnover requires consideration of observable differences between users and non-users. Based on the proposed mechanisms and previous empirical findings, this study hypothesizes a positive relationship between internet use and MSMI turnover.

H1: Internet use has a positive relationship with MSMI turnover.

2.2. The Effect of Internet-Based Business Activities on MSMI Turnover

Internet-based business activities may relate differently to turnover because each serves a distinct business function. Digital advertising can increase product visibility, whereas online product sales provide a direct channel for customer transactions and revenue generation (Dwiputri et al., 2022; Utomo et al., 2021). Internet-based raw-material purchasing can expand supplier searches, facilitate price comparisons, and reduce information costs. Meanwhile, research by Rahayu and Day (2015) and Trinugroho et al. (2022) suggests that business-development information

seeking may improve managerial decisions by providing access to market information, training, and operational knowledge. These activities may be particularly relevant to manufacturing firms because their performance depends on market access and production continuity.

Fintech lending provides another potential channel by facilitating access to working capital, which may support input purchases and business operations. However, borrowing also creates repayment obligations and financial risks, making financial literacy and productive fund allocation important considerations. Rahayu and Day (2015) and Trinugroho et al. (2022) suggest that the relationship between each activity and turnover may therefore depend on its practical use and complementary business capabilities, including logistics, product availability, customer service, and payment systems. Because advertising, product sales, procurement, information seeking, and fintech lending perform different functions, their estimated relationships with turnover may vary in magnitude.

H2: Internet use for advertising has a positive relationship with MSMI turnover.
H3: Internet use for product sales has a positive relationship with MSMI turnover.
H4: Internet use for raw-material purchasing has a positive relationship with MSMI turnover.
H5: Internet use for business-development information seeking has a positive relationship with MSMI turnover.
H6: Internet use for fintech lending has a positive relationship with MSMI turnover.

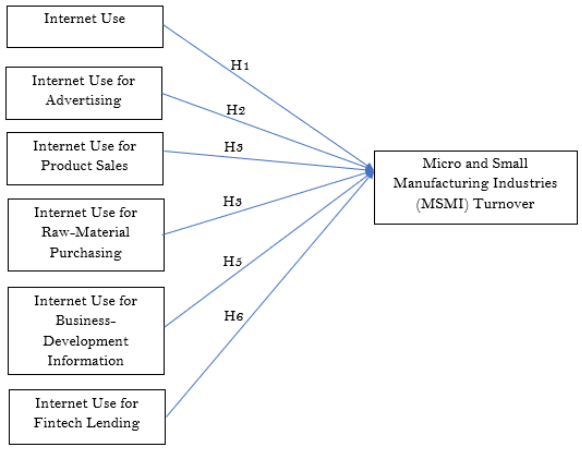


Figure 1. Research Framework

Figure 1 presents the conceptual framework examining the association between internet use and MSMIs turnover. The framework identifies six dimensions of internet use, including general internet use and five internet-based business activities: advertising, product sales, raw-material purchasing, business-development information, and fintech lending. The six hypotheses (H1–H6) examine whether internet use is associated with higher MSMI turnover and whether this association differs across the five business activities.

3. Methods

This study employs a quantitative cross-sectional design using data from the 2020 Annual Survey of Micro and Small Manufacturing Industries conducted by Statistics Indonesia (*Badan Pusat Statistik*/BPS). From 88,891 initial observations, 88,888 MSMIs remained after data cleaning, comprising 18,105 internet users and 70,783 non-users. Micro firms employ 1–4 workers, while small firms employ 5–19 workers. The unit of analysis is the individual MSMI, and business performance is

measured by gross monthly turnover in October 2020. Internet use is examined overall and across five activities: advertising, product sales, raw-material purchasing, business-development information seeking, and fintech lending. Table 1 presents the outcome, treatment variables, and covariates used to estimate the propensity scores. Turnover represents the business-performance outcome, while internet-use indicators define treatment status. Owner age and education, business age, industry classification, the proportion of own capital in 2019, and COVID-19 exposure are included as covariates to account for observed differences that may influence internet adoption and turnover.

Table 1. Variable and Operational Definitions

Variable	Operational Definition	Role
MSMI turnover	Monthly gross business turnover in October 2020	Outcome
Overall internet use	1 if the MSMI used the internet for business activities; 0 otherwise	Treatment
Internet use for advertising	1 if the MSMI used the internet for advertising; 0 otherwise	Treatment
Internet use for product sales	1 if the MSMI used the internet for product sales; 0 otherwise	Treatment
Internet use for raw-material purchasing	1 if the MSMI used the internet to purchase raw materials; 0 otherwise	Treatment
Internet use for information seeking	1 if the MSMI used the internet to seek business-development information; 0 otherwise	Treatment
Internet use for fintech lending	1 if the MSMI used the internet for fintech lending; 0 otherwise	Treatment
Owner characteristics	Owner age and education	Covariates
Business characteristics	Business age and industry classification	Covariates
Financial characteristic	Proportion of own capital in 2019	Covariate
COVID-19 exposure	Indicator capturing whether the business was affected by the pandemic	Covariate

Because internet adoption is not random, comparisons risk selection bias. PSM reduces observed imbalances by matching treated MSMIs with non-users having similar treatment probabilities (Rosenbaum & Rubin, 1983; Caliendo & Kopeinig, 2008; Austin, 2011). A logit model estimates scores using owner age and education, business age, 2019 own-capital share, COVID-19 exposure, and industry. Common support and balance are assessed through standardized bias, post-matching t-tests, and Pseudo-R^2 changes, following thesis procedures. For overall internet use, five-nearest-neighbor matching with replacement and a 0.03 radius caliper is used; robustness checks apply Epanechnikov kernel matching (bandwidth 0.06), radius-caliper matching (0.02), and three-nearest-neighbor matching. For activity-specific treatments, nearest-neighbor matching with a 0.03 caliper is used; robustness checks apply kernel bandwidth 0.01, caliper 0.02, and NN(3). The Average Treatment Effect on the Treated (ATT) estimates the turnover difference between treated MSMIs and matched controls. Since PSM adjusts only for observed covariates, unobserved confounding may remain; findings are interpreted within the observational design's limitations.

4. Results

Of the 88,888 MSMIs included in the final sample, 18,105 reported using the internet for business activities, whereas 70,783 did not, indicating that non-users constituted the larger share of the sample. Among internet-using firms, 9,979 used the internet for advertising, 14,919 for product sales, 6,454 for raw-material

purchasing, 5,586 for seeking business-development information, and 144 for fintech lending. Product sales therefore represented the most frequently reported internet-based activity, while fintech lending was rarely used. The activity counts describe the reported purposes of internet use and are not mutually exclusive categories. Descriptive statistics also reveal differences in average turnover across firms reporting different internet-based activities. Firms using the internet for product sales recorded average turnover of approximately IDR 27.5 million. The corresponding averages were IDR 39.7 million for firms using the internet to purchase raw materials, IDR 29.6 million for those seeking business-development information, and IDR 63.6 million for firms using fintech lending. Although these figures indicate variation in turnover across activity groups, they are descriptive comparisons only. They should not be interpreted as treatment effects, since firms may have substantially different characteristics before matching.

The common-support diagnostics indicate substantial overlap between treated and untreated firms, suggesting that comparable observations were available for matching. For overall internet use, 18,105 treated observations and 70,779 untreated observations fell within the common-support region, while only four untreated observations were excluded. Activity-specific analyses also demonstrated overlap, although the number of retained observations varied across treatments and matching specifications. The reported matching diagnostics further show that the preferred overall specification reduced standardized bias to below 5% across all covariates. Post-matching t-tests became statistically insignificant, indicating no significant differences in observed covariates between matched groups, while Pseudo-R^2 declined following matching. Comparable improvements in covariate balance were also observed across the activity-specific treatments. These diagnostic results suggest that matching improved the comparability of treated and comparison firms regarding their observed characteristics, thereby strengthening the basis for estimating treatment effects. Nevertheless, PSM cannot fully eliminate potential bias arising from unobserved factors that may influence both internet adoption and firm turnover. Table 2 presents the estimated Average Treatment Effects on the Treated (ATT) for overall internet use and five specific internet-based business activities under the principal and alternative matching specifications.

Table 2. ATT Estimates of Internet Use and Internet-Based Business Activities

Treatment	NN(5), caliper 0.03	Kernel	Caliper 0.02	NN(3)
Overall internet use	0.700***	0.700***	0.806***	0.812***
Advertising	0.049**	0.069***	0.063***	0.111 (n.s.)
Product sales	0.128***	0.126***	0.130***	0.156**
Raw-material purchasing	0.580***	0.591***	0.570***	0.662***
Information seeking	0.150***	0.151***	0.117***	0.263*
Fintech lending	0.685***	0.733***	0.656***	0.700***

*Notes: *** ($p < 0.01$), ** ($p < 0.05$), * ($p < 0.10$). NN(5) and NN(3) refer to five-nearest-neighbor and three-nearest-neighbor matching, respectively. Kernel specifications use an Epanechnikov kernel, with a bandwidth of 0.06 for overall internet use and 0.01 for activity-specific treatments. n.s. = not statistically significant.*

Table 2 presents the estimated average treatment effects on the treated (ATT) of overall internet use and specific internet-based business activities on MSMI turnover. The principal matching specification, employing five-nearest-neighbor matching with a 0.03 caliper, indicates a positive and statistically significant ATT of 0.700 for overall internet use ($p < 0.01$). Importantly, the estimated effect remains positive and statistically significant across all alternative matching specifications,

including kernel matching with different bandwidths and three-nearest-neighbor matching, ranging from 0.700 to 0.812. This consistency suggests that the relationship between internet use and turnover is relatively stable across alternative matching procedures. The findings provide empirical support for the relevance of internet adoption in understanding turnover differences between internet-using firms and their matched non-using counterparts.

The activity-specific estimates further demonstrate considerable variation in the magnitude and consistency of the observed relationships. Advertising exhibits the smallest principal ATT, at 0.049 ($p < 0.05$), whereas product sales records a higher estimate of 0.128 ($p < 0.01$). Although advertising remains statistically significant under kernel matching and the alternative-caliper specification, its significance disappears under three-nearest-neighbor matching. This variation suggests that the estimated relationship between advertising and turnover is comparatively sensitive to the matching procedure. In contrast, product sales maintain positive and statistically significant estimates across all specifications, ranging from 0.126 to 0.156. The consistency of these estimates indicates a relatively stable association between internet-based product sales and turnover.

Raw-material purchasing demonstrates a substantially larger principal ATT of 0.580 ($p < 0.01$), with estimates ranging from 0.570 to 0.662 across matching specifications. This magnitude exceeds the estimates for advertising, product sales, and information seeking, indicating that internet-based purchasing activities exhibit a comparatively strong relationship with turnover. The positive and statistically significant results across all specifications further support the consistency of this association. Information seeking also records a positive principal ATT of 0.150 ($p < 0.01$), although its magnitude varies from 0.117 to 0.263 across alternative specifications. Its significance declines to the 10% level under three-nearest-neighbor matching, suggesting comparatively greater sensitivity to the matching procedure. Nevertheless, the consistently positive estimates indicate that internet-based information seeking remains positively associated with turnover across the reported specifications.

Fintech lending presents another substantial estimated relationship, with a principal ATT of 0.685 ($p < 0.01$). The estimate remains positive and statistically significant across all matching specifications, ranging from 0.656 to 0.733. This consistency suggests that the observed association between internet-based financing and turnover is not driven exclusively by a particular matching approach. However, the interpretation requires additional caution because only 144 firms reported using internet-based fintech lending. The relatively limited treatment group may restrict the precision and generalizability of the estimates, particularly when considering the broader MSMI population. Accordingly, the findings indicate a potentially important relationship between digital financing access and turnover, rather than demonstrating that fintech lending necessarily improves business performance for all firms.

The results reveal heterogeneous relationships between internet-based business activities and MSMI turnover. Raw-material purchasing and fintech lending exhibit comparatively larger ATT estimates, while advertising and information seeking demonstrate smaller magnitudes and greater sensitivity under certain matching specifications. Product sales and overall internet use display relatively consistent estimates across alternative matching procedures. These differences suggest that internet adoption should not necessarily be interpreted as a uniform business activity, since its observed relationship with turnover may vary according to how firms utilize digital technologies. Nevertheless, the ATT estimates remain conditional on the propensity score matching assumptions, including adequate covariate balance, common support, and the absence of unobserved confounding.

Therefore, the findings should be interpreted as matching-adjusted differences in turnover rather than definitive causal effects.

5. Discussion

The findings indicate that internet use is positively associated with MSMI turnover during the COVID-19 pandemic, supporting the hypothesis that digital adoption can help sustain business performance during economic disruption. This result aligns with the inclusion, efficiency, and innovation mechanisms discussed by the World Bank (2016) and previous studies by Bertschek et al. (2013), Tarutė and Gatautis (2014), and Falentina et al. (2021), which link digital technologies to firm performance. It is also consistent with Affandi et al. (2024), who identified a positive relationship between digital adoption and sales growth among Indonesian micro and small enterprises, and Ekeoma (2024), who found that information technology adoption was positively associated with firm performance across emerging and developing economies. These findings suggest that internet use may help firms maintain market access and business operations when conventional transactions are disrupted.

The activity-specific estimates reveal that the relationship between digital adoption and turnover varies across business functions. Product sales are positively associated with turnover, supported by Utomo et al. (2021) and Dwiputri et al. (2022), who highlight digital adoption as a strategy for sustaining MSME performance during the pandemic. However, the estimated impact on product sales is smaller than that on raw-material purchasing and fintech lending. This pattern suggests that online selling alone may not capture the full business value of digitalization. Koutroumpis and Sarri (2024) similarly found that broadband improvements were associated with better financial performance among adopting small firms, emphasizing the importance of productive technology use rather than infrastructure availability alone.

Raw-material purchasing produces a relatively large and consistent ATT across the matching specifications. This finding highlights the potential importance of digital procurement for manufacturing firms, whose operations depend on reliable access to production inputs. Online supplier searches may reduce information costs and expand purchasing options when conventional supply channels are disrupted. Affandi et al. (2024), who examined digital adoption across several business processes, including electronic procurement, likewise provide a relevant basis for considering digitalization beyond marketing and sales. Posti and Maiti (2025) also demonstrate that ICT returns can vary across firms, reinforcing the importance of examining how technologies are used rather than treating adoption as a uniform practice.

Information seeking is positively associated with turnover, suggesting that access to business knowledge may support managerial decisions and business development. This finding complements research on technology adoption among Indonesian SMEs (Rahayu & Day, 2015; Trinugroho et al., 2022). In contrast, advertising has the smallest principal estimate and loses statistical significance under the three-nearest-neighbor specification. This result does not establish that advertising is ineffective; rather, its estimated relationship with turnover appears less robust across specifications. Advertising may need support from product availability, customer service, logistics, and functional sales channels to translate visibility into business outcomes.

Fintech lending also exhibits a relatively large positive ATT, but only 144 firms used this activity. The result should therefore be interpreted cautiously and cannot establish that digital borrowing benefits all MSMIs. Although digital finance may facilitate working-capital access, financing decisions also require financial literacy and an assessment of repayment capacity. Affandi et al. (2024) highlight the

relevance of financial literacy in the digital adoption context, supporting an approach that combines access to digital finance with responsible borrowing practices.

The results remain conditional on the PSM assumptions. Although improved covariate balance strengthens comparability between treated and comparison firms, matching cannot eliminate bias from unobserved characteristics (Dehejia & Wahba, 2002; Stuart, 2010). As Imbens (2004) and Smith and Todd (2005) emphasize, matching estimates can also depend on specification and sample construction. The findings should be interpreted as conditional associations rather than definitive causal effects. Policy initiatives should consequently support practical digital skills, procurement and sales systems, business-information access, and responsible digital finance, with assistance tailored to MSMIs' differing capabilities and business needs.

6. Conclusion

This study finds a positive association between internet use and turnover among MSMIs during the COVID-19 pandemic. The overall estimate remains positive and statistically significant across all matching specifications, indicating that the relationship is consistent under the alternative models examined. Activity-specific results reveal meaningful differences: raw-material purchasing and fintech lending have relatively large estimated associations with turnover, while information seeking and product sales also show positive relationships. Advertising has the smallest principal estimate, and its statistical significance varies across specifications. These findings suggest that the business value of internet adoption may depend on how digital tools are integrated into operational and commercial activities. The practical implication is that digitalization policies should extend beyond general internet access to include digital procurement capabilities, online sales development, access to reliable business information, and responsible digital financing. Support should be tailored to firms' operational needs and technological capabilities, while fintech lending initiatives should incorporate financial literacy and responsible borrowing practices.

Several limitations should be considered when interpreting these findings. First, the cross-sectional data capture MSMI conditions in 2020 and cannot establish how the relationships evolved after the pandemic. Second, Propensity Score Matching addresses differences in observed characteristics but cannot eliminate unobserved confounding; therefore, the estimates should not be interpreted as definitive causal effects. Third, the fintech lending treatment group contains only 144 firms, limiting the generalizability of its estimates. Future research could use longitudinal data to examine changes in turnover over time, apply alternative causal-inference methods where appropriate, and investigate additional firm characteristics and contextual factors. Studies with larger samples of digital finance users could also explore whether financing outcomes depend on loan utilization, financial literacy, and repayment capacity. Such research would provide a stronger basis for designing targeted digitalization policies for MSMIs.

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