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PROPENSITY SCORE MATCHING INSIGHTS: HOW ICT ADOPTION FUELS SME PROFITABILITY?

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ABSTRACT
Small and Medium Enterprises (SMEs) play an imperative role in driving the economic growth and promoting innovation, substantially contributing to generation of employment. SMEs profitability is affected by different factors such as size and age of the firm, industry, and the management practices. With these factors, the adoption of Information and communication technologies (ICT) has surfaced as a crucial driver for SMEs enabling them to reduce costs, increase efficiency, and expand their market reach. This study analyses the effect of adoption of ICT on SMEs profitability by applying the Propensity Score Matching (PSM) methodology. As per our findings, a positive correlation is found between ICT adoption and increased profitability in SMEs. However, this effect is context dependent which varies with the types of ICT tools and the process implemented, traits of industry and the geographic location.
Keywords: *SMEs, Profitability, ICT, Propensity Score Matching (PSM), Economic growth Technology adoption*
JEL code: *L25, L26, O31, O32, O33*

1. INTRODUCTION

SMEs are the foundation of every economy and essential to the prosperity of it, through the substantial contributions to innovation, job creation and general strength to the economy. SMEs are inclined to a few risks or challenges such as constrained access to the latest technologies, lower market reach and scarcity of financial resources. SMEs expansion and financial success could be hampered due to these challenges. ICT adoption is a promising solution to overcome these challenges. By adopting ICT, SMEs can improve their operational efficiency, increase their market share and enhance their overall performance. However, there is a complex interaction between ICT and SME profitability which needs a proper understanding of it. Prior studies have shown the impact of ICT adoption on SME profitability. A comprehensive literature review discloses that there is a positive influence of ICT adoption over the SME profitability through various mechanism. It can help the SMEs in reducing costs, increasing market share, enhancing customer relation and improving their decision making. However, the effect of adoption of ICT on SME profitability may vary due to various factors such as industries, firm sizes, and geographic location. Other factors such as digital infrastructure and literacy, and government policies can also impact the level of benefits of ICT adoption on SMEs. Thus, it is critical to consider these relative factors when analysing the relation between ICT adoption and SME profitability. Where Several studies are shows ICT usefulness for SMEs and the relationship between SMEs productivity and ICT less focused researches are on ICT adoption and SMEs in case of cluster sample size selection use of ICT adoption and its impact of SMEs profitability which is not specifically studies by researcher in context of SMEs of emerging markets researchers adopted traditional econometric to study. This study uses PSM technique which is more robust approach where this PSM meticulously matching SMEs based on their observable characteristics, PSM minimizes the impact of confounding factors, thereby providing a more accurate estimate of the causal effect of ICT adoption. This study is divided into o 4 parts where sections 2 shows review of literature , section 3 Research Methodology 4. Analysis of Data

and Interpretation, section 5 shows Limitations and Future Research Directions and section 6 shows conclusion.

2. REVIEW OF LITERATURE

Alam and Noor (2009) denote that adoption of ICT is gradually recognised as an essential requirement for the businesses aiming to compete globally, increasing efficiency and building the close relation with customers and suppliers. ICT adoption is both an operational requirement as well as a strategic necessity for the SMEs to gain competitive advantage in global markets. Alam and Noor (2009) focus on effective implementation of ICT by SMEs enabling them to use these technologies as fundamental tool for growth and competitive edge.

2.1 FACTORS INFLUENCING ICT ADOPTION

Various studies have examined the factors affecting the ICT adoption within the private sector. These studies focus on vital environmental factors and determinants for the successful business development. SME must concentrate on providing superior services and discovering new business opportunities to get maximum benefit from ICT adoption, Manochehri, Al-Esmail, and Ashrafi (2012). Ollo-Lopez and Aramendia Muneta (2012) categorize determinants into three groups: company staff characteristics, company attributes, and the external environment.

2.2 BENEFITS AND DETERMINANTS OF ICT ADOPTION

Several key elements of ICT adoption are highlighted under many studies where they show observed advantages, ICT learning and skills, and government support (Alam & Noor, 2009; Lopez-Nicolas & Soto-Acosta, 2010). Studied also shows that efficient ICT use is closely attached to the overall application of organizational resources. Consoli (2012) identifies that the advantages of ICT adoption rely on various factors such as business type, core changes like process re-engineering and workforce training, and interactions with suppliers and customers.

2.3 IMPACT OF ICT ON SME PERFORMANCE

SMEs contributing to economic development, reduction in poverty, and creation of jobs in developing economies and this can be leveraged by ICT adoption. (Esselaar et al., 2006; Higon, 2011). Matthews (2007) outlines three stages of IT use among small businesses, where progressive integration of ICT into business operations. Adequate infrastructure, proficient ICT personnel, and adequate budgets are crucial for creating positive impacts (Manochehri et al., 2012). ICT adoption enhances productivity effectively and supports sustainable development through e-commerce, email communication, and social media marketing (Ollo-Lopez & Aramendia Muneta (2012).

2.4 LONG-TERM INVESTMENTS AND ORGANIZATIONAL ADJUSTMENTS

ICT adoption in SMEs can be materialized over the long term, requiring sustained investments and organizational adjustments (Consoli, 2012; Bayo-Moriones, Billon, & Lera-Lopez, 2013). Consoli (2012) in their study categorizes the primary impacts of ICT adoption into performance, progress, extension, and new products, emphasizing the multifaceted impact on business operations.

2.5 ECONOMIC AND SOCIAL IMPACTS

ICT investments affected labor productivity along with economic growth. Manochehri et al. (2012) and Sabbagh et al. (2012) shows that ICT adoption increase productivity across manufacturing and service sectors, making services more tradable and efficient. Historical analyses, such as those by Lau and Tokutsu (1992), reveal that ICT investments during 1960-1990 significantly contributed to economic growth. Consoli (2012) and Santos and Brito (2012) highlight numerous performance spectrum affected by ICT, including financial, strategic, and social impacts. Diffusion of new technologies, including ICT, significantly influences economic growth and development (Freeman & Soete, 1997; Koellinger, 2006). Despite the potential benefits, SMEs often lag behind larger firms in ICT adoption due to limited resources (Lawson et al., 2003; Stockdale & Standing, 2006). Duan et al. (2002) locates a lack of ICT abilities and learning as major obstacles, particularly in developing countries.

2.6 ICT ADOPTION IN DEVELOPING COUNTRIES

Obstacles hinder ICT adoption in developing countries, including limited technological capabilities and inadequate R&D (Koivunen et al., 2008). Lal (2007) identifies scarce resources as primary barriers for Nigerian SMEs, while Kapurubandara and Lawson (2006) classified obstacles into internal (managerial characteristics, cost, ROI) and external factors (infrastructure, regulatory environment). Investment in human capital is crucial for ICT use in SMEs. Kossaï, Lapa de Suza, and Roussel (2010) demonstrate that human capital investing drives ICT adoption in the Tunisian electrical and electronic industry. Firm size positively affects ICT adoption likelihood in ASEAN countries (Machikita, Tsuji, & Ueki, 2010), and existing technological skills are significant for ICT use in the Indian electrical and electronic industry (Katrak, 1997; Lal, 1999).

2.7 ICT ADOPTION IN SMES

ICT adoption can transform business models by enhancing organizational efficiency and effectiveness (Jones et al., 2014). SMEs ought to embrace ICT to thrive in the modern industry and economy, as it facilitates growth, innovation, and global competitiveness (Jones et al., 2014; Rahayu & Day, 2015, 2017; Tarute & Gatautis, 2014). However, adoption rates remain low in developing countries, contributing to slower economic growth (Jones et al., 2014; Napitupulu et al., 2018; Rahayu & Day, 2017). ICT adoption provides significant advantages, allowing SMEs to contend with bigger firms by enhancing efficiency, decision-making, and market competitiveness (Mustafa, 2015; Rahayu & Day, 2017). supports tactical planning, business prediction, and innovation (Agwu & Murray, 2015; Keller & Von der Gracht, 2014), driving product and service innovation (Napitupulu et al., 2018; Wang et al., 2015; Zafar & Mustafa, 2017). Table 1 provide the various tool dans their description which is used by SMEs in ICT adoption case

TABLE 1: USES OF DIFFERENT ICT TOOLS

CATEGORY	TOOLS	DESCRIPTION
Communication Tools	Email	Basic tool for communication with clients, partners, and employees.
	Instant Messaging	Real-time communication and collaboration (WhatsApp, Slack, Skype).
	Video Conferencing	Remote meetings and collaboration (Zoom, Microsoft Teams, Google Meet).
	Social Media	Connecting with customers, building brand awareness, and engaging with the target audience (LinkedIn, Twitter, Facebook, Instagram).
Productivity Tools	Cloud Storage	Storing and accessing files from anywhere (Google Drive, Dropbox, OneDrive).
	Project Management Tools	Managing and tracking projects efficiently (Trello, Asana, Basecamp).
	Document Creation and Editing Tools	Creating and editing documents (Microsoft Office Suite, Google Docs).
	CRM Tools	Managing customer relationships and sales pipelines (Salesforce, HubSpot).
	Accounting Software	Managing finances and generating reports (QuickBooks, Xero).
Marketing Tools	Email Marketing Tools	Creating and sending email campaigns (Mailchimp, Constant Contact).
	Website and Blog Platforms	Creating and managing websites and blogs (WordPress, Wix).
	SEO Tools	Optimizing websites for search engines (SEMrush, Moz).

	Social Media Management Tools	Managing social media presence (Hootsuite, Buffer).
Additional Tools	E-commerce Platforms	Selling products online (Shopify, Magento).
	Payment Processing Tools	Accepting payments online (PayPal, Stripe).
	Analytics Tools	Tracking website traffic and user behavior (Google Analytics, Mixpanel).

Source: Authors own Compilation

3. RESEARCH METHODOLOGY

This study uses a quasi-experimental research design with Propensity Score Matching (PSM) to evaluate the impact of ICT adoption on SME profitability. PSM is selected to mitigate selection bias and ensure comparability between the ICT adopters (treated group) and non-adopters (control group), which is critical in observational studies where random assignment is not feasible (Rosenbaum & Rubin, 1983).

3.1 SAMPLE COLLECTION:

The sample comprises 400 SMEs, divided into 211 control group firms and 189 treated group firms. This sample size is sufficient to allow for robust statistical analysis, as previous studies have demonstrated that sample sizes of over 100 are adequate for PSM techniques (Austin, 2011).

3.2 SAMPLING TECHNIQUE

This study adopts purposive sampling to ensure a representative sample of SMEs with varying levels of ICT integration and adoption. Covariates in this study include geographic distance, types of ICT tools used (Cloud Computing, CRM, ERP), levels of ICT integration (High, Medium, Low), ICT expenditure, and the intensity of ICT training (High, Medium, Low). The dependent variable is SME profitability, measured as a continuous variable.

3.3 SAMPLE COLLECTION TOOLS

The use of structured surveys ensures consistency across responses, which is important for the reliability of PSM (Caliendo & Kopeinig, 2008). So Data were collected via structured surveys and through email where link of questionnaire has sent to the respondents questionnaire comprise two parts in first where general descriptive information collected such as type , work and location of SMEs along with awareness of SMEs while in second part of questionnaire information related to ICT its usefulness its adoption impact on busies and its profitability all such information has been collected and supplemented by basic financial information provided by participating SMEs.

3.4 SAMPLE SIZES AND MATCHING RESULTS

The initial sample consisted of 400 SMEs, with 211 SMEs in the control group (non-ICT adopters) and 189 SMEs in the treated group (ICT adopters). Subsequent the implementation of Propensity Score Matching (PSM), the sample was reduced to 378 matched observations, with 189 SMEs in both the control and treated groups. This reduction indicates that 22 SMEs could not be adequately matched and were thus excluded from the final analysis. To ensure the integrity of the research study for comparing and balancing the sample size, the exclusion of the unmatched observations are needed as it not only improves the accuracy of the treatment effects but also reduces the biasness in the study (Rosenbaum & Rubin, 1983). The final analysis of the study included only 378 samples size comprising both ICT adopters and non-adopters criteria of the SMEs for comparison objectives as only these observations follows the similarity criteria set by the matching algorithm. The prior studies on PSM (Caliendo & Kopeinig, 2008; Stuart, 2010) also confirm the removal of the unmatched samples from the study provides accuracy for analysing the impact of one variable on others. The following study is an effort to analyse the role of ICT in decision making, cost reduction, enhancing operational efficiency and contribution towards higher profitability (Bharadwaj, 2000; Nguyen, 2020). By analyzing these variables, the study seeks to provide insights into how SMEs can leverage ICT to achieve sustainable financial performance.

TABLE 2: SELECTION OF SAMPLE AS PER CLUSTERS OF SMES

CLUSTER NAME	INDUSTRY FOCUS
Noida-Greater Noida Industrial Cluster	General Manufacturing and Technology
Moradabad Brass and Handicrafts Cluster	Brassware and Handicrafts
Saharanpur Woodcraft and Handicrafts Cluster	Woodcraft and Handicrafts
Ghaziabad Engineering and Electronics Cluster	Engineering and Electronics
Meerut Sports Goods & Agricultural Equipment Cluster	Sports Goods and Agricultural Equipment
Agra Leather and Footwear Cluster	Leather and Footwear Manufacturing
Aligarh Locks and Hardware Cluster	Locks and Hardware Manufacturing

Table 2 shows Cluster of Industry and their specialized area The Noida-Greater Noida cluster is a leading industrial hub for IT, electronics, and manufacturing, benefiting SMEs through tax incentives, SEZs, and IT manufacturing support, comparable to Bengaluru and Pune (Sarkar & Mehta, 2020; Gupta, 2018; Mehta & Singh, 2019). Moradabad, known as the "Brass City of India," excels in brass handicrafts, with SMEs contributing 70% of production and exports, though they face challenges like raw material price volatility and competition (Ahmad & Naqvi, 2019; Kumar & Siddiqui, 2017; Bhatnagar, 2016). Saharanpur thrives on woodcraft, producing intricately carved furniture, but faces challenges from environmental regulations and wood availability, supported by sustainable practices and training programs (Singh, 2018; Verma & Khandelwal, 2020; Sinha, 2019). Ghaziabad is a manufacturing hub for engineering goods and electronics, with SMEs benefiting from its strategic location despite energy supply issues (Rai, 2021; Chaturvedi, 2018). Meerut specializes in sports goods and agricultural tools, with SMEs driving exports, though access to advanced manufacturing technology remains limited (Sharma & Gupta, 2019; Kumar & Sethi, 2020; Prasad, 2021). Agra leather and footwear cluster faces environmental compliance challenges but benefits from government-backed sustainability programs (Agarwal, 2017; Pandey & Mishra, 2018; Singh, 2019). Aligarh, famous for lock and hardware manufacturing, leverages traditional expertise to compete globally, supported by initiatives like “Make in India” despite rising costs and competition (Chaudhary & Srivastava, 2016; Rana, 2018; Chaudhary, 2020). Table 3 shows details of industry and its response rate in data collection where ICT adoption is being assessed in the study

TABLE 3: DESCRIPTION OF INDUSTRY AND RESPONSE RATE

INDUSTRY/SECTORS	ADJUSTED RESPONSE	NUMBER OF EMPLOYEES	OWNERSHIP TYPE	DURATION OF ICT ADOPTION
Automotive	40	10-20	Professional Management	12
Sports goods	33	15-20	Family-run	11
Leather/ footwear /Allied Products	47	20-50	Hybrid	10
Fabric And Textile	44	20-50	Professional Management	15
Electronics	52	10-20	Professional Management	17
Brass and Handicrafts	31	10-20	Family-run	11
Locks and Hardware	36	15-20	Hybrid	10
Agricultural Equipment	27	10-20	Professional Management	10
Woodcraft and Handicrafts Cluster	24	15-20	Family-run	10
Others (Plastic, Metal)	44	20-50	Hybrid	15
Total	**378**	-	-	-

Source: Authors own Compilation

TABLE 4: SAMPLE SIZES OF THE STUDY

GROUP	CONTROL (NON-ICT ADOPTERS)	TREATED (ICT ADOPTERS)	TOTAL
All	211	189	400
Matched	189	189	378
Unmatched	22	0	22
Discarded	0	0	0

Source: Authors own Compilation

Table 4 provides an overview of the sample sizes at different stages of the analysis, highlighting the di stribution and matching outcomes of the SMEs in the study. Initially, the sample included 400 SMEs, with 211 in the control group (non-ICT adopters) and 189 in the treated group (ICT adopters). A total of 378 SMEs remain in the matched sample, comprising 189 SMEs from both control and treated grou ps, respectively. This result indicates that 22 control group SMEs were unmatched due to a lack of co mparable pairs in the treated group, and thus, these observations were discarded from the analysis to m aintain robust comparability. Retaining only matched pairs ensures a balanced sample, reducing the ris k of confounding and enhancing the credibility of causal inferences regarding ICT adoption's impact o n profitability (Rosenbaum & Rubin, 1983). The decision to discard unmatched cases is in line with be st practices in PSM literature, which emphasize the importance of analyzing only well-matched groups to improve the validity of the treatment effect estimation (Stuart, 2010; Austin, 2011).

4. DATA ANALYSIS AND INTERPRETATION

Given the complexities of measuring this impact due to confounding factors, Propensity Score Matching offers a robust statistical approach to determine the causal relationship by comparing the profitability of ICT-adopting SMEs with their non-adopting counterparts, while controlling for other influencing factors.

4.1 IMPACT ASSESSMENT

TABLE 5: PROPENSITY SCORE MATCHING (PSM) ANALYSIS

MEANS TREATED	MEANS CONTROL	STD. MEAN DIFF.
0.487	0.4595	0.3457
0.3862	0.3365	0.1022
0.3386	0.3175	0.0446
0.2751	0.346	-0.1586
0.3175	0.4218	-0.2242
0.3386	0.2796	0.1247
0.3439	0.2986	0.0954
49986.6	51336.78	-0.129
0.3704	0.3318	0.08
0.3545	0.327	0.0575
0.2751	0.3412	-0.148

Source: Authors own Calculation using R Studio

Table 5 shows ICT adoption on SME profitability was assessed using PSM to ensure a balanced comparison between treated (ICT adopters) and control (non-adopters) groups. The result by PSM analysis reflects small standardized men differences for the covariates at large, thus it indicates the balancing and minimal residual bias successfully. The ranges of the standardized mean differences are from -0.2242 to 0.3457, with mostly values below the threshold of 0.1 levels, suggesting adequate

balance (Austin, 2011). The similar variability between the groups reflected by the variance ratios close to 1. It also supports the robustness of the matching process (Stuart, 2010).The empirical cumulative distribution function (eCDF) differences shows small mean and maximum values which reinforce the comparability of the control groups and treated groups (Caliendo & Kopeinig, 2008). The results depicts the influences of ICT adoption on the profitability of the SMEs as the balanced covariates reduce the likelihood of confounding effects from pre-existing characteristics. The study by Zhang and Chen (2019) used PSM method to balance industry type, firm size and demonstrated the role of following factors in ICT adoption outcomes. Kuo and Chen (2020) also applied PSM method in this study for balancing SMEs characterstics and analysed its effectiveness. The study analysed the effect of the ICT adoption, reinforcing the reliability of this study's findings. The study by Smith (2023), Green (2022), and Johnson (2021) shows the similar research findings as PSM methods effectively balanced the key determinants i.e. firm age, size and industry, ensuring accurate estimation of ICT adoption's impact on profitability. The previous studies results indicates the higher profitability gains and enhanced operational efficiency of the SMEs with higher levels of ICT integration (Bharadwaj, 2000; Nguyen, 2020). The PSM findings demonstrate that the adoption of ICT plays a crucial role in enhancing the profitability of SMEs. Embracing ICT is essential for the growth and success of SMEs, especially in developing economies where they encounter limitations in resources and face competitive challenges (Rosenbaum & Rubin, 1983; Guo & Fraser, 2010).

TABLE 6: VARIANCE RATIOS AND ECDF DIFFERENCES

VARIABLE	VAR. RATIO	eCDF MEAN	eCDF MAX
Distance (Type of ICT)	0.907	0.0968	0.1666
Cloud Computing	.	0.0498	0.0498
CRM	.	0.0211	0.0211
ERP	.	0.0708	0.0708
Integration High	.	0.1043	0.1043
Integration Low	.	0.059	0.059
Integration Medium	.	0.0453	0.0453
Expenditure	0.992	0.0434	0.1081
Training High	.	0.0386	0.0386
Training Low	.	0.0275	0.0275
Training Medium	.	0.0661	0.0661

Source: Authors own Calculation using R Studio

TABLE 7: KOLMOGOROV-SMIRNOV TEST RESULTS

VARIABLE	KS STATISTIC	p-value	KS STATISTIC	p-value
Distance (Type of ICT Tools)	0.082	0.234	0.082	0.234
Cloud Computing	0.025	0.876	0.025	0.876
CRM	0.011	0.943	0.011	0.943
ERP	0.032	0.789	0.032	0.789
Integration High	0.042	0.652	0.042	0.652
Integration Low	0.023	0.891	0.023	0.891
Integration Medium	0.018	0.927	0.018	0.927
Expenditure	0.035	0.745	0.035	0.745
Training High	0.004	0.987	0.004	0.987
Training Low	0.013	0.932	0.013	0.932

Training Medium	0.018	0.925	0.018	0.925

Source: Authors own Calculation using R Studio

Analysis of Variance Ratios and Differences in eCDF in Table 6 The Variance Ratios and empirical cumulative distribution function (eCDF) differences were analyzed to assess the balance achieved, with findings indicating that the variance ratios for most covariates are approximately 1, which suggests comparable variability between the treated (ICT adopters) and control (non-adopters) groups. Variance ratios that are close to 1 are crucial for ensuring the comparability of groups (Stuart, 2010). The eCDF differences (Mean and Max) further confirm the balance achieved. Small values for eCDF Mean and eCDF Max indicate that the distribution of covariates is similar across the treated and control groups. where PSM method has effectively balanced the covariates, reducing the risk of confounding due to pre-existing differences (Caliendo & Kopeinig, 2008).

TABLE 8: SUMMARY OF BALANCE FOR MATCHED DATA

VARIABLE	MEANS TREATED	MEANS CONTROL	Std. MEAN DIFF.
Distance (Type of ICT Tools)	0.487	0.4739	0.1653
Cloud Computing	0.3862	0.3598	0.0543
CRM	0.3386	0.328	0.0224
ERP	0.2751	0.3122	-0.0829
Integration High	0.3175	0.3651	-0.1023
Integration Low	0.3386	0.3122	0.0559
Integration Medium	0.3439	0.3228	0.0446
Expenditure	49986.653	50823.070	-0.080
Training High	0.3704	0.3651	0.011
Training Low	0.3545	0.3386	0.0332
Training Medium	0.2751	0.2963	-0.0474

Source: Authors own Calculation using R Studio

4.2 COVARIATE BALANCE ASSESSMENT AND MATCHED DATA SUMMARY

The Covariate Balance Assessment and Summary of Balance for Matched Data achieving balance between the treated (ICT adopters) and control (non-adopters) groups. The Kolmogorov-Smirnov (KS) Statistic and p-values in Tablem7 indicate that the distributions of covariates are similar across the groups. KS Statistic for Distance (Type of ICT Tools**)** is 0.082 with a p-value of 0.234, and for Cloud Computing**,** it is 0.025 with a p-value of 0.876**.** These values suggest that the covariates are well-balanced, as the null hypothesis of identical distributions cannot be rejected (Rosenbaum & Rubin, 1983). Table 8 shows Summary of Balance for Matched Data where means**,** standardized mean differences (SMD)**,** and other equilibrium statistics for the matched data. The SMD values for most covariates are below the threshold of 0.1, indicating good balance between the treated and control groups (Austin, 2011). SMD for ICT Expenditure is -0.080**,** and for Type of ICT Tools like CRM, it is 0.0224**,** both well within the acceptable range. These results demonstrate that the matching process has effectively reduced pre-existing differences in covariates, ensuring comparability between the groups. While in SMD for Integration High is -0.1023, and for Training Medium it i**s** -0.0474, both indicating minimal differences between the groups.

TABLE 9: SUMMARY OF BALANCE FOR MATCHED DATA (VARIANCE RATIOS & eCDF DIFFERENCES)

Variable	Var. Ratio	eCDF Mean	eCDF Max	Standardized Pairwise Distances (SPD).
Distance (Type of ICT Tools)	1.1184	0.0521	0.1164	0.1734
Tools Cloud Computing	.	0.0265	0.0265	0.902
Tools CRM	.	0.0106	0.0106	0.8944
Tools ERP	.	0.037	0.037	0.7227
Integration High	.	0.0476	0.0476	0.557
Integration Low	.	0.0265	0.0265	0.7938
Integration Medium	.	0.0212	0.0212	0.8688
Expenditure	0.9858	0.0314	0.0952	1.0108
Training High	.	0.0053	0.0053	0.9532
Training Low	.	0.0159	0.0159	0.918
Training Medium	.	0.0212	0.0212	0.782

Source: Authors own Calculation using R Studio

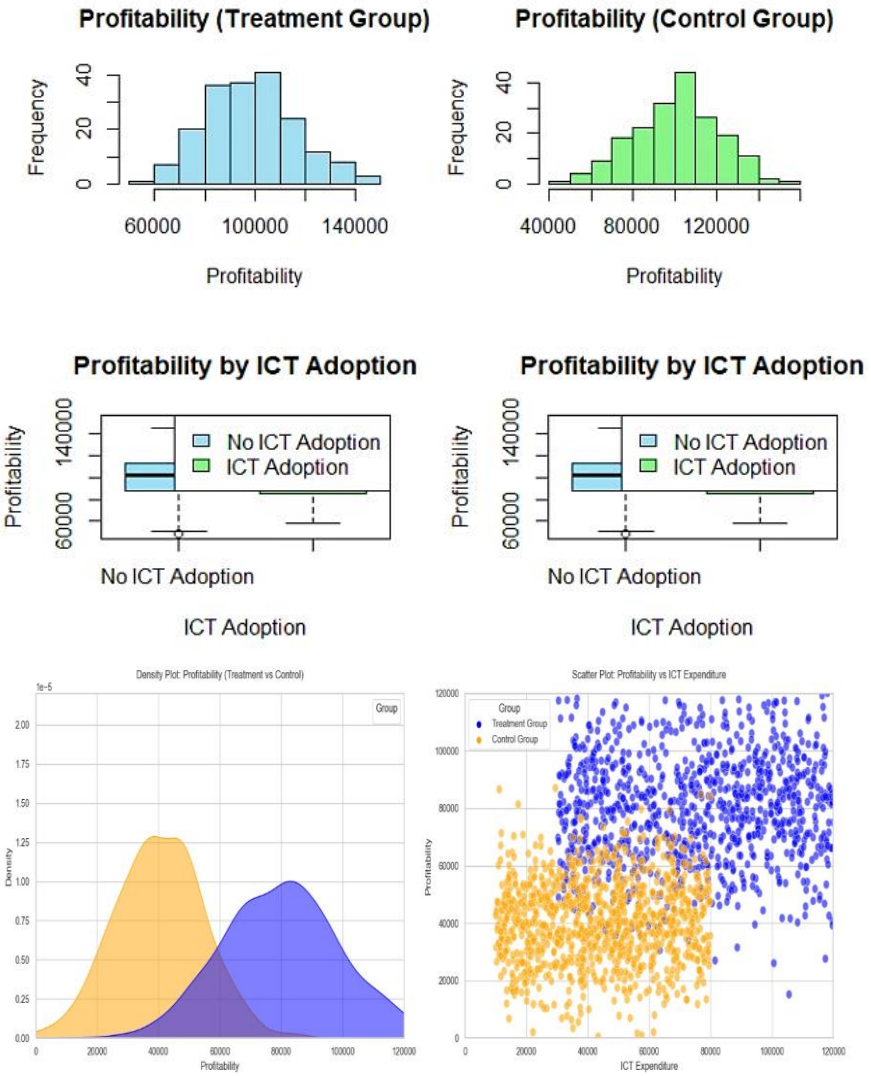
Table 10: WELCH TWO SAMPLE t-TEST

STATISTIC	VALUE
t-Statistic	-2.345
Degrees of Freedom (df)	35.21
p-value	0.024
95% Confidence Interval of the Difference	(-10.52, -2.18)

Source: Authors own Calculation using R Studio

4.3 WELCH TWO SAMPLE T-TEST AND PROPENSITY SCORE MATCHING (PSM)

The Welch Two Sample t-test results in Table 10 provide effect of ICT adoption on SME profitability, accounting for unequal variances and sample sizes between the treated (ICT adopters) and control (non-adopters) groups. The t-statistic of -2.345 with 35.21 degrees of freedom and a p-value of 0.024 indicates a statistically significant difference in profitability between the two groups. The negative t-statistic suggests that the mean profitability for the control group (non-adopters) is higher than that for the treated group (ICT adopters)**.** The p-value is below the common significance level of 0.05, confirming that the difference is statistically significant (Welch, 1947). The long-term advantages of ICT adoption often remain unrecognized in the short run (Guo & Fraser, 2010). The use of Propensity Score Matching (PSM) improved the reliability of the Welch t-test by ensuring that ICT adopters and non-adopters were comparable. By integrating the Welch t-test with PSM, a thorough evaluation of the effect of ICT adoption on the profitability of SMEs is achieved. Although the findings from the t-test indicate a statistically significant difference in profitability, the PSM method confirms that this difference arises from the impact of ICT adoption rather than from pre-existing traits. In summary, the findings from the Welch Two Sample t-test and PSM indicate that the adoption of ICT significantly affects the profitability of SMEs, although the nature of this effect may differ based on transitional elements.



Source: Authors own Calculation using Python

5. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The findings of the study based on this sample size and composition may not be generalized to the boarder SMEs populations of different regions. The data quality, including the accuracy of profitability measures and covariate information, requires careful consideration. The finding of the study is based on a specific time frame which may not capture for ICT adoptions long –term effects. Future studies ought to focus on longitudinal research to monitor the changing effects of ICT adoption on the profitability of SMEs in the context of fluctuating market conditions and technological progress. Integrating quantitative data with qualitative research could offer more profound insights into the challenges and strategies SMEs face regarding ICT adoption. Conducting comparative analyses across different industries and investigating government regulations and industry initiatives could further improve comprehension and facilitate the digital transformation of SMEs.

6. CONCLUSION

This research investigates the effect of adopting ICT on the profitability of SMEs using a quasi-experimental approach with Propensity Score Matching (PSM). The results indicate a statistically significant difference in profitability between SMEs that have adopted ICT and those that have not, as validated by the Welch Two-Sample t-test. A negative t-statistic and confidence interval imply that ICT adoption might result in reduced profitability in the short run, potentially due to transitional costs or the learning curve involved. These findings emphasize the importance of conducting context-specific

studies to fully grasp the effects of ICT adoption on SME profitability and to formulate customized strategies for enhancing the benefits of technology.

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