Journal of Renewable Energy and Sustainable Development (RESD) Volume 9, Issue 1, June 2023 - ISSN 2356-8569
http://dx.doi.org/10.21622/RESD.2023.09.1.021

Received on, 04 April 2023 Accepted on, 06 June 2023 Published on, 20 June 2023

Drivers for, and barriers to solar energy use by manufacturing Micro Small and Medium Enterprises (MSMEs) in Tanzania

Felichesmi S. Lyakurwa

Mzumbe University, Department of Engineering Management Studies, Po Box 87, Mzumbe, Tanzania
Email: felichesmi.lyakurwa@mu.ac.tz

ABSTRACT

Choice of solar energy by manufacturing Micro, Small and Medium Enterprises (MSME's) has been associated with manufacturing sustainability. In this study, the Structural Equation Modeling (SEM) technique was employed to establish drivers for, and barriers to solar energy use by manufacturing MSME's in selected districts in Morogoro region. The SEM results revealed social-economic, technological and environmental factors hindering deployment of solar energy by manufacturing MSME's. Also, the results indicated that there are several factors that hinder manufacturing MSME's use of solar energy for different operations including the environmental concern (i.e., staff/employers' concern about air pollution resulted from energy use, and staff/employers' concern about climate change); solar energy awareness (i.e., experience in previous use of solar energy, and understanding of different types of solar PV which can be used at industry level), and solar energy generation cost (i.e., the generation of solar energy may cause additional cost, and solar energy requires high initial investment cost). Hence, the results of this study can be used by energy policymaking instruments to make informed decisions for renewable energy investment in the country's manufacturing sector for manufacturing sustainability.

Index-words: *Manufacturing sustainability, Renewable energy, Solar energy, SEM model*

I. INTRODUCTION

To date, there is little doubt that fossil fuels are main energy source in the global energy mix despite the highest contribution to the carbon dioxide (CO_2) concentrations in the atmosphere. In 2021, the global CO_2 emissions from energy combustion and industrial processes reached 34.9 $GtCO_2$, an increase of 4.8% from the CO_2 in 2020 (Deng & Davis, 2022). Hence, without appropriate technologies that reduce CO_2 emissions, the global average atmospheric CO_2 concentration, as well as ocean and surface temperatures, will continue to rise (Chen et al., 2022). In the world, the magnitude of CO_2 emissions varies from one sector to another whereby the industry has the highest contribution (32%), followed by building operations (28%), while transportation (23%), building materials (11%) and others contributing (6%) (Ali & Ahmad, 2020). Eleftheriadis & Anagnostopoulou (2015) documented a strong association between CO_2 emissions and rise in global temperature, and climate change. For example, Tollefson, (2021) documented that climate change impacts have increased the global surface temperature by around 1.1°C compared to average in 1850-1900, a level that has not been witnessed in the past 125000 years ago whereby the IPCC's best estimated remains at 3°C. Maximillian et al., (2019) and Yang et al., (2022) revealed that rising of the global temperature caused by Greenhouse Gases (GHG) emission has caused significant damage to the human living environment like extinction of some species, droughts, ocean acidification and sea-level rise. This has affected significantly the livelihoods of people because earning from fishing is low, reduced number of jobs, thereby leaving the community food insecure. Considering the negative social, economic and environmental effects of CO_2 emissions, many governments in the world have invested heavily on designing efficient climate change policies including emission trading schemes, carbon trading and polluter pays principle.

In spite of the short, and moderate term CO_2 emissions reduction targets can be achieved with use of such economic pricing instruments, yet ambitious emission reduction goals can be difficult to achieve without pervasive diffusion of a low-carbon technologies (Ren et al., 2021). Usually, diffusion of renewable energy sources in the national energy mix provides a basis for achieving mass reductions in CO_2 emissions in long term. For example, the European Union (EU) has set a target of 20% CO_2 emission reduction that will be achieved through consumption of more renewable energy sources (Council, 2009). Also, in 1990 the EU leaders committed about 80-95% reduction of CO_2 emissions by 2050 such that it will not be materialized unless a magnitude of 95-100% of the country's decarbonization of electricity sector is achieved (Höhne et al., 2019). According to Shahsavari & Akbari, (2018) solar photovoltaic (PV) is the most appropriate technology for a source of renewable electricity in developing countries particularly in rural areas because solar PV reduces demand for fossil fuels, and related emissions such as CO_2, nitrogen oxides (NO_x) and sulfur dioxide (SO_2). Moreover, it was projected that

http://dx.doi.org/10.21622/RESD.2023.09.1.021

utilization of solar PV by production systems will reduce about 69-100 million tons of CO_2, 126,000-184,000 tons of SO_2, and 68,000-99,000 tons of NO_x by 2030 such that these reductions will decrease human exposure to serious diseases including heart attacks, and Asthma by 2030. In Tanzania, many efforts have been made to reduce CO_2 emissions, whereby reduction of CO_2 emission from cement production was reduced with replacement of fossil fuel (i.e., coal) with sawmill residues. Replacement of coal in cement production has reduced GHG emissions by 455-495 kg of CO_2eqMWh^{-1} which is equivalent to 83-91% decrease in GHG emissions (Sjølie, 2012). Also, in efforts to reduce CO_2 emissions, the government of Tanzania has invested a total of $112.4 million for renewable energy generation in the period of twelve years from 2007 to 2019 (Lyakurwa, 2022).

In the face of vast investment to ensure access, and use of renewable energy by different production sectors in the country, yet deployment of renewable energy for different applications is inadequate. Lyakurwa & Mkuna, (2018) and Elasu et al., (2023) documented several factors hindering adoption of solar energy including consumer's beliefs about renewable energy benefits, perception of self-effectiveness, political and institutional factors, environmental concern, renewable energy development and awareness, and financial abilities. According to Hasan et al., (2022) and Zulu et al., (2022), the uptake of renewable energy technologies is hindered by several factors mainly technology advancement, owner's perception, incentive policy, customer's behaviour and price of electricity that can be grouped into six groups mainly technical, economic, institutional policy, social, market and organizational. In regard to the manufacturing industries, renewable energy use for different processes is determined by different factors including socio-economic, technology, regulatory and environmental (Seetharaman et al., 2019). Based on the empirical evidence, access to clean, reliable and affordable energy for domestic and industrial uses is challenge to many developing countries of Africa that contributed greatly to dependence on the non-renewable energy mainly fossil fuels for different domestic and industrial applications. Fossil fuels are characterized with ever-increase in price, harmful effect on human health and quality of ecosystem like deterioration of aquatic lives, climate change and global warming effects.

Moreover, majority African countries including Tanzania, are blessed with renewable energy sources such as solar energy which is readily available, clean, affordable and can be used for both domestic and industrial purposes (Lyakurwa, 2022). Despite the benefits of renewable energy (i.e., solar PV), the extent to which solar energy is used for different industrial applications is low. This has brought several probing questions that tries to uncover factors hindering use of solar energy for various industrial applications. Hence this study was aimed to establish drivers for, and barriers to solar energy use by manufacturing MSME's for different industrial operations.

A. Theoretical framework

This study was guided by the theory of constraints (TOC) which has the objective of profit maximization through increased performance of a production system. Saleh et al., (2019) revealed that profit maximization can be achieved via efficient utilization, and management of all input resources e.g., energy, manpower, machine and equipment, materials, and working methods, among others. Hence, aggressive business organization places more focus on identified constrains because its elimination offers highest return towards effective and efficient resource utilization, and management. Constraint refers to as the weakest link in process of a production system whereas its improvement can be achieved through five distinct stages namely constraint identification, analysis, elevation and subordinating everything to the constraint. Application of TOC is the most appropriate strategy to solve factors hindering achievement of the goals (e.g., productivity improvement & green manufacturing) by an industry through bottlenecks identification and work out to eliminate or eradicate them. Hence, it brings benefit to industries with increased profit due to reduced production cost mainly by adoption of appropriate renewable energy technologies. In this regard, TOC can be used to establish as to why manufacturing MSME's do not use solar energy for different industrial operations. The understanding will inform formulation of strategies and policies that will promote use of solar PV by manufacturing industries for sustainable industrial development.

Kynčlová et al., (2020) sustainable industrial development refers to the situation whereby governments formulate policy and strategies that require industries to operates in a way to meet the economic objectives together with social inclusiveness and minimizing natural resource use, and environmental impacts. Usually this can be achieved with effective implementation of the United Nations Sustainable Development Goals (SDGs), preferably Goal 7: affordable and clean energy, Goal 9: industry, innovation and infrastructure, and Goal 13: climate action. The TOC therefore, is closely linked with barriers to solar energy use by manufacturing industries because they all aim at profit maximization and sustainable industrial development which can be achieved through a shift from using fossil fuels to renewable energy i.e., solar PV. Also, implementation of this theory can be achieved through application of reliable, clean and affordable energy sources by manufacturing MSME's to ensure optimal use of resources leading to less environment impacts in course of production processes. It is the interest of this study to make use of the constraint's theory to explore factors hindering manufacturing MSME's use of solar energy for manufacturing sustainability.

II. DATA AND METHODS

B. Study area

This study was conducted in the four (4) districts in Morogoro region namely Morogoro Municipal council, Mvomero district, Kilombero and Kilosa district council. Morogoro region is located at latitudes 6.8278°South of equator, and longitudes 37.6591° East of Greenwich Meridian. The region covers a total area of 70,624 Sq. Kms with a population of 2,218,492 (URT, 2013). The study was conducted in the selected districts because many households are livestock keepers and farmers whereas their produce requires value addition by manufacturing MSME's. According to Lyakurwa (2022) manufacturing enterprises are classified into four (4) broad categories based on the number of employees, total investment and sales turnover (Table 1).

TABLE I: CLASSIFICATION OF ENTERPRISES

Category	Employees	Capital investment in Machinery (TZS)
Micro enterprise	1 – 4	5 million
Small enterprise	5 – 49	>5 to 200 million
Medium enterprise	50 – 99	>200 to 800 million
Large enterprise	100+	>800 million

URT (2012)

Also, Morogoro region has adequate number of renewable energy sources including solar PV, biomass, biogas, wind and hydro power, to mention few. Despite the availability, the selected districts as other districts in Tanzania experiences inadequate access to reliable, clean and affordable energy sources whereby majority manufacturing MSME's use non-renewable energy for different applications. The dependency on non-renewable energy sources has contributed greatly to the regions' failure to realize the Tanzania National Five-Year Development Plan 2021/22 - 2025/26, National Strategy for Growth and Reduction of Poverty (NSGRP), the SGDs, and the Tanzania Development Vision 2025 (URT, 2000; URT, 2010; URT, 2021; Sonter & Kemp, 20212015). Hence, developing barriers to solar energy use by manufacturing MSME's is critical towards achievement of the SDGs, NSGRP, Tanzania vision 2025 and National Five-Year Development Plan of 2021/22 to 2025/26.

C. Research design, data sources, and collection process

A cross sectional survey research design was employed to establish barriers to solar energy use by the manufacturing MSMEs in the selected four (4) districts in Morogoro region. According to Van der Stede (2014), this design enables collection of large amounts of data at one location in time in the most economical way. The method was also supported by Connelly (2016) which documented that, a cross sectional survey design is mostly appropriate when the study intends to answer questions of who, what type, where, how many and how much as revealed by this study. A well-structured questionnaire and interviews guide questions were used to collect primary data from the manufacturing MSME's located in Morogoro Municipal council, Mvomero, Kilombero and Kilosa district councils. The multistage sampling technique was applied in the selection of representative manufacturing MSME's (i.e., a sample size *(n)* of 242 enterprises) in the selected districts.

D. Methods for data analysis

The preliminary, descriptive and inferential statistical analysis methods were employed in the analysis of the collected data about workers perceptions about sustainable manufacturing practices as well as drivers for, and barriers to solar energy use by the manufacturing MSME's in the selected districts in Morogoro region. Preliminary analysis involved data quality check and testing the assumptions of Exploratory Factors Analysis (EFA) such that all missing values were checked. The normality of data was also checked to establish whether the collected data are good for the Structural Equation Modeling (SEM) through Confirmatory Factor Analysis (CFA). Thereafter, the descriptive and inferential analysis were carried out. The descriptive analysis was conducted to different data groups mainly gender, work experience, education level, number of employees, and capital invested in the business, among others. The descriptive analysis intended to provide an insight of some findings, which may not necessarily be in the focus of the study's specific objectives. The inferential analysis i.e., EFA and CFA were performed.

The EFA was conducted in each construct (i.e., Environmental Concern (Ec), Solar Energy Awareness (sea), Self-Effectiveness Perception (sep), Solar Energy Generation Cost (segc), Solar Technology Advancement (sta), Perceived Benefits of Solar Energy (pb), MSME's Intention to Use Solar Energy (msme'siuse), and Risk/Trust Perception of Solar Energy (rtse)), and confirm variables in different groups of the factors hindering use of solar energy by manufacturing MSME's. The SEM through CFA has been applied in modeling drivers for adoption of manufacturing technologies and renewable power generation (Hariyani & Mishra, 2023; Jabeen et al., 2019), and barriers to sustainable construction and sweetened beverages consumption (Durdyev et al., 2018; Wang & Chen, 2022). The confirmed factors were analyzed by using CFA so as to identify the relative importance of each towards deployment of solar energy by manufacturing enterprises. Thereafter, the inferential analysis mainly correlation analysis was used to characterize the relationship between the variables i.e., factors influencing decision to use solar energy by manufacturing MSME's.

III. RESULTS AND DISCUSSION

E. Respondents profile

Table II presents the descriptive statistics of the respondent characteristics for drivers for, and barriers to solar energy use by manufacturing MSME's in Tanzania.

http://dx.doi.org/10.21622/RESD.2023.09.1.021

TABLE II: RESPONDENT PROFILE

S/No.	Variable measure	N	%
Gender	Male	166	72
	Female	66	28
Age	18-24	37	16
	25-31	83	35
	32-38	81	34
	>39	35	15
Work experience	1-5	91	42
	6-10	78	36
	11-15	19	9
	16-20	19	9
	>20	11	5
Marital status	Married	86	49
	Single	91	51
Workers education	Primary	13	6
	Secondary	112	50
	Degree	98	44

The results (Table II) indicate that out of 232 staff working in the manufacturing MSME's, 166(72%) were male and 66(28%) were female which implies that tasks performed by these industries are not masculine and a sign of gender balanced working environment. In regard to the workers age, 38(17%) have ages ranging 18-24 years, 83(35%) ages 25-31 years, 80(34%) ages 32-38 years, while 35(15%) aged more than 39 years old. The results imply that majority working staff are young, matured and energetic person that reflects empowerment of youths. The results for the working experience showed that majoring staff are new employees with working experience ranging 1-5 years, that is 91(42%), followed by a working experience of 6-10 years i.e., 78(36%), while the manufacturing MSME's have few staff with a working experience more than 20 years, that is 11(5.0). Considering the workers education level, majority have secondary education, 112(50%), followed by degree holders, a total of 98(44%), and 13(6%) have a primary education. The results imply that the surveyed manufacturing MSME's have employed staff trained at different levels to work in different production sectors.

F. Drivers for, and barriers to solar energy use by manufacturing MSME's

The CFA revealed seven (7) factors that drive manufacturing MSMEs' deployment of solar energy in different operations. With the CFA, it was assumed that there would be a single dominant factor whereas a number of factors were specified whereas the covariance of the 7 factors are fully explained by the single latent variable plus the unique variance of each factor. In this case, the unique variance or error variance, is being estimated for each of the seven (7) observed indicator variables (Figure 1). In the CFA, it was assumed that deployment of solar energy by a manufacturing MSMEs' should explain all the variance among seven factors. At first place, weak results were obtained such that stronger results will be obtained by removal of the measurement error given the latent variables are subsequently used as independent or dependent variables in a SEM. The CFA model was fitted by using a maximum likelihood estimation method whereby variance-covariance matrix of the estimators i.e., the standard errors were computed using an observed information matrix. Usually, with the assumption of normality, this method is often the best option and is fairly robust even with same violation of normality since it uses a listwise deletion approach (Lee et al., 2002).

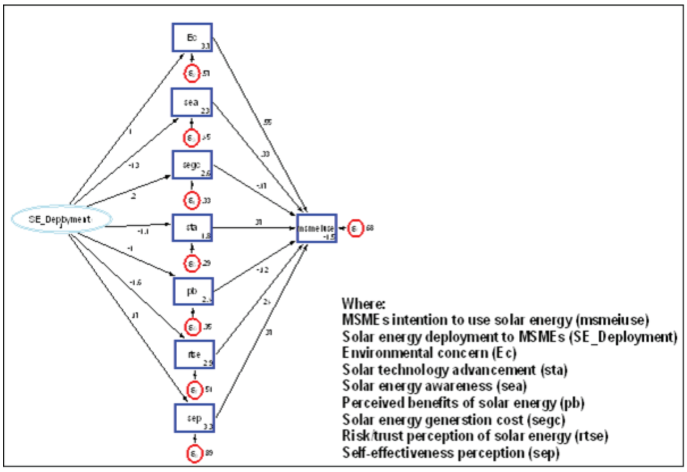

Figure 1: CFA Model for drivers to the solar energy use by MSMEs'

Figure 1 is the path diagram for a SEM model with observed exogeneous variables and a latent variable. The model can be represented with a mathematical notation by a general equation 1 as follows:

$$Y_i=\beta_{i0}+M+\beta_{1i} X_i+ \dots +B_{in} X_n+\epsilon_i;\ given\ i=1,\dots ,n \qquad (1)$$

where,

$(Y,X_1,\dots ,X_n)$~iid with mean μ and covariance matrix Σ;

$$\epsilon=(\varepsilon_1,\varepsilon_2,\varepsilon_3)', E(\epsilon)=(0,0,0)', var(\epsilon)=\begin{bmatrix}\sigma_1^2 & 0 & 0\\ 0 & \sigma_2^2 & 0\\ 0 & 0 & \sigma_3^2\end{bmatrix}, E(M)=0, \text{and } var(M)=\sigma_M^2; var(M)=\sigma_M^2$$

Y is the dependent exogeneous variable (MSMEs intention to use solar energy);

Xs are the independent observed exogeneous variables; and

M is the single latent variable i.e., Deployment of Solar energy to MSMEs.

Fitting the CFA model

The Comparative Fit Index (CFI) and Tucker Lewis Index (TLI) are both incremental fit indices values >0.95 whereby these indices indicate a very good fit (Sahoo, 2019) structural equation modeling is a buzz word in the arena of research in management, social sciences, and other equivalent fields. Although the theoretical base bears its significance in building the measurement and structural models, assessing different goodness-of-fit indices (GOFI. Shi et al., (2019)the Tucker–Lewis index (TLI indicated that values from 0.90 or above are considered evidence of the acceptable model fit. Also, the Standardized Room Mean Square Residual (SRMR) values up to 0.05 are considered indicative of a close-fitting model whereas the values ranging between 0.05 up to 0.10 suggest acceptable fit. The SEM model fitting results presented in Table III showed that, the CFI (0.348) and TLI (0.088) values are lower than 0.90. Thus, the CFI and TLI indicates poor model fitting such that re-analysis was performed to generate standardized results.

TABLE III: SEM MODEL FITTING RESULTS

Fit statistic	Value	Description
Likelihood ration		
Chi2ms(20)	235.501	model vs. saturated
p>chi2	0.000	
p>bs(28)	358.757	baseline vs. saturated
p>chi2	0.000	
Population error		
RMSEA	0.221	Root mean square error of approximation
90% CI, lower bound	0.196	
upper bound	0.247	
pclose	0.000	Probability RMSEA<=0.05
Information ccriteria		
AIC	3950.776	Akaike's information criteria
BIC	4032.332	Bayesian information criteria
Baseline comparisonn		
CFI	0.348	Comparative fit index
TLI	0.088	Tucker-Lewis index
Size of residuals		
SRMR	0.166	Standard root mean squared residual
CD	1.000	Coefficient of determinationn

CFA model estimation and interpretation

Table IV indicates that there are 21 observations with missing values excluded in the model because the default estimation method i.e., maximum likelihood uses listwise deletion such that all observations which do not have a response for all factors are dropped off (Chen et al., 2020)whereas the model of interest to the researcher is at the composite (scale score. All observed factors from Environmental Concern (ec) to Self-Effectiveness Perception (sep) in the model are all endogenous variables i.e., these measurement variables depend on the latent variable i.e., the Solar Energy Deployment (SE-Deployment). Also, the maximum likelihood estimator maximizes the log-likelihood function such that with the listwise deletion method, only 221 observations were available with no missing values. The results present the "Measurement" and a "Variance". The measurement gives estimates of unstandardized measurement coefficients i.e., factor loadings, their standard errors, and a z-test for each estimate along loadings. To identify the variance of the latent variable, (i.e., Solar Energy Deployment), the software fixes the loading of the first indicator at 1.0 that is called, a reference indicator whereas all unstandardized estimates will change if there is a change in reference indicator.

TABLE IV: CFA MODEL ESTIMATION AND INTERPRETATION

Structural equation model
Estimation method = ml Number of observations = 221
Log Likelihood = -1617.7867
(1) Ec [SE_Deployment] = 1

Measurement	Coef.	Std. Err.	z	p>IzI	[95% Conf. Interval]	
Ec						
SE_Deployment	.1671627	.0772	2.17	0.030	.0158534	.318472
Const.	4.902182	.2426813	20.20	0.000	4.426535	5.377829
sea						
SE_Deployment	-.6727413	.0789552	-8.62	0.000	-.8257267	-.5197558
Const.	2.911463	.1539569	18.91	0.000	2.609713	3.213213
segc						
SE_Deployment	.3142185	0.0731089	4.30	0.000	.1709278	.4575093
Const.	4.399605	.2198134	20.02	0.000	3.968779	4.830432
sta						
SE_Deployment	-.7953117	.0839691	-9.47	0.000	-.9598881	-.6307354
Const.	2.750931	01471264	18.70	0.000	2.462568	3.039293
pb						
SE_Deployment	-.2359973	.0764013	-3.09	0.002	-.3857411	-.0862535
Const.	4.10418	.2064804	19.88	0.000	3.699486	4.508874
rtse						

Structural equation model Estimation method = ml Log Likelihood = -1617.7867 (1) Ec [SE_Deployment] = 1	Number of observations = 221					
Measurement	**Coef.**	**Std. Err.**	**z**	**p>IzI**	**[95% Conf. Interval]**	
SE_Deployment	**-.2337238**	**.0867011**	**-3.01**	**0.003**	**-.3859403**	**-.0815072**
Const.	**3.926254**	**.1984981**	**19.78**	**0.000**	**3.537205**	**4.315303**
sep						
SE_Deployment	**.2292345**	**.0867011**	**2.64**	**0.008**	**.0593035**	**.3991654**
Const.	**3.618576**	**.1847959**	**19.58**	**0.000**	**3.256383**	**3.980769**

The CFA results revealed that, three factor loadings (i.e., msmeiuse (p_{value}=0.030), rtse (p_{value}=0.039) and sep (p_{value}=0.001)) are statistically significant (all p_{value} < 0.050). This is construed to mean that such the indicator variables (MSME's intention to use solar energy (msmeiuse), Risk Perception of Solar Energy (rtse), and Self-Effectiveness Perception (sep)) are significantly related to their respective factors, and therefore the main drivers for the solar energy use by manufacturing MSME's in Tanzania. The results are in-line with the study by Schoeneberger et al., (2020) which explored drivers for deployment of solar PV by manufacturing industries in US whereby economic, environmental and technological factors were critical for solar PV deployment.

G. Barriers to solar energy use by manufacturing MSME's

Factor hindering manufacturing MSMEs' use of solar energy for different activities are explained by eight (8) constructs i.e., Environmental Concern (Ec), Solar Energy Awareness (sea), Solar Energy Generation Cost (segc), Solar Technology Advancement (sta), Perceived Benefits of Solar energy (pb), MSME's Intention to Use Solar Energy (msme'siuse), Risk/Trust Perception of Solar Energy (rtse)), and Self-Effectiveness Perception (sep). The correlation results (Table V) showed that factors hindering solar energy use by manufacturing MSMEs' are environmental concern (positive correlation=0.2070), segc (positive correlation=0.0726) and sep (positive correlation=0.0816), while the factors such as sta (-0.1195), pb (-0.0123), msme'siuse (-0.067) and rtse (-0.0477) have negative correlation.

TABLE V: CORRELATION ANALYSIS

	Factors	Ec	sea	segc	sta	pb	msmeiuse	rtse
Factors	1							
Ec	0.2070	1						
sea	-0.0255	-0.0572	1					
segc	0.0726	-0.0244	-0.1975	1				
sta	-0.1195	-0.1579	0.5321	0.29	1			
pb	-0.0123	0.079	0.1071	0.02	0.2074	1		
msmeiuse	-0.067	0.4052	0.3094	0.13	0.3091	0.118	1	
rtse	-0.0477	-0.0709	0.193	0.18	0.1742	0.4428	0.2007	1
sep	0.0816	0.2966	-0.2565	0.18	-0.112	0.0355	0.325	0.0855

CFA of factors hindering use of solar energy by manufacturing MSMEs'

The exploratory factor analysis (EFA) was conducted in each construct by using the Principal Component Factor method which involved several processes including data examination, factor analysis, rotation and prediction of values. The examined data are presented in Table VI.

TABLE VI: DATA EXAMINATION

Variable	Obs.	Unique	Mean	Min	Max	Label
Ec	233	18	3.682	1.60	5.00	Environmental concern
sea	236	18	2.374	1.00	5.00	Solar Energy Awareness
segc	241	13	2.585	1.00	4.00	Solar Energy Generation Cost
sta	236	13	1.894	1.00	5.00	Solar Technology Advancement
pb	241	15	2.466	1.00	5.00	Public Benefits of Solar Energy
msmeiuse	240	17	3.156	1.00	5.00	MSME's Intention to Solar Energy
rtse	237	16	2.889	1.00	5.00	Risk Perception of Solar energy
sep	240	16	3.256	1.00	5.00	Self-Effectiveness Perception

The examination results (Table VI) revealed that there were eight constructs whereas their mean values range from 1.894 to 3.6815.

The factor analysis revealed eight principle factors with eigen values, and proportions as indicated in Table VII.

TABLE VII: FACTOR ANALYSIS RESULTS

Factor analysis/correlation			number of obs=221	
Methods: Principal-component factors			retained factors=3	
Rotation:(unrotated)			number of params=21	
Factor	Eigenvalues	Differences	Proportion	Cumulative
Factor1	2.10884	0.37864	0.2636	0.2636
Factor2	1.73019	0.34917	0.2163	0.4799
Factor3	1.38103	0.55016	0.1726	0.6525
Factor4	0.83087	0.11617	0.1039	0.7564
Factor5	0.7147	0.18972	0.0893	0.8457
Factor6	0.52497	0.15444	0.0656	0.9113
Factor7	0.37054	0.03167	0.0463	0.9576
Factor8	0.33887		0.0424	1
LR test: independent vs. saturated: chi2(28) = 353.08 Prob>chi2=0.000				
Factor loadings (pattern matrix) and unique variances				
Variables	Factor1	Factor2	Factor3	Uniqueness
Ec	0.0705	0.6788	-0.4300	0.3494
sea	0.7418	-0.3022	-0.1044	0.3475
segc	-0.333	0.3354	0.5737	0.4476
sta	0.775	-0.2775	-0.0822	0.3157
pb	0.4744	0.2283	0.5257	0.4465
msmeiuse	0.6122	0.5200	-0.3535	0.2299
rtse	0.4893	0.2419	0.6660	0.2585
sep	-0.0538	0.7795	-0.0669	0.3850

The eigenvalues explain factors in terms of variability such that only three components i.e., Ec, sea, segc were retained because their eigenvalues are greater than 1 (Table VII). This indicates that the main factors hindering manufacturing MSMEs' use of solar energy falls in the three constructs i.e., environmental concern (Ec): staff/employers' concern about air pollution resulted from energy use, staff/employers' concern about climate change, staff/employer concern about source of energy which do not deteriorate the quality of ecosystem – biodiversity, decline of animal species, staff/employer's concern on water/land pollution caused by energy use by MSME's and staff/employer's concern about waste reduction); solar energy awareness (sea): Experience in previous use of solar energy, awareness of solar PV use and needs/benefits, understanding of different types of solar PV which can be used at industry, availability of technical solutions for solar PV and awareness of the benefits-costs of solar PV; and solar energy generation cost (segc): The generation of solar energy may cause additional cost, Solar energy requires high initial investment cost, Solar energy consumption needs a high Set-up & installation cost, and Solar PV systems requires high repair cost. These results are in-line with Lowe & Drummond, (2022) high rates of growth appear likely to continue. In this paper we use 'top-down' extrapolation of global trends and simple and transparent models to attempt to falsify the proposition that PV and wind have the potential to achieve dominance in global primary energy supply by 2050. We project future deployment of PV and wind using a logistic substitution model, and examine a series of potentially fundamental constraints that could inhibit continued growth. Adopting conservative assumptions, we find no insuperable constraints across physical and raw materials requirements, manufacturing capacity, energy balance (EROEI study about global wind and solar energy supply, which revealed that use of renewable energy for different industrial purposes is hindered by various social (e.g., health impacts of the energy use for different industrial purposes), economic (e.g., high investment cost), and environmental (e.g., emission of GHGs) factors. These barriers to solar energy use not only resulted into social, economic and environmental problems but also delayed the growth and development of the manufacturing sector in Tanzania.

For example, Rocco et al., (2020)together with a low electrification rate, are a limitation to growth, this paper studies the implications on the country's sustainable development of expanding the electricity sector. The analysis is based on the joint use of the OSeMOSYS open-source power system optimization model and the Leontief Input-Output model (based on the Tanzanian Social Accounting Matrix found that lack of infrastructure for hydro-electric generation is the main cause of low electrification rate and ultimately has limited the growth of manufacturing sector in the country. With the industrialization strategy in Tanzania access to clean, affordable and reliable energy source is critical since it the only way manufacturing industries can improve its operational performance i.e., ensure quality products, reduced cost of production and idle time, increase productivity, and achieve production flexibility. These will ensure a competitive position of the manufacturing MSME's in the local and international markets due to low production cost and ability to set a competitive selling price as well as compliance to the global standards like assurance of environmental performance of manufactured after use e.g., eco-labelling. In addition, the proportions explain the contribution of each factor in the model whereby factor1 (i.e., environmental concern) contribute about 26.36% of the total variance, which is the strongest factor. Also, uniqueness explains the percentage of variance for the factor that is not explained by the common factors. Also, Table VII revealed that all values are not greater than 0.6 which implies that these values are considered low. Therefore, the higher the uniqueness, the more likely that it is more than just a measurement error. Factor rotation maintains that factor 1 (i.e., the environmental concern) is the strongest factor with a proportion of 25% (Table VIII.

TABLE VIII: FACTOR ROTATION

Factor analysis/correlation			Number of obs = 221	
Method: Principal-component factors			Retained factors = 3	
Rotation: Orthogonal varimax (Kaiser off)			Number of params = 21	
Factor	Variances	Difference	Proportion	Cumulative
Factor1	1.9705	0.28614	0.2463	0.2463
Factor2	1.68436	0.11915	0.2105	0.4569
Factor3	1.56521		1957	0.6525
LR test: independent vs. saturated: chi2(28) = 353.08, Prob>chi2=0.000				
Rotated factor loadings (pattern matrix) and unique variances				
Variable	Factor1	Factor2	Factor3	Uniqueness
Ec	-0.0918	0.7921	-0.1214	0.3494
sea	0.7915	-0.02	0.1602	0.3475
segc	-0.6041	-0.0579	0.4292	0.4476
sta	0.8024	-0.0004	0.2014	0.3157
pb	0.1433	0.0803	0.7256	0.4465
msmeiuse	0.4124	0.7615	0.142	0.2299
rtse	0.1064	0.0325	0.8539	0.2585
sep	-0.3535	0.6825	0.1559	0.385
Factor rotation matrix				
	Factor1	Factor2	Factor3	
Factor1	0.8513	0.2577	0.4571	
Factor2	-0.4215	0.8546	0.3033	
Factor3	-0.3125	-0.4509	0.8361	

Table IX presents the predicted values based on the varimax rotated loadings of the variables by a regression method.

TABLE IX PRINCIPLE COMPONENT PREDICTED VALUES

Predict factor 1, factor 2, factor 3 (regression scoring assumed) Scoring coefficients (method=regression; based on varimax rotated factors)			
Variables	Factor1	Factor2	Factor3
Ec	0.03963	0.48426	-0.12607
sea	0.3967	0.02452	0.04462
segc	0.34591	0.06233	0.33393
sta	0.39903	0.01556	0.06958
pb	0.01692	0.00092	0.46113
msmeiuse	0.20042	0.44704	0.00984
rtse	0.01211	0.03818	0.55167
sep	0.19649	0.4003	0.08449

The results (Table X) revealed that the mean score regarding factors hindering manufacturing MSMEs' use of solar energy to be 2.79, and a standard deviation of 0.38. Also, the means score of the factors hindering solar energy deployment revealed a normal distribution curve (Figure 2).

TABLE X: MEAN SCORE OF THE FACTORS HINDERING USE OF SOLAR ENERGY

Summarize: SE_Deployment, detail				
SE_Deployment				
	Percentiles	Smallest		
1%	1.94375	1.541667		
5%	2.270833	1.57619		
10%	2.43125	1.94375	obs	242
25%	2.535417	1.972917	Sum of wgt	242
50%	2.7125		Mean	2.786757
		largest	Std. Dev	0.3818454
75%	3.04375	3.7125		
90%	3.30625	3.7125	variance	0.1458059
95%	3.40000	3.7125	skewness	0.2019058
99%	3.71250	3.8750	kurtosis	3.365797

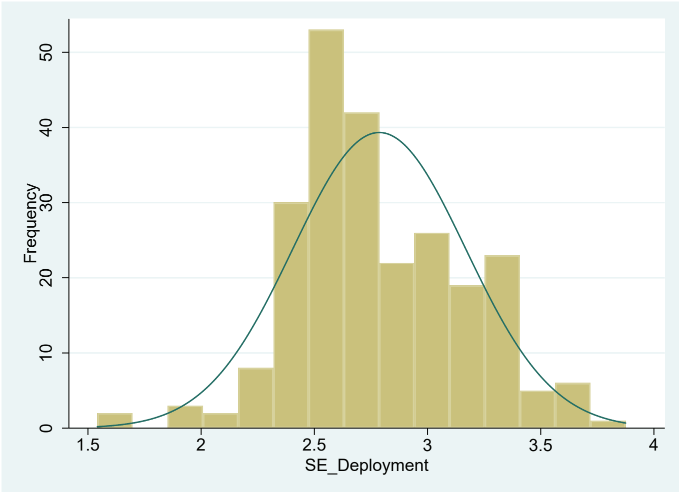

Figure 2: Distribution of factors hindering solar energy

IV. CONCLUSION

The main objective of this study was to determine drivers for, and barriers to solar energy use by manufacturing MSME's in the selected districts in Morogoro region. As the first study to model drivers for, and barriers to solar energy use by manufacturing MSME's in Tanzania, the main drivers for solar energy use were established by using the SEM. The results revealed that drivers for manufacturing MSME's deployment of solar energy for different operations includes the environmental concern, solar energy awareness, energy generation cost, technological advancement, benefits of solar use, and risk perceptions. In this regard, manufacturing MSME's management have significant influence on deployment of solar energy for different industrial operations. For example, the extent to which top management and leaders, are exposed to the cost and benefits of renewable energy, determines decisions made for solar energy use, and even approve education programme to the staff about renewable energy technologies. In addition, SEM results indicates that there are three main factors that hinder deployment of solar energy by manufacturing MSME's including environmental concern, solar energy awareness, and solar energy generation cost.

As far as solar energy generation cost is one of the factors hindering MSME's deployment of solar energy, effective policy could involve offering tax subsidy to renewable energy production facilities i.e., machines and equipment; together with enforcement of National Environmental Management Act of Tanzania and its regulations like the sub-section which states about "polluter pays principle" for industries to strictly use energy sources that are environmentally friendly. The SEM results therefore, provides critical information to energy policymaking instruments in Tanzania about drivers for and barriers to solar energy deployment by manufacturing MSME's and make informed decisions about renewable energy technologies to be considered for investment in Tanzania.

ACKNOWLEDGEMENTS

This study was supported by VLIR-UOS Project 3, Mzumbe University, Tanzania.

REFERENCES

[1] K. A. Ali, M. I. Ahmad, and Y. Yusup, "Issues, impacts, and mitigations of carbon dioxide emissions in the building sector," *Sustainability (Switzerland)*, vol. 12, no. 18, 2020, doi: 10.3390/SU12187427.

[2] L. Chen, V. Savalei, and M. Rhemtulla, "Two-stage maximum likelihood approach for item-level missing data in regression," *Behav Res Methods*, vol. 52, no. 6, 2020, doi: 10.3758/s13428-020-01355-x.

[3] L. M. Connelly, "Cross-Sectional Survey Research," *MEDSURG Nursing Journal*, vol. 25, no. 5, p. 369, 2016.

[4] "Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC ," *Official Journal of the European Union*, vol. L 140, no. 16, pp. 16–42, 2009.

[5] Z. Liu, Z. Deng, S. J. Davis, C. Giron, and P. Ciais, "Monitoring global carbon emissions in 2021," *Nat Rev Earth Environ*, vol. 3, no. 4, pp. 217–219, Mar. 2022, doi: 10.1038/s43017-022-00285-w.

[6] J. Elasu, J. M. Ntayi, M. S. Adaramola, and F. Buyinza, "Drivers of household transition to clean energy fuels: A systematic review of evidence," *Renewable and Sustainable Energy Transition*, vol. 3, 2023, doi: 10.1016/j.rset.2023.100047.

[7] I. M. Eleftheriadis and E. G. Anagnostopoulou, "Identifying barriers in the diffusion of renewable energy sources," *Energy Policy*, vol. 80, 2015, doi: 10.1016/j.enpol.2015.01.039.

[8] A. S. M. M. Hasan, M. A. Kabir, M. T. Hoq, M. T. Johansson, and P. Thollander, "Drivers and barriers to the implementation of biogas technologies in Bangladesh," *Biofuels*, vol. 13, no. 5, 2022, doi: 10.1080/17597269.2020.1841362.

[9] Niklas Höhne *et al.*, *A possible 2050 climate target for the EU*. Cologne: NewClimate Institute, 2019. [Online]. Available: https://newclimate.org/sites/default/files/2019/09/EU2050_Target_Adequacy.pdf

[10] C. L. O. Peters and C. Enders, "A primer for the estimation of structural equation models in the presence of missing data: Maximum likelihood algorithms," *Journal of Targeting, Measurement and Analysis for Marketing*, vol. 11, no. 1, 2002, doi: 10.1057/palgrave.jt.5740069.

[11] R. J. Lowe and P. Drummond, "Solar, wind and logistic substitution in global energy supply to 2050 – Barriers and implications," *Renewable and Sustainable Energy Reviews*, vol. 153. 2022. doi: 10.1016/j.rser.2021.111720.

[12] F. S. Lyakurwa, "Achieving Sustainability in Manufacturing Micro, Small and Medium Enterprises (MSMEs') in Tanzania Through Adoption of Solar Energy," *Journal of Industrial Engineering and Halal Industries*, vol. 3, no. 2, pp. 77–89, 2022, doi: doi.org/10.14421/jiehis.3853.

[13] F. S. Lyakurwa and E. Mkuna, "Political-institutional barriers to energy access and efficiency in Tanzania: a case study of Mvomero District," *Afrika Focus*, vol. 31, no. 1, 2018, doi: 10.21825/af.v31i1.9045.

[14] L. Ren, S. Zhou, T. Peng, and X. Ou, "A review of CO2 emissions reduction technologies and low-carbon development in the iron and steel industry focusing on China," *Renewable and Sustainable Energy Reviews*, vol. 143, p. 110846, Jun. 2021, doi: 10.1016/j.rser.2021.110846.

[15] *Tanzania in Figures 2012*. National Bureau of Statistics Ministry of Finance, 2013. [Online]. Available: https://www.nbs.go.tz/nbs/takwimu/references/Tanzania_in_figures2012.pdf

[16] M. Sahoo, "Structural Equation Modeling: Threshold Criteria for Assessing Model Fit," in *Methodological Issues in Management Research: Advances, Challenges, and the Way Ahead*, 2019. doi: 10.1108/978-1-78973-973-220191016.

[17] C. Saleh, T. Immawan, A. B. Hassan, and M. N. Zakka, "Profit Optimization Through the Application of Theory of Constraints (TOC): A Case Study in Printing Company," in *IOP Conference Series: Materials Science and Engineering*, 2019. doi: 10.1088/1757-899X/530/1/012045.

[18] C. A. Schoeneberger, C. A. McMillan, P. Kurup,

S. Akar, R. Margolis, and E. Masanet, “Solar for industrial process heat: A review of technologies, analysis approaches, and potential applications in the United States,” *Energy*, vol. 206. 2020. doi: 10.1016/j.energy.2020.118083.

[19] Seetharaman, K. Moorthy, N. Patwa, Saravanan, and Y. Gupta, “Breaking barriers in deployment of renewable energy,” *Heliyon*, vol. 5, no. 1, 2019, doi: 10.1016/j.heliyon.2019.e01166.

[20] D. Shi, T. Lee, and A. Maydeu-Olivares, “Understanding the Model Size Effect on SEM Fit Indices,” *Educ Psychol Meas*, vol. 79, no. 2, 2019, doi: 10.1177/0013164418783530.

[21] H. K. Sjølie, “Reducing greenhouse gas emissions from households and industry by the use of charcoal from sawmill residues in Tanzania,” *J Clean Prod*, vol. 27, 2012, doi: 10.1016/j.jclepro.2012.01.008.

[22] L. J. Sonter and S. Kemp, “Connecting the UNESCO Sustainable Development Goals with Australian Early Childhood Education Policy to Transform Practice,” *International Journal of Early Childhood Environmental Education*, vol. 9, no. 1, 2021.

[23] U. R. of Tanzania, “National Strategy for Growth and Reduction of Poverty II: NSGRP II,” *Ministry of Finance and Economic Affairs Tanzania*, no. July, 2010.

[24] J. Tollefson, “IPCC climate report: Earth is warmer than it’s been in 125,000 years,” *Nature*, vol. 596, no. 7871, 2021, doi: 10.1038/d41586-021-02179-1.

[25] URT, “The Tanzania Development Vision 2025,” *Ministry of Planning*. 2000.

[26] URT, “National Five Year Development Plan 2021/22-2025/26: Realising Competitiveness and Industrialisation for Human Development,” *The United Republic of Tanzania*, no. June, 2021.

[27] W. A. Van der Stede, “A manipulationist view of causality in cross-sectional survey research,” *Accounting, Organizations and Society*, vol. 39, no. 7, 2014, doi: 10.1016/j.aos.2013.12.001.

[28] S. L. Zulu, M. Chabala, and E. Zulu, “Perceptions and beliefs influencing intention to use solar energy solutions in Zambian households,” *Built Environment Project and Asset Management*, vol. 11, no. 5, 2021, doi: 10.1108/BEPAM-01-2021-0010.