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Dominant factors for solar energy choice by Manufacturing Micro, Small and Medium Enterprises (MSMEs') in Tanzania

Felichesmi Lyakurwa[1]

[1]Department of Engineering Management Studies, Mzumbe University, Po Box 87, Morogoro, Tanzania

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abstract

Energy demand by manufacturing industries has increased significantly whereby fossil fuels consumption is dominant. Increased concern over resource depletion, and environmental impacts, suggests future dependence on renewable energies. Tanzania is blessed with abundant solar energy and its exploitation may contribute to increased energy access. Despite the paybacks of renewable energy, studies on the exploration of the dominant factors for energy choice by manufacturing MSME's are scarce. This study explored the dominant factors for solar energy choice by manufacturing MSME's. Questionnaires were used to collect data (n = 236) from employees in manufacturing MSMEs' whereby descriptive and multinomial probit (MNP) model were employed to establish the dominant factors. The findings of MNP revealed that not expensive energy, and other factors (e.g., availability of solar appliances) have significant influence on solar PV use, while the adoption of hydro-electricity was significantly influenced by not expensive and advised to use energy. Easy access, and not expensive have significant influence on fossil fuels. The Confirmatory Factor Analysis (CFA) results revealed that all factors (i.e., environmental, social, and economic) have significant influence on workers perception of sustainable manufacturing. These findings provide critical information for policy making instruments in Tanzania for informed decisions in the formulation of policies in the utilization of renewable energy technologies.

Introduction

Today, energy is not only a basic need, but also an important variable for the satisfaction of all human needs as the magnitude of energy use is necessary for social-economic development (Urbano et al., 2021). Energy sources are categorised into conventional, and renewables. The former refers to energy generation from nonrenewable sources like fossil fuels, which contribute greatly to climate change, and global warming such that majority countries have introduced policies that promote renewable energy technologies. The latter is energy generation from different renewable sources including biomass, sunlight, biogas, wind, geothermal, and hydropower. Renewable energy sources have been broadly used for various industrial purposes namely electricity generation, space heating, and off-grid especially for rural energy i.e., lighting, mobile phones charging, and powering machines (Lyakurwa and Mkuna, 2019; Kumar & Majid, 2020). To date, the global energy use statistics show that industrial sector use more delivered energy than other end-use sectors that consume about 54% of the world's total energy (IEO, 2016).

The global energy demand has been triggered by several factors including energy intensity of manufacturing sector, population growth, as well as a country's implementation of industrialization's agenda. The International Energy Outlook report (IEO, 2021) shows that global energy demand has increased from 470 in 2010 to 610 British thermal units (Btu) in the year 2020 such that predictions for the year 2050 stands at 820 Btu in which consumption of nonrenewable energy is dominant. Reliance on nonrenewable energy sources for industrial uses does not only threaten the efforts to realize the Sustainable Development Goals (SDGs: 7) that promotes access to safe, reliable, and affordable energy, but also affects a society's participation in the social-economic activities.

* Corresponding author.
E-mail addresses: felichesmi.lyakurwa@mu.ac.tz (F. Lyakurwa).

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According to Stern (2006), despite the fact that fossil fuels have significant contribution to the world's economic growth, they release Green House Gasses (GHGs) into the atmosphere and this contributes significantly to climate change and global warming. EPA (2021) documented that the global CO_2 emissions caused by burning fossil fuels has increased from 500 to 10,000 million metric tons in 1900's and 2010's respectively.

Moreover, increased concern about over-resource depletion, environmental impacts, and increased energy price suggests future reliance on renewable energy sources for different uses (Worrell et al., 2009; Höök and Tang, 2013; URT, 2021). Despite the fact that the world is blessed with many renewable energy sources, only 16% of total energy consumption is derived from renewable energy sources while traditional biogas contributes 10%, 3.2% hydroelectric power, and other renewable energy sources contributing 2.8% (UNEP, 2011). In the world, the total energy supplied by energy sources mostly comes from fossil fuels especially oil (34.6%), coal (28.4%), and natural gas (22.1%) while renewable energy generates 12.9% (IPCC, 2012). Based on the health effects of fossil fuels, and inadequate access to clean, reliable, and affordable energy, many countries in the world have invested heavily in renewable energy. Accordingly, developing countries outpace developed countries on renewable energy investment and in 2019, a total of $152.2 billion was invested compared to the $130 billion investment in developed countries (UNEP, 2020). Though there is a substantial increase in renewable energy investment in developing and middle-income countries of which large finance is on solar energy, China and India have lowered their investment. Many countries in Africa have attained the highest level of investment in renewable energy excluding South Africa where the total investment is elevated from $750 million to $3.6 billion due to strong performance which was realized by some countries like Egypt (UNEP, 2011).

In order to increase access to safe energy, and in compliance with the SDGs, the government of Tanzania has invested a total of $112.4 million for off-grid energy generation in the past twelve (12) years ranging 2007-2019 (IRENA & CPI, 2020). Despite the substantial investment in renewable energy technologies, its adoption is inadequate. Hence, Worrell et al. (2009), and Urbano et al. (2021) suggest a total transformation by manufacturing industries from use of fossil fuels to renewable energy. This situation has been triggered by ever-increased fuel price, human health problems, and inadequate access to the national electric grid. It was also identified by OECD (2018) that small and medium enterprises especially in manufacturing sector have high environmental footprints contributing 60 - 70% of industrial pollution in Europe, and thus, switching from fossil-fuels to renewable energy is necessary. Tanzania as other developing countries in Africa, is blessed with renewable and non-renewable energy resources and produces a good amount of natural gas, and coal for power generation. According to Bonjour et al. (2013), more than 85% of the total population in Tanzania use traditional fuel for different uses.

Bishoge et al. (2018) showed that, the electrification by source of energy in Tanzania follows the pattern of 75% households being electrified by the national energy grid, 24.7% with solar energy, and 0.3% by individual energy generated from other sources including small generators. These results indicate the potential of solar PV towards an increase of energy access particularly, in communities in the rural areas of Tanzania. In addition, the Africa Energy Outlook Report of year 2019 shows that, the African continent has the richest solar resources in the world; however, only 5 gigawatts of solar PV installed which is less than 1% of the global installed capacity (AEO, 2019). In Tanzania, solar home systems, and small-scale commercial systems contribute 75% of solar PV installed capacity which is very significant to the National Solar Market (Ondraczek, 2013). In 2008, about 40,000 solar home systems were installed such that its annual sales ranged between 4,000 and 8,000 units (IRENA, 2017). Tanzania has also very high levels of solar energy intensity, ranging from 2,800 to 3,500 hours of sunshine annually, and a global radiation of 4 to 7 kWh per square meter per day and its exploitation may contribute to the national energy access (Sarakikya, 2015; TIB, 2021).

Aslam et al. (2021) documented that many African governments including Tanzania, can increase households with access to clean, reliable, and affordable energy via the utilization of renewable energy sources mainly solar energy which is readily available. Bishoge et al. (2018) added that, renewable energy can increase employment opportunities in Tanzania from 10.3 million in 2017 to 24 million by 2030. In spite of the chances available to exploit renewable energy, studies to establish factors that affect choice of solar energy by manufacturing MSME's are inadequate. This has brought several probing questions on the guiding factors for the manufacturing MSME's choice of solar energy for different industrial applications. And also, whether employees working at different levels in the manufacturing industry (i.e., strategic, tactical and operational), have positive/negative perception about sustainable manufacturing practices and why. This study therefore, was intended to establish the dominant factors for solar energy choice by manufacturing MSME's, and workers' perceptions about sustainable manufacturing practices.

Theoretical Framework

This study followed the Innovation Decision Process Theory, which is amongst the four theories of diffusion discussed by Rogers (1995) and these are innovation decision process, individual innovativeness, rate of adoption, and perceived attributes. Baregheh et al. (2009) explains innovation as a continuous process through which ideas have been transformed into new, improved, and changed entities i.e., goods and/or services. The theory describes diffusion as a process which occurs over-time in five different phases namely knowledge, persuasion, decision, implementation, and confirmation. Following the Rogers' innovation decision theory, a manufacturing MSME can leave the innovation decision process at any phase i.e., knowledge, persuasion, decision, implementation or confirmation. Also, beyond the five phases of the process, the theory specifies prior conditions that are critical for the adoption of any innovation including previous practice, perceived needs or problems, and innovativeness of the manufacturing MSME's. The theory also distinguishes between knowing an innovation exists, knowing the appropriate use of the innovation, and knowing why a certain strategy works in a particular environment. In addition, this theory outlines factors which influence a manufacturing MSME's favorable or unfavorable attitude towards the innovation (e.g., solar energy) like the relative advantage of innovation, the compatibility of the innovation with current beliefs and practices, complexity of the innovation, how easy it is to try the innovation, and whether the manufacturing MSME can benchmark with her immediate competitor to make informed decisions.

Rogers (2003) defines diffusion as a process by which an innovation is communicated through certain channels over time amongst members of a social system whereby theoretical foundation of diffusion is based on four discrete elements such as innovation, communication channels, time, and social systems. This theory contends that all potential adopters of innovation should learn about concerned innovation, persuade advantages of that innovation, decide to adopt, implement, and reaffirm or reject the choice to innovation. Many population groups, and individuals perceive the same innovation differently because of some characteristics including relative advantage in which attributes which adopters seek in a new technology or the degree to which innovation is perceived better than existing idea (Eder et al., 2015). Greenhalgh et al. (2004) revealed that all potential users will not consider the innovation if they do not see its relative advantage which is measured in economic returns, and social benefits especially the users' satisfaction as well as its environmental performances. Similarly, the innovation decision process theory applies to the situation where a manufacturing MSME needs to make a decision in choosing an alternative energy source including solar energy because before they decide to use, firstly, they conduct research with the aim of understanding the social-economic, and environmental benefits of the energy source to use. These understandings of the energy source, such as selection of energy source which has the highest utility, guides the way such that once they find different situation (e.g., low utility) rejects the innovation. For example, other studies have documented that a household's decision to deploy renewable energy is determined by several factors including energy efficiency, accessibility and availability of the appliances, serviceability or repair of the system, and investment cost, among others (Lyakurwa & Mkuna, 2019; Lia & Li, 2023). Hence, the innovation decision process theory is relatively complex especially in the developing countries since understanding the perceptions of adopters, that is, early adopters, early majority, later majority and laggards is critical. The study therefore intended to follow the Innovation Decision Process theory to establish dominant factors for the choice of solar energy by manufacturing MSME's in Tanzania.

Material and methods

Study area

This study was conducted in Mvomero, Morogoro Municipal council, Kilombero, and Kilosa district councils in the Morogoro region of Tanzania. Morogoro region is located at latitudes 6.8278°South of equator, and longitudes 37.6591° East of Greenwich Meridian. The region covers an area of 70,624 Sq. Kms, with a total population of 2,218,492, and household size of 4.4 (URT 2013). Morogoro region was selected for this study because majority of its households are livestock keepers, and farmers whose produce requires value addition by Manufacturing MSME's. The URT (2012) has classified enterprises into four distinct groups according to number of employees, or total investment, and/or sales turnover (Table 1).

Table 1: Groups of Micro, Small, Medium and Large Enterprises

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

Source: URT, (2012)

The region was also selected because of the abundant renewable energy sources there including solar PV, biomass, biogas, wind and hydro power, among others. Though the region is blessed with different renewable energy sources, majority of the districts in the region experience scarce access to clean, reliable, and affordable energy, a situation which has made them to rely on non-renewable energy for various industrial processes. The reliance on the non-renewable energy mainly fossil fuels may be a sign of 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 II), the SGDs, and the Tanzania Development Vision 2025 (URT, 1999; URT, 2010; URT, 2021; Sonter & Kemp, 2021). Therefore, establishing dominant factors for choice of solar energy by manufacturing MSME's is crucial in achieving the NSGRP, SDGs, Tanzania vision 2025, and the National Five-Year Development Plan 2021/2 -2025/26.

Research design

A cross sectional survey research design was employed to explore factors for selection of solar energy by manufacturing MSMEs in Tanzania. Krishnaswami & Ranganathan (2005) and Ndunguru (2007) stipulated that this design enables one to collect large quantity of data at one location in time, and in an economical way. Also, Yin (2003) supported the method arguing that, a cross sectional survey design is mostly appropriate when the study intends to answer the questions of who, what type, where, how many, and how much questions, as can be observed in this study.

Data sources and collection process

This study targeted workers in the manufacturing MSMEs located in Mvomero, Morogoro Municipal council, Kilombero and Kilosa district councils of Morogoro region. A structured questionnaire, interviews and focus group discussions were employed to collect primary data (i.e., a sample size *(n)* of 236 enterprises) from working staff in the manufacturing MSMEs in Morogoro region. Multistage sampling technique was also applied in the choice of a representative manufacturing MSMEs in the selected districts such that descriptive, and inferential statistical methods i.e., multinomial probit (MNP) models, ANOVA, and Structural Equation Modeling (SEM) through Confirmatory Factor Analysis (CFA) technique were applied in the data analysis.

Data analysis

Modeling choice of solar energy by manufacturing MSMEs

MNP models have been widely used in modeling discrete choices such as choice of a particular voter in a multiparty election (Michael & Nagler, 1998), choice of graduation year by high school students (Jepsen 2008), the household choice of fuelwood (Jumbe & Angelsen, 2011), and household's choice of energy for cooking, heating, lighting and powering machines (Lyakurwa & Mkuna, 2019), because of the feasibility of predicted probabilities that can be obtained from a multiple choice. Therefore, this study has employed MNP model in favor of other probabilistic choice models including multinomial logit model (MNL) based on assumptions related to residual values. Usually, the MNL models assume residual values to be identical, and independently distributed whereby MNP models consider residual values, as independent, and normally distributed (Gido et al., 2016). The choice of solar energy is presented by a MNP model equation 1 as:

Energy Choices $(Y_{ir}) = \beta_0 + \beta_1 X_{1ir} + \beta_2 X_{2ir} + \ldots + \varepsilon_{ir}$ ……………………………… (1)

whereby Y_{ir} is a categorical value for energy choices, X_i represents energy use decision factors including easy to access, not expansive, energy efficiency, and advised to use, among others. Usually, energy choices considered in the districts include solar PV, hydro electric-power, and fossil fuels (i.e., diesel and coal) whereby it was assumed that, manufacturing MSMEs will use energy source with the highest utility.

Perceptions of workers about the sustainable manufacturing practices

The Structural Equation Model (SEM) through CFA technique was used to determine factors influencing workers' perceptions on sustainable manufacturing practices. According to Haroon et al. (2021), sustainable manufacturing practices are influenced by different factors like environmental (i.e., reduction of waste generation and pollution emission), social factors (i.e., the welfare of local community and employees, and obedience to government laws and regulations), and economic factors (i.e., reduced cost of solar items, increased productivity, and increased use of appropriate technology). The MNP model for the workers' perception on sustainable manufacturing is presented by equation 2 as follows:

Workers' Perceptions $(Y_{ir}) = \beta_0 + \beta_1 Env\_cons + \beta_2 Social\_fact + \beta_2 eco\_fact \ldots + \varepsilon_{ir}$ ……… (2)

where, Env_cons refer to the environmental concern, Social_fact means social factors and eco_fact refers to the economic factors.

The ANOVA test was also employed to test the hypothesis that, "Worker perceptions have significant influence towards implementation of sustainable manufacturing practices by manufacturing MSME's".

Results and Discussion

Descriptive results for the energy choice decision by manufacturing MSMEs'

Frequencies (N) and percentages (%) were obtained from descriptive results of the age, gender, reason for energy choice, and working experience of the working staff in the manufacturing MSMEs. The findings (Figure 1) indicated that out of 232 respondents (i.e., workers working at different levels in the surveyed manufacturing MSME's), about 168(72%) were males and 64 (28%) females. The results imply that majority of the working staff in the manufacturing MSMEs were males because of the nature of tasks performed which are masculine, and requires an energetic person. Regarding the age of working staff, out of 236 respondents, 38(16%) aged between 18-24, 83(35%) aged 26-31, 80(34%) aged32-38 and 35(15%) were found to age > 39 years. The results show that many working staff ages, range between 26-38 years, an energetic age group and matured to work in industries that require masculine people.

Figure 2 presents workers' experience in the manufacturing MSMEs. Out of 218 working staff, 91(41.7%) of the workers have a working experience of 1-5 years, while 78(35.8%) have a working experience of 6-10 years, 19(8.7%) with a working experience of 11-15 years while 11(5%) staff were found to have a working experience more than 16 years.

Figure 1: Respondents' age and gender

Figure 2: Workers' experience

In relation to manufacturing MSMEs' motive for selection of energy source, the findings (Table 2) documented that energy efficiency is the main factor for the choice of natural gas 138(63%), hydro-electric energy146(63.2%), solar PV 115(62.2%), and fossil fuels 140(65.7%) for a diverse industrial use (e.g., lighting, heating and powering machines). Hence, energy efficiency is the main guiding factor for the energy choice decision by manufacturing MSMEs followed by easy to access the specific energy source. Also, the findings showed that easy access to the energy source ranked number 2 after energy efficiency and the scores in each energy source were: natural gas 54(25%), hydro-electric power 57(24.7%), solar PV 43(23.2%) and 50(23.5%), for the fossil fuels.

Table 2: Descriptive results for energy choice decisions by manufacturing MSMEs’

S/No.	Variable measure /Reason for choice	N	%	Rank
Natural gas	Energy efficiency	138	63	1
	Easy to access	54	25	2
	Not expensive	16	7	3
	Advised to use	7	3	4
	Others	3	1	5
Total		218	100	
Hydro-electric power	Energy efficiency	146	63.2	1
	Easy to access	57	24.7	2
	Not expensive	17	7.4	3
	Advised to use	7	3.0	4
	Others	4	1.7	5
Total		231	100	
Solar PV	Energy efficiency	115	62.2	1
	Easy to access	43	23.2	2
	Not expensive	16	8.6	3
	Advised to use	6	3.2	4
	Others	5	2.7	5
Total		185	100	
Fossil fuel	Energy efficiency	140	65.7	1
	Easy to access	50	23.5	2
	Not expensive	17	8.0	3
	Advised to use	3	1.4	4
	Others	3	1.4	5
Total		213	100	

*N = frequency, Percent = %

Table 3: MNP model for choice of natural gas

Log likelihood =-100.62923

Variable		coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Easy_to_access							
	ng	0.236517	0.501953	0.47	0.638	-0.74729	1.220327
	_cons	-0.47207	0.450927	-1.05	0.295	-1.35586	0.411732
Not _expensive							
	ng	0.814183	0.719432	1.13	0.258	-0.59588	2.224245
	_cons	-1.66931	0.672017	-2.48	0.013	-2.98644	-0.35219
Energy efficiency		(base outcome)					
Advised_to_use							
	ng	12.50921	0.320198	39.07	0	11.88163	13.13678
	_cons	-13.9302	.	.	.	.	.
Others							
	ng	-13.3324	.	.	0	.	.
	-cons	-1.13835	0.541432	-2.1	0.036	-2.19954	-0.07717

MNP results indicated that majority of the manufacturing industries use natural gas because of energy efficiency (P_{value} < 0.05), advised to use (P_{value}=0.001), and other factors (P_{value} < 0.005) (Table 3). The findings imply that manufacturing MSMEs use energy source which have the highest efficiency, and usually, they have prior information about the energy source to use for different industrial applications. Moreover, other factors than easy to access the energy source, not expansive, energy efficiency and advised to use were found to contribute significantly to the manufacturing industry’s use of natural gas. The results agree with the innovation decision process theory which postulates that an individual will adopt a new technology after being aware of its costs (e.g., investment costs, risks in use) and benefits (e.g., efficiency and effectiveness, no human health effects, affordability, easy to repair). These findings are similar to those established by Mathur et al. (2022) who documented that natural gas has many benefits towards industrial applications like lower capital investment, and operating costs, high energy efficiency, as well as lower GHG emissions than other fossil fuels.

The MNP model for choice of solar PV by manufacturing MSMEs’

As explained by equation 1, the MNP results indicated several guiding factors for manufacturing MSME’s choice of solar PV in different industrial processes (Table 4).

Table 4: MNP model for choice of solar PV

MNP regression				Number obs=219			
Log likelihood = -215.99589				Chi2 (4) = 1528.64			
				Prob> chi2 = 0.000			
Variable		Coef.	Std. Err.	z	P> |Z|	[95% Conf. Interval]	
Easy_to_access							
	spv	-0.24649	0.298951	-0.82	0.410	-0.83242	0.339442
	_cons	-0.5967	0.259223	-2.3	0.021	-1.10477	-0.08864
Not _expensive							
	spv	1.093297	0.63572	1.72	0.085	-0.15269	2.339286
	_cons	-2.58183	0.608194	-4.25	0.000	-3.77387	-1.3898
Energy efficiency		(base outcome)					
Advised_to_use							
	spv	0.515517	0.620602	0.83	0.406	-0.70084	1.731874
	_cons	-2.48439	0.574719	-4.32	0.000	-3.61082	-1.35796
Others							
	spv	10.37764	0.267734	38.76	0.000	9.852891	10.90239
	-cons	-12.5692	.	.	.	.	.

Table 5: MNP model for choice of Hydro-electric power

MNP regression				Number of obs=216			
Log likelihood = -205.47117				Chi2 (4)=3175.96			
				prob>chi2 = 0.000			
Variable		Coef.	Std. Err.	z	p>|z|	[95% Conf. Interval]	
Easy to access							
	hep	-1.27843	0.98297	-1.3	0.193	-3.20522	0.6481678
	_cons	0.51929	0.97434	0.53	0.594	-1.39038	2.428971
Not expensive							
	hep	8.89449	0.17668	50.34	0.000	8.548189	9.240795
	_cons	-10.5476	.	.	.	.	.
Energy efficiency		(base outcome)					
Advised_to_use							
	hep	9.09974	0.28194	32.27	0.000	8.547145	9.652348
	_cons	-11.5434	.	.	.	.	.
Other							
	hep	-2.48341	1.06738	-2.33	0.020	-4.57544	-0.3913865
	_cons	0.17297	1.03608	0.17	0.867	-1.85773	2.203667

The MNP model results (Table 4) for manufacturing MSMEs' choice of solar PV for diverse industrial applications revealed that the reason not expensive (P_{value}=0.085), energy efficiency (P_{value}<0.05)' and other factors than (P_{value}<0.05) have significant influence on manufacturing MSMEs' choice of solar PV for different uses. It implies that the cost of solar PV appliances, energy efficiency, and other factors such as utility, availability, and reliability of solar appliances are the main drivers for the choice of solar. The results therefore, agree with the innovation decision process theory that an individual will implement new innovation, if it will have more advantages than disadvantages as shown by the results that solar energy choice is determined by affordability (not expensive) and energy efficiency. The results revealed that solar energy adoption brings several benefits like environmental conservation, human health problems, increased access to reliable, affordable and clean energy compared to the traditional as well as fossil fuels. Also, solar energy adoption can be seen from different user categories including innovators, early adopters, early majority, late majority and laggards. All these concepts are well explained by the Innovation Diffusion Theory. In addition, these findings are similar to the United States future energy (US, 2021) report which indicated that apart from greening the environment, utilization of solar energy by manufacturing industries creates more jobs, savings of hydro-electricity, as well as increase access to safe, clean and reliable energy.

The MNP model for choice of Hydro-electricity by manufacturing MSMEs'
The findings (Table 5) of MNP model presented by equation 1 revealed that reason not expensive, energy efficiency, and other reasons than have P_{values} < 0.05, while advise to use by experts or friends has a P_{value}=0.020. The results imply that those factors have significant influence on industry's choice of hydro-electric power for different activities. Also, easy access to hydro-electric power do not have significant influence (P_{value}=0.193) on the manufacturing MSME's choice of this energy. The findings are in line with the study of Nasir (2014) which found that hydro-electric power is chosen for industrial uses due to its high energy efficiency, clean, affordable and reliable, although it requires high initial investment cost. Considering the accrued benefits of hydro-power, a study by Lyakurwa & Mkuna (2019) has suggested that governments should endorse taxi subsidy on electricity bills as well as the connection charges.

The MNP model for choice of fossil fuel by manufacturing MSMEs'

The findings (Table 6) of the MNP model explained by equation 1 for the manufacturing MSMEs' choice of fossil fuels for various industrial uses are presented. The findings showed that all factors in the model have significant influence on the manufacturing MSMEs choice of fossil fuels that is use of generators mainly for powering machines, and lighting. Also, the reason, due to easy to access has a P_{value}=0.006, while not expensive, energy efficiency, advised to use, and other factors were documented to have P_{value}<0.05. Looking at the results, there is a lot of sense, and meaning considering that diesel generators are used in the majority manufacturing MSMEs in Tanzania, and provides useful information to energy policy making and planning organs in Tanzania, particularly, in the formulation of strategies for effective deployment of renewable energies for manufacturing sustainability. These findings are similar to those of Branca (2021), where it is established that process industries in Europe in the past used fossil fuels to power industries due to energy intensity and efficiency.

The SEM model that is explained by equation 2 revealed three (3) factors particularly, environmental concern (Env_cons), social (social_fact), and economic factors (eco_fact) that determine workers' perceptions about sustainable manufacturing practices. It was assumed that there would be a single dominant factor whereas a number of factors were specified such that the covariance of the 3 factors is fully explained by the single latent variable plus the unique variance of each factor. The unique variance or error variance therefore, is being estimated for each of the three (3) observed indicator variables (Figure 3).

In the CFA, it was assumed that workers' perceptions about sustainable manufacturing practices should explain all the variance among three (3) factors. At first place, weak results were obtained such that stronger results will be obtained by removal of the measurement error given that the latent variables are subsequently used as independent or dependent variables in a SEM. This is because measurement error, by its nature, only adds noise to our measurement and thus, it lacks the explanatory power of the model. Hence, the CFA model was fitted by using a maximum likelihood estimation method whereby the variance-covariance matrix of the estimators was computed using an observed information matrix.

Table 6: MNP model for choice of fossil fuel

MNP regression

Log likelihood =-121.56643

Variable		Coef.	Std. Err.	z	p>|z|	[95% Conf.	Interval]
Easy_to_access							
	Ff	1.21928	0.441003	-2.76	0.006	-2.0836	-0.349319
	Cons	0.17044	0.40041	0.43	0.670	-0.61435	0.955282
Not expensive							
	Ff	11.3997	0.214415	53.17	0.000	10.979	11.81999
	_cons	-12.8905	.	.	.	.	.
Energy efficiency		(base outcome)					
Advised_to_use							
	Ff	-13.6426	.	.	0.000	.	.
	_cons	-0.43017	0.450816	-0.95	0.340	-1.3137	0.4534092
Others							
	Ff	-13.6368	.	.	0.000	.	.
	_cons	-0.87522	0.517976	-1.69	0.091	-1.8904	0.1399903

SEM for worker's Perception on Sustainable Manufacturing Practices

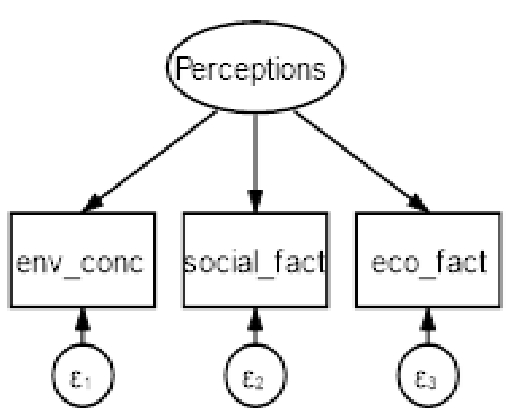

Figure 3: SEM Model for workers' perceptions on sustainable manufacturing

Table 7: SEM model fitting results

Structural equation model

Estimation method = ml

Log likelihood = -494.12628

envi_con. = 1

Measurement	Coef.	Std Err.	z	p>IzI	[95% Conf. Interval]	
envi_con.						
Perceptions	1 (constrained)					
cons.	2.060345	0.037854	59.73	0.000	1.992741	2.127948
social_fact						
Perceptions	1.117706	0.161706	6.91	0.001	0.800768	1.434643
cons.	2.497845	0.037854	65.99	0.000	2.423653	2.572036
eco-fact						
Perceptions	0.819108	0.120394	6.8	0.002	0.583141	1.055075
cons.	1.756897	0.035431	49.59	0.000	1.687453	1.82634

Table 8: ANOVA test

Sustainable practices	Mean	Std. Dev.	Freq.
No	1.970571	0.509669	73
Yes	2.047481	0.523656	106
Total	2.016115	0.517943	179

Analysis of Variance (ANOVA)

Source	SS	df	MS	F	Prob> F
Between groups	0.255708	1	0.255782	0.95	0.3303
Within groups	47.49551	117	0.268336		
Total	47.75121	178	0.268265		

Barlett's test for equal variances: chi2 (l) = 0.0620, Prob>chi2 =0.803

The model measurement components were mainly the environmental concern (env_conc.), social factors (social_fact) and economic factors (eco_fact) that were employed to measure endogenous latent variable (i.e., perceptions), representing the perceptions of workers about sustainable manufacturing practices (Table 7). The model vs. saturated chi-squared test indicates the model is fit. Hence, there is no any modification indices to report, since all modification indices values are less than 3.8414588820694123. The results of the model show that all factor loadings are statistically significant because all p_{value} are <0.005 which implies that all the indicator variables are significantly related to their respective factors. This means that workers' perceptions about sustainable manufacturing practices are determined by environmental concern (i.e., reduced use of resources and climate change impacts, improves the ecosystems supply of goods and service), social factors (i.e., improved welfare of employees and local community, livelihood staff/community), economic factors (i.e., increased productivity, reduced production cost and increased use of appropriate technology.

ANOVA test

Table 8 presents ANOVA test results for the hypothesis that workers' perception has significant influence on implementation of sustainable manufacturing practices by manufacturing MSMEs'

The ANOVA test revealed *F*-statistic of 0.95, and a corresponding P_{value}=0.3303, whereby given the P_{value} is > than alpha = 0.05, thus, does not reject the null hypothesis that "a worker's perceptions have a significant influence on implementation of sustainable manufacturing practices by manufacturing MSMEs' in Tanzania". This implies that, there is no statistically significant difference in the mean change in a worker's perceptions between at least two of the sustainable operational groups.

Conclusion

The dominant factors for the choice of solar PV by manufacturing MSME's for different uses were established. Since it is the first study to model dominant factors for manufacturing MSME's choice of solar PV in the selected districts in Morogoro region, the main decision factors were identified according to the MNP analysis. Energy efficiency, and not expensive were the factor triggering manufacturing MSME’s choice of solar energy to power the machines. The CFA results also indicated that all factors (i.e., environmental, social, and economic) have significant influence on workers’ perception about sustainable manufacturing practices. Thus, the CFA and MNP model results can be used by energy policy making institutions in Tanzania to make informed decisions on energy investment for sustainable manufacturing in the country.

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