Embedding Supply Chain Agility in Relationship between Energy Management Practices and Renewable Energy Supply Chain: An Empirical Investigation

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Abstract--- In present economy, energy management practices is one the important source for reducing the energy consumptions in industrial sector and creating sustainability in organizations by producing renewable energy supply chain. The purpose of the current study is to investigate the relationship among energy management practices such as management commitment, energy awareness, energy knowledge, energy audit with renewable energy supply chain. It further investigates the supply chain agility as mediator. The nature of the current study is descriptive and quantitative. The data for present study is collected from manufacturing companies in Thailand by using self-administered questionnaire. 300 questionnaires are distributed in manufacturing companies by using simple random sampling technique. The smart PLS has been used for data analysis. The finding of the study shows that all the hypotheses are accepted and shows the positive and significant results. The findings reveal that the energy management practices such as management commitment, energy awareness, energy knowledge, energy audit have significant influence on renewable energy supply chain and supply chain agility significantly mediates the relationship. Further discussion and limitation of the study is also discussed at the end of the study.

Key Words: *management commitment, energy awareness, energy knowledge, energy audit, supply chain agility, renewable energy supply chain*

1. Introduction

Now the days, energy management practices in supply chain management is one of the vital concepts for conserving the energy resources and creating the energy efficiency in organization that create competitive edge by enhancing the productivity and performance of organization [34]. The energy management practices must be following in supply chain management activities from the point of production to ultimate consumers. The partners of supply chain and energy management all play an active role in creating energy efficiency and renewable energy in organizations. For creating a competitive edge it is compulsory for organizations to follow the renewable energy supply chain. Moreover, the renewable energy supply chain can be conceptualized as transformation of raw energy into usable energy, involves an effective set of management principles from the point of acquisition of energy resources to point of consumption of energy resources [1]. Also, the integration of supply chain and raw material create a renewable energy supply chain, in these tactic waste, fossil fuels used in energy production that create a sustainable environment.

Similarly, the energy management is "a key to develop the unused potentials of energy saving, increase the energy saving efficiency and spread the energy saving culture in organization by providing benefits of energy saving and reduced the energy saving consumption deprived of affecting production and quality of production" [2]. Moreover, energy management consisted on four practices namely: management commitment, energy awareness, energy knowledge and energy audit. According to [3] the management commitment consider as the important tool for creating the sustainability in organization by taking decisions from top management related to

energy conservation. The involvement of employees for producing energy efficiency is important role that can achieved by management commitment [4]. The energy knowledge, awareness, and audit are possible in organization to enhance the energy efficiency and consume less energy in overall the supply chain management practices that increases the productivity and profitability [5-7]. The agility of supply chain management increases the flexibility in supply chain management and reduces the time factor by speeding the supply chain by using different technologies [35, 39]. Thus, the supply management practices must be flexible to adapt the change easily [8]. The objectives of the current study are as follows:

1. To investigate the management commitment has significant effect on renewable energy supply chain.
2. To determine the influence of energy awareness on renewable energy supply chain.
3. To elaborate the energy knowledge has positive and significant relationship with renewable energy supply chain.
4. To examine the energy audit has positive and significant relationship with renewable energy supply chain.
5. To investigate energy management practices such as management commitment, energy awareness, energy knowledge and energy audit has strong influence on renewable energy supply chain conciliating by supply chain agility.

Based on the above objectives following are the research questions of the current study:

1. How management commitment effects on renewable energy supply chain?
2. Does the energy awareness have effects on renewable energy supply chain?
3. Does the energy knowledge have effect on renewable energy supply chain?
4. How energy audit effects on the renewable energy supply chain?
5. To what extent energy management practices such as management commitment, energy awareness, energy knowledge and energy audit has effect on renewable energy supply chain mediating by supply chain agility?

Further, this paper consists on literature review of the all variables that affect the renewable energy supply chain, energy management practices such as management commitment, energy awareness, energy knowledge and energy audit and supply chain agility literature. Next, this paper discusses the hypothesis development, research framework, methodology, findings, discussion and limitations of current study.

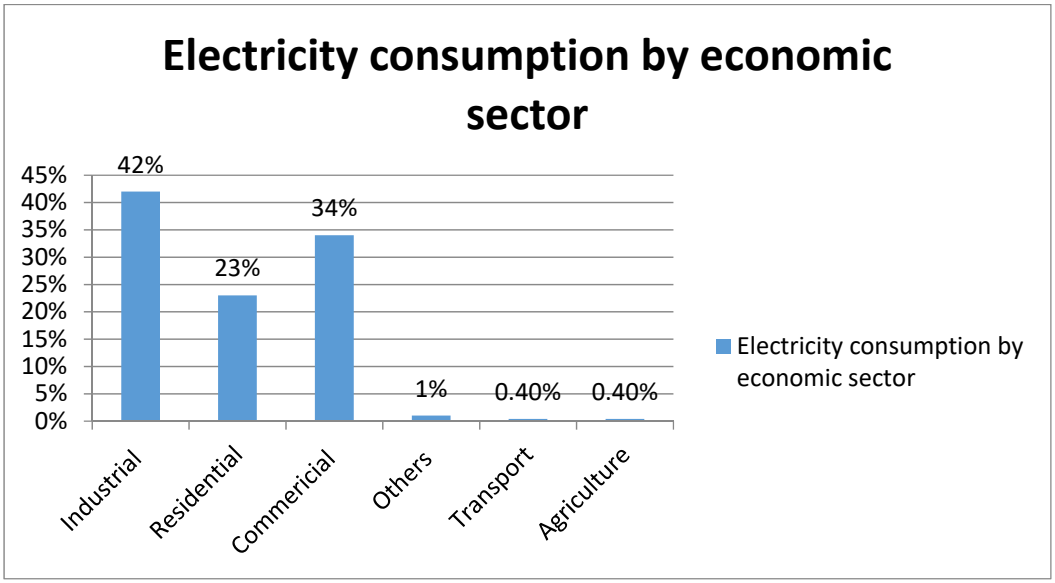


Figure 1:

EPPO [9]

For electricity consumption by economic sector, the industrial sector (76914 GWh or 42%), the commercial sector (61446 GWh or 34%), the residential sector (41443 GWh or 23%) and the other, transport and agriculture are 1% or less than 1% such as 0.40% respectively. The industrial sector is the key consumers for energy consumption in economy. So, there is need to do the study on industrial sectors in manufacturing firms for creating the energy efficiency, as shown in figure 1. Thus, this study will be beneficial for the policy makers and governments to develop a road map regarding the supply chain of the renewable energy. It will also point out what are the factors which do contribute towards the renewable energy supply chain and how it can be effectively managed.

2. Literature Review

2.1. Renewable Energy Supply Chain

Supply chain includes numerous players who perform their activities on diverse rules and situation, it contains the producer of material and product, assemble the product and deliver the product. Similarly, it is interrelated process that includes the number of chronological activities from dissemination of product and service to its (customers) end user [10]. Further, for reducing the supply chain management and environmental issues, it is probable to monitor converse shifts of resources, share the procedures and knowledge with supply chain partners. By the collaboration of supply chain management and environment organization can reduced the risk related to environment and produce the product that is more environmental friendly [11]. The supply chain management shows a crucial role in production of renewable energy [12]. Renewable energy resources have genuine association for sustainable supply chain.

Supply chain management plays an active role for the production of renewable energy. The energy security in industry can be possible by sustainable supply chain management. Industries have extensive uses of energy, shortage of resources, price fluctuation and change from fossil fuel based energy to the renewable energy are the basic activities of supply chains [1, 12]. The supply chain management and renewable energy integrations boosted the effectiveness of renewable energy in the process of supply chain management. Furthermore, the renewable energy supply chain contains the physical movement of renewable energy product from the point production to the point of consumption [13]. Moreover, the renewable energy supply chain composed of five steps from raw material to the end user product namely: supply, generation, conduction, dissemination and demand [14].

Similarly, transformation of raw energy into usable energy, involves an effective set of management principles from the point of acquisition of energy resources to point of consumption of energy resources. The integration of supply chain management with renewable energy increase the energy accessibility and convert the fossil fuel system into supply chain renewable energy [1]. The performance of renewable energy supply chain can be improved by growing the elasticity of supply chain management and improving efficiency by controlling cost in supply chains, with the intention of reducing the price of renewable energy to create a competitive edge [15].

2.2. Energy Management Practices

Energy management is a key to utilize the untapped possibilities of energy saving, increase the energy saving efficiency and spread the energy saving culture in organization by providing benefits of energy saving and reduced the energy saving consumption deprived of affecting production and quality of production [2]. Therefore, the energy management helps to maintain the quality and productivity of manufacturing firms by monitoring their energy consumption patterns, review the results of these pattern related energy data analysis and train and motivate the staff to create energy efficiency and effectiveness by controlling its consumption [16]. Moreover, energy management practices able to increase the environmental sustainability and improves the energy efficiency by introducing new technology, reducing energy consumption in nonproductive phases to another energy consumption process [17-19]. This paper discussed the four dimensions of energy management practices namely: management commitment, energy awareness, energy knowledge and energy adult. Similarly, the practices related to energy management vary from one industry to another industry on the bases of their intensity of energy, consumption of energy, size of the

organization, topographic and quality management [20].

The energy management must relate with renewable energy for reducing cost, increasing stability in prices, boosting the energy efficiency, and reduction in operational cost. The energy management practices must relate with renewable energy.

1. Management Commitment

The management commitment is important for creating energy efficiency by staff involvement. Similarly, the management of the organization having a strong knowledge about the energy integration with business vision, the commitment of top management is necessary for taking long term and logical decision for providing perfect course of action about energy management [3, 4]. Although, [21] explained that the integration between energy management and renewable energy make it possible the stable energy management, reducing the operational cost, increases the energy effectiveness. On the same way, the renewable energy plays an important role for creating energy efficiency, develop the behavior for involved in green practices for energy management and encourage the behavior for reducing carbon emission that pollute the environment . Management commitment and renewable energy both are important factors for the organizations, the success of renewable energy practices largely depends upon the commitment of management. Thus, the management commitment must understand the importance of energy management efficiency and consider this as main priority [22, 23].

2. Energy Awareness

Energy awareness is one of the important energy management practices, but energy awareness is deficit in more of the organization that shows by its energy consumption patterns. However, energy awareness is possible with latest technologies that calculate real time energy consumption that help the organizations to analyze and create awareness for taking better long term decisions for organization [6]. Similarly, the energy awareness can be improved by the communication of organizational management about energy saving practices. Also, the top management plays an important role for reducing the utilization of resources [24].Moreover, the training creates awareness among employees of organization about the energy resources go towards the energy conservation [25].

3. Energy Knowledge

Knowledge creates awareness among employees about the energy management practices. There is lack of knowledge related to energy conservation resources in manufacturing organizations that create the energy efficiency [26]. Similarly, the insufficient knowledge related to energy efficiency make the upper management disable to change the waste into energy and also the management struggle for utilizing the energy efficiently [5]. Therefore, complexity theory also explains the relationship among partners, it is especially important to sustain interface among the elaborated partners for knowledge and information distribution as well as creation of significance [27].

4. Energy Audit

Energy audit is analyzing, survey and inspection of utilization of energy flows for reducing the energy used without effecting negatively the final production of the organization. However, the energy audit is one the important area for taking better decision about the energy management. In industrial sector, energy audit is one of the important, reliable and systematic sources. Although, energy adult analyze the areas of energy consumption, try to reduce the energy consumption for creating energy efficiency, help to recognize entirely the energy flows in a facility, calculate energy usage, in an effort to steadiness the full energy contribution with its usage [7].Similarly, [25] demonstrated that the energy audit has some benefits such as reducing the operating cost by reducing the energy consumption, reduction in environmental pollution , improve the performance by increasing the productivity and profitability of any organization etc.

2.3. Supply Chain Agility

The supply chain agility has different definition and concepts, it means that adapt speedily the changing unpredictable environmental condition by supply chain management system [28, 36]. Thus, supply chain management system must be flexible to adapt change easily by all the partners of supply chain management for the smooth flow of goods and

services from point of production to the end consumers [8, 29]. Moreover, supply chain agility can be created by using the latest technologies of internet for the energy saving in supply chain process. Energy saving can be easily possible and be track by using the latest technologies that create agility in supply chain and make the system more effective. Previously, the supply chain agility has significant, direct and positive relationship with performance [37] but this study considers the supply chain agility as mediator [30].

2.4. Hypotheses Development

The present study is aim to explain the energy management practices, renewable energy supply chain and agility of supply chain. On the bases of above mentioned literature following are the hypotheses of the study:

H1. There is positive and significant relationship between management commitment and renewable energy supply chain.

H2. Energy awareness has significant and positive relationship with renewable energy supply chain.

H3. Energy knowledge has significant and positive relationship with renewable energy supply chain.

H4. There is positive and significant and positive relationship with energy adult and renewable energy supply chain.

H5. There is positive and significant relationship between management commitment and supply chain agility.

H6. Energy awareness has significant and positive relationship with supply chain agility.

H7. Energy knowledge has significant and positive relationship with supply chain agility.

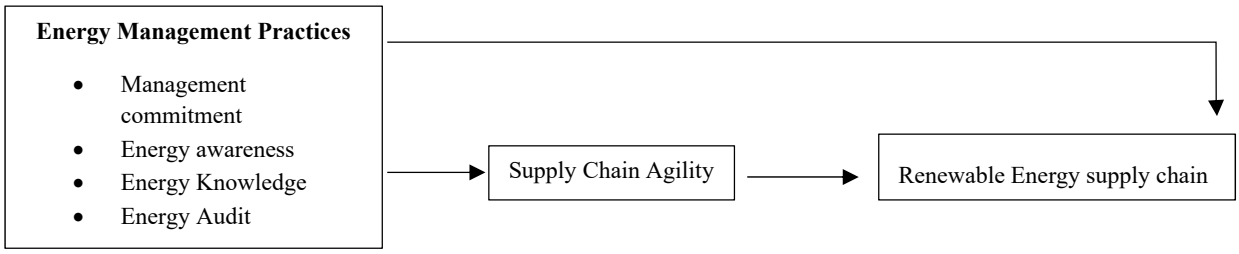
H8. There is positive and significant and positive relationship between energy adult and supply chain agility.

H9. Supply chain agility is significant mediator between relationship of energy management practices (management commitment, energy audit, knowledge and awareness) and renewable energy supply chain.

2.5. Theoretical Framework

Following figure 2 is showing the relationship directions between the variables.

Figure 2:



3. Methodology

The sample population in this study is manufacturing firms in Thailand. The target population of the study is individual where data collected from the employees about the energy management practices such as management commitment, energy awareness, energy knowledge and energy audit, how to generate renewable energy supply chain and the supply chain management agility role in conserving energy resources. The data were collected through administrative questionnaire by distributing questionnaire by post, face to face and via email. The nature of the data collection is cross sectional, the data is collected in one point of time. The nature of the study is descriptive in which study describe the all variable that consider under this study. The study is quantitative and primary data is used under this study.

Population is large number of peoples which cannot be covered under study the sample size is solution that represent the whole population and generalize the study. Previously different techniques have been proposed by researchers for determining the sample size. One of sample size technique explained that sample size at least 20% of the whole population [31]. According to [32] for sample size the researcher needs to use the ratio, from the large population size there is small ratio sample size. Although very often

the total number of population is finite in such cases it becomes much easier to select the sample and collect data. For the finite population the [32] table is used for selecting the sample size [32]. However, in current situation the population was not limited. Similarly, for structural equation model of 200 to 400 respondents is enough for sample size [33]. On the bases of above mentioned arguments the 300 employees was determined to collect the data as sample size in current study.

Later, after deciding the sample size the next question is to determine the sampling technique is used under this study. There are number of sampling technique available in research but in this study simple random sampling technique is used. However, it is selected because of the large geographical area of the Thailand and extensive manufacturing firms. The results of the study are presented in the next section.

4. Findings

Confirmatory Factor Analysis

Table 1. Confirmatory Factor Analysis

Construct	Items	Loadings	Alpha	CR	AVE
Energy Audit	EAU1	0.831	0.827	0.886	0.661
	EAU2	0.835			
	EAU3	0.712			
	EAU4	0.866			
Energy Awareness	EAW1	0.478	0.721	0.836	0.646
	EAW3	0.929			
	EAW4	0.92			
Energy Knowledge	EK1	0.857	0.808	0.87	0.578
	EK2	0.805			
	EK3	0.515			
	EK4	0.838			
	EK5	0.735			
Management Commitment	MC1	0.866	0.724	0.817	0.542
	MC2	0.484			
	MC3	0.626			
	MC5	0.89			
Renewable Energy Supply Chain	RESC1	0.728	0.885	0.908	0.553
	RESC2	0.767			
	RESC3	0.733			
	RESC4	0.729			
	RESC5	0.731			
	RESC6	0.77			
	RESC7	0.751			
	RESC8	0.741			
Supply Chain Agility	SCA1	0.878	0.887	0.917	0.691
	SCA2	0.814			
	SCA3	0.885			
	SCA4	0.852			
	SCA5	0.717			

Table 1 is representing the figures for the confirmatory factor analysis. It is performed to assess the validity and reliability of scale. Table is denoting the values of reliability for the variables namely; energy audit, energy awareness, energy knowledge, management commitment, renewable energy supply chain and supply chain agility are 0.827, 0.721, 0.808, 0.724, 0.885, and 0.887 respectively. The value for the reliability must be greater than 0.7. As per the table all the values fall under the range which affirms that scales are reliable.

Further the values of CR and AVE are the determining the convergent validity. The values of CR for the variables namely; energy audit, energy awareness, energy knowledge, management commitment, renewable energy supply chain and supply chain agility are 0.886, 0.836, 0.870, 0.817, 0.908 and 0.917 respectively. Whereas the values of AVE for the variables namely; energy audit, energy awareness, energy knowledge, management commitment, renewable energy supply chain and supply chain agility are 0.661, 0.646, 0.578, 0.542, 0.553 and 0.691 respectively. All the value for both of the parameters are within acceptable range (CR>0.8, AVE>0.5) which affirms that scale is valid.

4.1. Discriminant Validity

Fornell & Larckers Criterion

Table 2. Discriminant Validity

	EAU	EAW	EK	MC	RESC	SCA
EAU	0.813					
EAW	0.388	0.804				
EK	0.427	0.558	0.76			
MC	0.583	0.269	0.311	0.736		
RESC	0.621	0.589	0.568	0.503	0.744	
SCA	0.541	0.538	0.505	0.49	0.731	0.831

After the convergent validity is established the next test was performed to assess the discriminant validity which has been measured by using two tests; one is Fornell & Larckers Criterion and second is Heterotrait-Monotrait Correlation Ratio.

Table 2 is showing the results for the Fornell & Larckers Criterion values; as per the parameter the values of correlation of a variable with itself must be greater than other in the same column. As per the table all values of correlation are greater than the others.

4.2. Cross Loadings

Table 3. Cross Loading

	EAU	EAW	EK	MC	RESC	SCA
EAU1	**0.831**	0.273	0.326	0.42	0.479	0.413
EAU2	**0.835**	0.295	0.35	0.337	0.492	0.374
EAU3	**0.712**	0.331	0.343	0.691	0.467	0.474
EAU4	**0.866**	0.353	0.365	0.438	0.57	0.486
EAW1	0.129	**0.478**	0.237	0.046	0.188	0.146
EAW3	0.404	**0.929**	0.548	0.277	0.579	0.541
EAW4	0.328	**0.920**	0.492	0.246	0.537	0.486
EK1	0.349	**0.501**	0.857	0.219	0.422	0.405
EK2	0.367	0.392	**0.805**	0.259	0.463	0.388
EK3	0.224	0.269	**0.515**	0.245	0.324	0.244

EK4	0.305	0.475	**0.838**	0.19	0.387	0.378
EK5	0.347	0.447	**0.735**	0.267	0.519	0.456
MC1	0.519	0.225	0.26	**0.866**	0.432	0.438
MC2	0.25	0.087	0.095	**0.484**	0.176	0.167
MC3	0.28	0.102	0.122	**0.626**	0.256	0.216
MC5	0.558	0.293	0.339	**0.890**	0.501	0.491
RESC1	0.443	0.466	0.394	0.351	**0.728**	0.505
RESC2	0.461	0.432	0.37	0.403	**0.767**	0.518
RESC3	0.492	0.426	0.459	0.344	**0.733**	0.451
RESC4	0.474	0.417	0.456	0.364	**0.729**	0.459
RESC5	0.415	0.467	0.4	0.338	**0.731**	0.57
RESC6	0.411	0.444	0.385	0.373	**0.770**	0.586
RESC7	0.508	0.432	0.46	0.426	**0.751**	0.639
RESC8	0.488	0.421	0.453	0.382	**0.741**	0.598
SCA1	0.466	0.49	0.466	0.406	0.583	**0.878**
SCA2	0.454	0.43	0.364	0.386	0.641	**0.814**
SCA3	0.46	0.464	0.476	0.449	0.643	**0.885**
SCA4	0.472	0.474	0.484	0.476	0.643	**0.852**
SCA5	0.394	0.366	0.284	0.3	0.52	**0.717**

Table 3 is showing the values for the cross loadings. All the values of a particular variable must be greater than itself and others in same column. All the values falls under the acceptable range. Thus it satisfies another criterion for the discriminant validity.

4.3. Heterotrait-Monotrait Correlation Ratio

Table 4. Heterotrait-Monotrait Correlation Ratio

	EAU	**EAW**	**EK**	**MC**	**RESC**	**SCA**
EAU						
EAW	0.461					
EK	0.517	0.695				
MC	0.699	0.342	0.372			
RESC	0.722	0.678	0.664	0.574		
SCA	0.628	0.607	0.582	0.549	0.82	

HTMT is the latest technique for the assessment of discriminant validity according to which all the values in table must be less than 0.85. As per table 4 all the values are less than 0.85. As per table 4 all the values are less than 0.85 which establishes the discriminant validity. Thus, from all the criteria the discriminant and convergent validity is established. Following figure 3 is showing the output for CFA model:

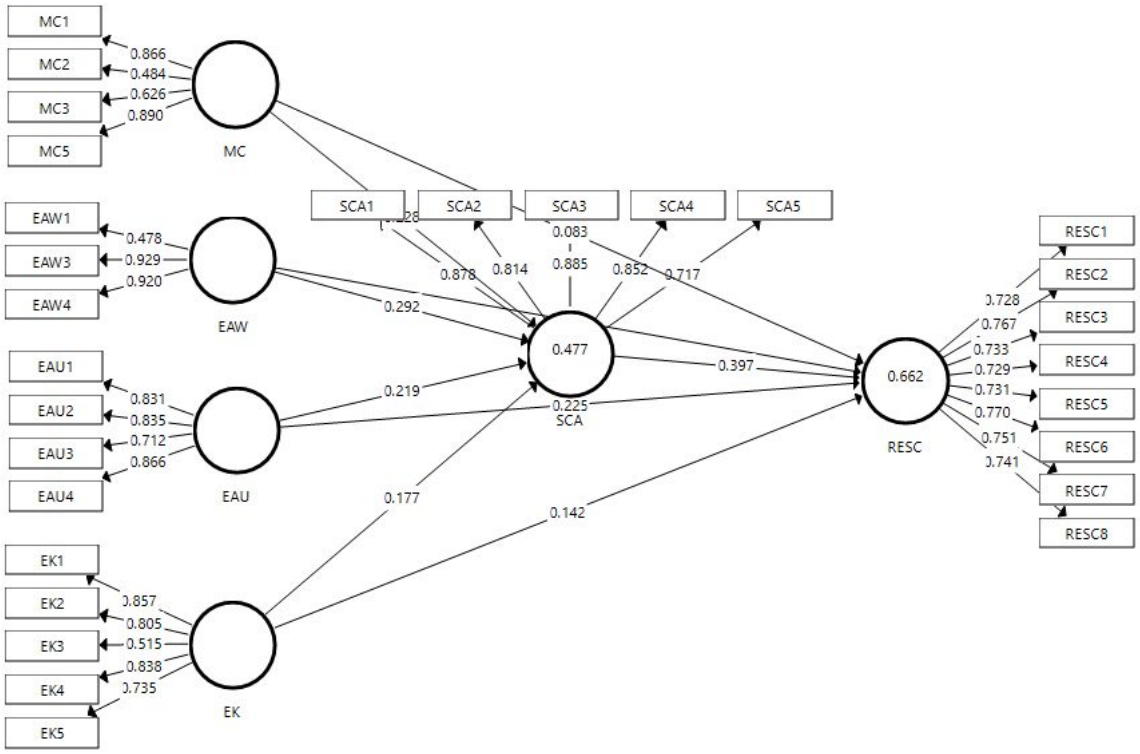


Figure 3: Structural Equation Modeling

4.4. Structural Equation Modeling

Table 5. Results

Relationships	Beta	SD	t value	p value	Decision
EAU -> RESC	0.225	0.034	6.683	p<0.05	Supported
EAU -> SCA	0.219	0.036	6.011	p<0.05	Supported
EAW -> RESC	0.186	0.039	4.815	p<0.05	Supported
EAW -> SCA	0.292	0.035	8.284	p<0.05	Supported
EK -> RESC	0.142	0.027	5.172	p<0.05	Supported
EK -> SCA	0.177	0.033	5.309	p<0.05	Supported
MC -> RESC	0.083	0.03	2.747	p<0.05	Supported
MC -> SCA	0.228	0.034	6.651	p<0.05	Supported
SCA -> RESC	0.397	0.033	12.158	p<0.05	Supported

Table 5 is showing the details about the relationships between the variables. All the independent variables are found to be significantly associated with dependent variable. Energy audit, awareness, knowledge and management commitment found to be associated renewable energy supply chain and the relationships are valued at 0.225, 0.186, 0.142 and 0.083 respectively. All the relationships are significant and thus supported the hypothesis.

Further the association between all independent variables and mediator are also significant. The associations between variables namely; Energy audit, awareness, knowledge, management commitment and supply chain agility are valued at 0.219, 0.292, 0.177 and 0.228 respectively. All the relationships are also significant.

4.5. Specific Indirect Effects

Table 6. Specific Indirect Effects

Relationships	Beta	SD	t value	p value	Decision
EAU -> SCA -> RESC	0.087	0.017	5.055	p<0.05	Supported
EAW -> SCA -> RESC	0.116	0.016	7.375	p<0.05	Supported
EK -> SCA -> RESC	0.07	0.015	4.645	p<0.05	Supported
MC -> SCA -> RESC	0.091	0.015	6.235	p<0.05	Supported

Table 5 is showing the significant mediation relationships between the variables. As per the results supply chain agility found to be significantly mediated between the relationships of the variables namely; energy audit, awareness, knowledge, management commitment and renewable energy supply chain. All the relationships are significant; thus supported the hypothesis. Following figure 4 is showing the output for the structural equation modeling. The figure 4 is showing the direction of the relationships and path values for each relationship.

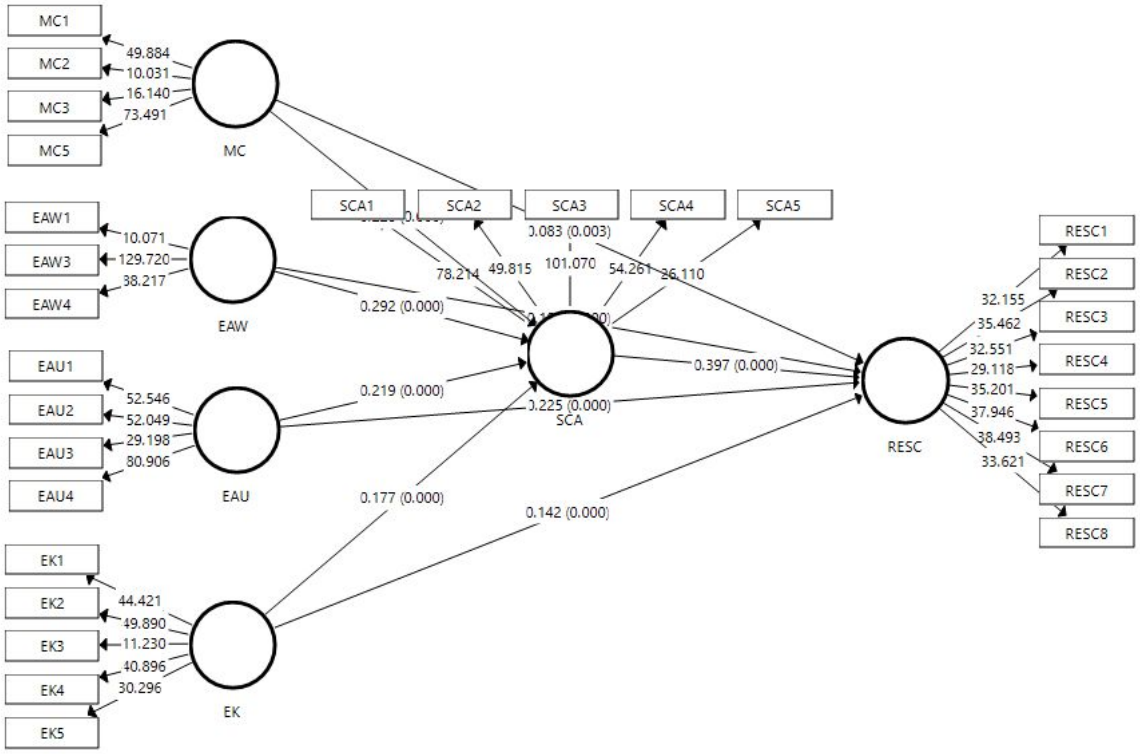


Figure 4: Structural Equation Modeling

5. Discussion

The objective of the current study is to examine the effect of energy management practices management commitment, energy awareness, energy knowledge and energy audit on renewable energy supply chain. This study also elaborated the effect of supply chain management on energy management practices namely: management commitment, energy awareness, energy knowledge and energy audit on renewable energy supply chain mediating by supply chain agility. The renewable energy supply chain is one of the important factors for creating sustainability in economy because the renewable energy means that using the raw material, waste and fossil fuels for

creating energy. However, this work shows that the internal configuration of an association plays an essential role in applying and embracing energy management practices and strengthening competitive advantage in the industrial sector. The literature discovered the four elements of energy management practices namely management commitment, energy awareness, energy knowledge and energy auditing specific findings relating to each key element have been discovered under the studies. Similarly, the energy accessibility improves by renewable energy supply chain. Thus, previous studies show that energy management practices has influence on renewable energy supply chain [5, 6, 14, 16, 21]. The hypothesis H1 is accepted that shows that management commitment has significant and positive relationship with renewable energy supply chain [21, 22]. Next the hypothesis H2 is also accepted, it shows that energy awareness has significant and positive relationship with renewable energy supply chain [24, 25]. It shows that if the employees of manufacturing organization are aware about energy resources and its proper utilization then they can easily has positive use of waste to generate energy. Moreover, hypothesis H3 is also accepted, that shows positive and significant influence of energy knowledge on renewable energy supply chain [7, 27]. On the same way, the hypothesis H4 is also accepted, energy audit has significant and positive relationship on renewable energy supply chain. Therefore, the hypothesis H5 is also accepted that shows the positive and significant mediating role of supply chain agility on energy management practices and renewable energy supply chain. The findings shows that when employees of manufacturing organization are well knowledge and follow all the energy management practices then it positively influences the renewable energy supply chain and supply chain agility improve the supply chain management time efficiency and effectiveness by increasing the speed and flexibility.

5.1. Limitations and Future Direction

The cross sectional data is used in this study, the type of study will be longitudinal in future to collect data on different times. It will show the more authentic results of energy management practices that affecting the renewable energy supply chain and mediates by agility of supply chain management. The current study collected data from manufacturing organization. Further, researchers can perform the comparative studies with other industries such as IT industries, chemical industries pharmaceutical industries. The unit of analysis of this study is employees of the organization. Moreover in future researcher can collect data form upper management and lower management to better understand that how agility of SCM and energy management practices improves the renewable energy supply chain. In developing economy there is lack of using the energy management practices as compare to the developed economy. The economies like Malaysia, Bangladesh, Pakistan, China, and India facing the deficit of energy in their economy. There is need to do the studies in Asian economies to increase the productivity and performance of the country.

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