Framework For Building Technological Capability In The Nigerian Solar Energy Industry Using Structural Equation Modelling

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Abstract

The study on capability has continued to gain ground as recognisable progress is being made in the resource-based view (RBV) theory. As a matter of fact, it has become more relevant in the context of a developing nation, such as Nigeria, as a means to create economic development. Using the Panda and Ramanathan (1996) methodology for measuring technological capability (TC) in the electric sector, this paper adopted the indicators from the paper to build a framework for TC development in the Nigerian solar energy industry in addition to others. The results of the structural equation modelling (SEM) showed that the paths of interactions among the stakeholders, factors affecting TC accumulation and government policy implementations would only be significant to TC of the solar energy firms through the mediated effects of the technological competence of the universities.

Key words: Technological Capability, Competence, Resource-based View, Structural Equation Modelling, Solar Energy.

1. Introduction

This study is premised on the evolutionary theory relative to the resource based view (RBV) which views firms as bundles of resources and technological capabilities (Aeron and Jain, 2015). Historically, capabilities related theoretical stream originates from Penrose (1959), Day and Wensley (1988), Teece et al. (1990) and Leonard-Barton (1992) studies, distinctive or core capabilities stream of research applying the RBV as theoretical basis. Evolutionary economics has a long history in the field of economics. However, the most influential work in this area is undoubtedly Nelson and Winter (1982). Like all evolutionary theories, Nelson and Winter's theory examines the implications of three fundamental processes: variation, selection, and retention. Indeed, this is what makes Nelson and Winter's work evolutionary in character. In the Nelson and Winter framework, firms vary in the routines they have developed to conduct their businesses. In this sense, routines become the fundamental unit of analysis in Nelson and Winter's work. In the face of competition, Nelson and Winter's selection mechanism showed that some of these routines are revealed to be more efficient and effective than others. The least efficient and effective routines are either abandoned or changed or a firm is likely not to be able to survive in the long run. The most efficient and effective routines generate competitive advantages for firms. Routines are an example of firm resources and capabilities that makes analogy between the resource-based view and the evolutionary theory (Barney, 2001). Indeed, if one adopts the definition of capabilities as the ability of firms to use their resources to generate competitive advantages, then the definitions of routines and capabilities are virtually indistinguishable. However, the intention here is to build a sustainable technological capability in the solar energy industry by adopting the framework presented in Panda and Ramanathan (1996). So, we define technological capability as 'a set of functional abilities, reflected in the firm's performance through various technological activities and whose ultimate purpose is firm-level value management by developing difficult-to-copy organizational abilities' (Panda and Ramanathan, 1996). Our action in adopting this methodology is based on two reasons. First, the paper discussed about the technology capability assessment of a firm in the electricity sector, and secondly, it developed a methodological framework for building technological capability. These reasons we find useful to build technological capability in the Nigerian solar energy industry.

Meanwhile, the interdependence between energy availability, its supply, demand and utilization is one of the factors that control national development in relation to population explosion and rural-urban integration (Hermann, 2001; Ajayi et al., 2011). Based on this, efforts are always geared toward seeking ways of producing sufficient energy for the populace. Such ways include those that are produced from modules and which are both sustainable and efficient. Renewable energy (RE) sources involve the harnessing of natural energy flows from sunlight, wind, waves, hydro, ocean currents, and tides (Akinbami, 2001). Nigeria is well endowed with sufficient renewable energy resources to meet its present and future development requirements which have minimal or zero supply logistic problems (Jekayinfa and Omisakin, 2005). The National Energy Policy (2013) considers hydropower potentials to 10,000MW for large hydropower and 738MW for small hydropower (SHP). Other sources include wind energy with a potential of 150,000 terra joules per year, generated by an average wind speed of 2.0 to 4.0 m/s, solar radiation estimated at 3.5 to 7.0 kWh/m2/day, and biomass at 144 million tonnes per year (Akuru and Okoro, 2010; Shaaban and Petinrin, 2014). But, these resources are yet to be fully explored.

In order to maximise and achieve these potentials the Nigerian government has shown commitment in the recently revised edition of the Renewable Energy Master Plan (REMP) initially developed in 2005 under the sponsorship of the United Nations Development

Programme- UNDP (ECN, 2012). REMP was put in place to provide road map for the effective implementation of the RE component of the National Energy Policy (NEP). The obligations are on the long-term basis for renewable electricity to contribute about 20 percent of total electricity supply in the country as well as the national fuel supply to be supported by 10 to 20 percent of renewable fuels (biofuels). This is in accordance with various international debates on sustainable development that have favoured energy production from RE sources. Many international and regional declarations have also favoured increasing generation from the RE sources. Such instance includes the European Union ratification of the Kyoto protocol in her framework accord of eliminating greenhouse gas emission level of 1990 by 20 percent.

This development has engendered countries to actively engage in the integration of RE into their national energy mix. Such countries include the United States of America (USA) intensifying efforts at increasing generation from installed wind power capacity (Ajayi and Ajayi, 2013). Similarly, China has also increased efforts of wind-to-electricity generation, despite being widely acclaimed to be a very high emitter of anthropogenic carbon dioxide (Leggett et al., 2008; Wen, 2009; International Energy Agency (IEA), 2011). China installed capacity of 4.0 MW in 1990 went up to 567 MW in 2003. By 2010, the country was reported to have the World's largest installed capacity and this is projected to reach 20 GW by 2020 (National Renewable Energy Laboratory- NREL, 2004). Only a meagre of RE development was noticeable from Africa, just four countries generated electricity from geothermal, solar and wind sources in 2003. These countries include Kenya and Egypt with 0.3 GWh each, and, Morocco and South Africa with 0.2 GWh each. This therefore signifies a long way for sustainable energy development in Africa (Ajayi and Ajayi, 2013). Particularly in Nigeria where there is abundant potential of RE sources in form of solar and hydropower energy being under-utilized.

Presently in Nigeria, the national power utility operates well below its estimated installed capacity (Oladeji, 2009). Likewise, the demand for electricity is far beyond the available capacity of 4,500 MW, which can only meet one-third of the estimated demand (Saifuddin et al., 2016). This is reflected in the incessant power outages being witnessed in the country. As laudable as RE potentials are to Nigeria’s electricity generation, perceived high costs of investment and political-will have shunt its development. By contrast, solar photovoltaic (PV) module prices have fallen around 75 percent since 2008 and with a number of other RE technologies becoming economical in the United Arab Emirates (IRENA, 2015). This was made possible with advancement in skills and capital accumulation as a result of progress in technological competences and capabilities (IRENA, 2015).

This development in lower cost of producing PV modules has stimulated the government of Nigeria to state categorically in their newly drafted policy document National Energy Master-Plan, 2014, that the nation shall aggressively pursue the integration of solar energy into the nation's energy mix, which is to be based on the established potentials and available technologies nationwide (ECN, 2014). Interestingly, the country enjoys abundant amounts of sunshine which literature has shown that the potential and viability of solar energy sources in Nigeria is estimated at 290 days of sunlight in a year (Uduma and Arciszewski, 2010). The average solar insolation in Nigeria is estimated to vary between 4.0 kWh/m2/day at the southern coasts to 7.0 kWh/m2/day at the northern part of the country (Freling and Lahl, 2005). The daily average is estimated at 5.5 kWh/m2/day which shows that availability of abundant sunshine is a positive indicator that Nigeria is an ideal candidate for investment in solar energy resource development.

But the knowledge of industrialisation is a learning and capability-building process (Ogbimi, 2007). Although, research on innovation processes has shown that the technological capabilities held by firms comprise not only information codified in capital goods or documents (patents, manuals, etc.), but also include the tacit knowledge embodied in individual skills and firm routines (Dosi, 1988; Huenteler et al., 2014). These elements of knowledge are costly to transfer and therefore highly organization-specific (von Hippel, 1994). This means that removing trade barriers and providing developing countries with intellectual property rights (IPR) and resources for technology imports is not sufficient to enable countries to catch up to the technological frontier (Ockwell et al., 2010). Rather, catching up requires building local technological capabilities through the cumulative, costly and time-consuming process of technological learning (Bell and Figueiredo, 2012). Technological capability building is the outcome of complex interactions among individuals, firms, and other organizations within specific institutional frameworks and geographical locations (Iammarino et al., 2008). Thus, this paper tends to find out the paths these variables: technological competence in the universities, factors affecting technological capabilities in the firms, interactions among stakeholders in solar energy industry, and government policy implementation on renewable energy relate to the technological capability in the Nigerian solar energy firms.

The rest of the paper is organised as follows: methodology, sampling procedure, analytical methods, results and discussion, and conclusion.

2. Methodology

The methodology for this paper includes the following variables, the sampling procedure, analytical methods which include factor analysis, confirmatory factor analysis and the structural equation modelling.

2.1 Variables

Technological capability The conceptual framework is based on established relationships in the literature on the measurement of technological capability based on the one proposed by Panda and Ramanathan (1996). They categorised technological capabilities into strategic, tactical and supplementary. In addition, another capability, which is not technological, called steering capability, is included to emphasize the fact that, without it, technological capabilities cannot be effectively deployed and upgraded. The indicators for these capabilities were used to measure TC using the likert scale technique.

Technological competence The work of von Tunzelmann and Wang (2003) differentiated competence from capability. They believed that competence is a planned property of an individual or a firm which has a typical enhancement produced within or outside the organisation. Iammarino et al. (2012) described competence as a pre-requisite or resource for innovation activity. But firms in the developing countries are handicapped to carry out internal research and development (R&D) and therefore rely heavily on the external sources such as the knowledge institutions (Ladan, 2009). Technological competence is understood to be stemming from R&D embarks upon in the university's departments. So the knowledge produced or acquired from the knowledge institutions remains the only critical resource in organisations to build sustained competitive advantages in the developing nations. Questions were drawn from both the handbook of renewable energy technology by Zobaa and Bansal (2011), and proceedings of local journals on solar energy in the country.

Factors affecting technological capability TC development is affected by a number of factors which include both the internal: technology available in the company, its culture, size, strategy, structure, and learning; and the external factors include the following economy size, trade regime (use of local materials), fiscal policies of government, and factor market conditions. This is as contained in Panda and Ramanathan (1996).

Interactions It has been established that firms gain ideas for innovating from a wide variety of different sources and their innovative performance depends on how successful they are at appropriating knowledge from these sources (Laursen and Salter, 2004). The ability of a firm to access and interact with knowledge bases within the national innovation system is a strong indicator of firm's technological capabilities (Oyelaran-Oyeyinka, 2003). Several other scholars have shown the importance of interactions among the stakeholders in building TC (Duysters and Lokshin, 2011; Iammarino et al. 2012; Leeuw et al., 2014; Egbetokun, 2015a&b). Questions on interactions were localised within the industry.

Government policies implementation This variable is important as Panda and Ramanathan (1996) emphasised that most state owned projects are now being turned to public owned gradually. Also the essence of regulatory authority is believed to stimulate competitiveness and innovation which are by-products of TCs of the firms (Goldstein and Hilliard, 2008). Questions were drawn from the newly drafted policy document National Energy Master-Plan (ECN, 2014).

2.2 Study area and sampling procedure

The study areas were selected purposively from five (5) geo-political zones in Nigeria as follows: North Central Zone: Federal Capital Territory (FCT), Niger and Kwara states; North West Zone: Sokoto state; South East Zone: Enugu state; South-South Zone: Rivers state; South West Zone: Lagos, Osun, Ondo and Ogun states. The following areas, Abuja, Port-Harcourt and Lagos were selected due to predominance of solar energy firms. The choice of the remaining states was as a result of the presence of universities offering science and engineering courses required to build competence and capability to support the solar energy industry.

The target population considered in this study includes: solar energy companies and universities offering related courses. The selection of the universities was based on the following criteria: National University Commission ranking of the universities; frequency of published papers relating to renewable energy (importantly solar energy); proximity of university to research institute established for the purpose of renewable energy development; and proximity of university to a commissioned project on solar energy. Meanwhile, the selection of the firms dealing in solar energy technologies was based on a simplified formula (equation 1) for proportions at 95 percent confidence level as described by Yamane (1967) found in Israel (2012). A total of 218 (60 firms and 158 universities faculty members) questionnaire were administered. But after data cleaning a total of 200 (50 firms and 150 universities faculty members) questionnaire were certified for use.

2.3 Analytical methods

***Exploratory factor analysis* (EFA)**

An EFA may be used for a variety of purposes such as reducing a large number of items from a questionnaire or survey instrument to a smaller number of components, uncovering latent dimensions underlying a data set, or examining which items have the strongest association with a given factor (DiStefano et al., 2009). Many indicator variables were used to understand a construct in this study. So, to find an underlying structure to the entire set of latent variables, factor analysis technique was used. The objective was to find means of condensing the information contained in a number of original variables "indicators" to smaller set of variables with a minimal loss of information. Factor analysis provided insight into interrelationships among variables and underlying structure, which is an excellent starting point for many other multivariate techniques. Factor analyses were sequentially used in this study as follow: identifying latent structure, achieving data reduction and variable selection. The critical assumptions underlying factor analysis are more conceptual than statistical. The overriding concern in factor analysis is much on character and composition of variables included in the analysis as their statistical qualities. The following empirical measures were used to aid diagnosing the factorability of the correlation matrix. Data matrix must have substantial high correlation (more than 0.3), Bartlett test of sphericity provides statistical test for the overall significance of all correlations within a correlation matrix. Also, measure to quantify the degree of inter-correlations among variables and the appropriateness of factor analysis is the measure of sampling adequacy (MSA). This index ranges from 0 to 1, but it is always advisable that a MSA above 0.5 be achieved before proceeding with the factor analysis.

The selection of extraction method is based on the objective of analysis and amount of prior knowledge about variance of variables. The decision on the number of factors to be retained is usually based on factors eigenvalues greater than 1.0. The oblique rotational method was used in this study because it is more flexible and factor axes will be orthogonal. It is also more realistic because the theoretically important underlying dimensions are not assumed to be uncorrelated with each other (few constructs in the real world are uncorrelated).

Confirmatory factor analysis **(CFA)**

The technique of CFA analyses a priori measurement models in which both the number of factors and their correspondence with the indicators are explicitly specified. It is a way of testing how well measured variables represent a smaller number of constructs. Standard CFA models have the following characteristics (Kline, 2011):

1. Each indicator is a continuous variable represented as having two causes; a single factor that the indicator is supposed to measure and all other unique sources of influence (omitted causes) represented by the error term.

2. The measurement errors are independent of each other and of the factors.

3. All associations between the factors are un-analysed (the factors are assumed to co-vary).

CFA is applied to test the extent to which a researcher makes a priori, theoretical pattern of factor loading on pre-specified constructs (variable loading on specific constructs) represent actual data. Thus, instead of allowing statistical method to determine the number of factors and loading as in EFA, CFA statistics tells us how well our theoretical specification of the factors matches reality (the actual data). In a sense, CFA is a tool that enables this study to either "confirm" or "reject" our preconceived theory. Confirmatory Factor Analysis found in Analysis of Moment Structure (AMOS) was used to examine and validate the measurement model, including examining convergent and discriminant validity. This enabled the study to test how well the measured variables represent the constructs. No valid conclusion exists without valid measurement. Measurement theories are represented using visual path diagrams. The path diagram shows the linkages between specific measured variables and their associated constructs, along with the relationship among constructs. Paths from the latent constructs to the measured items (loadings) are based on the measurement theory. When CFA is applied, only the loadings theoretically linking a measured item to its corresponding latent factor are calculated. All others are assumed to be zero (no cross loading). Lastly, it is important to note that the essence of CFA is to compute the confirmatory factor scores. CFA methods have additional advantages over EFA, including conducting measurement at the latent level, distinguishing the error component from what is shared with a factor, including multiple fit indices, and allowing for much greater flexibility in constructing a model (Hair et al., 2010).

Construct validity is measured by standardized loading estimates should be at least 0.5 and preferably 0.7 and average should be greater to suggest adequate convergent validity.

Moreover, variance-extracted (total variance explained) should equal or exceeds 50 percent, while average estimates for two factors also should be greater than the square of the correlation between two factors to provide evidence of discriminant validity. Construct reliability should be 0.7 or higher to indicate adequate convergence or internal consistency. The overall model fit and path coefficient stability are determined by significance of Chi Square, Absolute Fit measures such as Goodness of fit index(GFI); Root mean square error of approximation (RMSEA), Root mean square residual (RMSR); standard root mean residual (SRMR), or Incremental Fit Indices such as : Normed fit index (NFI), comparative fit index (CFI) and Relative fit index (RFI), also Parsimony Fit Indices; Adjusted goodness of fit index (AGFI) and Parsimony normed fit index (PNFI). The rule of thumb according to Hair et al. (2010) is that at least one absolute fit index and one incremental fit index, in addition to chi-square results is sufficient for model fit.

Structural equation model **(SEM)**

Structural equation modelling is a general term that has been used to describe a large number of statistical models used to evaluate the validity of substantive theories with empirical data. Statistically, it represents an extension of general linear modelling (GLM) procedures, such as the ANOVA and multiple regression analysis. One of the primary advantages of SEM over other applications of GLM is that it can be used to study the relationships among latent constructs that are indicated by multiple measures. It is also applicable to both experimental and non-experimental data, as well as cross-sectional and longitudinal data. SEM takes a confirmatory (hypothesis testing) approach to the multivariate analysis of a structural theory, one that stipulates causal relations among multiple variables. The causal pattern of inter-variable relations within the theory is specified a priori. The goal is to determine whether a hypothesized theoretical model is consistent with the data collected to reflect this theory.

SEM contains one or more linear regression equations that describe how endogenous structures depend upon exogenous structures (Karadag, 2012). SEM is generally composed of a measurement model, which define how implicit variables or theoretical structures rely upon observed variables, and a structural model, which define casual connections and effects among the implicit variables. The mostly exercised applications in SEM can be divided into two groups: path analysis, and verifying factor analysis. This study made use of the path analysis in examining the goodness of fit of the model and the causality of the constructs.

Path shows the direction of the relationship in a structural model and represents the structural relationship that was estimated. The major difference between SEM and CFA models is that emphasis moves from relationships between latent constructs and measured indicator variables to the nature and magnitude of the relationship between constructs.

The focus in SEM analysis is testing structural relationships by examining overall and relative model fit as a measure of acceptance of the proposed model and structural parameter estimates on a path diagram. The structural model fit assessment is similar to that of CFA model fit. The good practices dictate that one absolute index, one incremental index and the chi-square be used at a minimum (Hair et al., 2010).

3. Results and Discussion

In order to extract the relationships between TC and other variables discussed earlier multivariate data analysis is performed in two-stage model building process for applying structural equation modelling (SEM) (Aragon et al., 2014). The data analysis is conducted in two steps: first, using confirmatory factor analysis and second, path analysis in structural equation model.

The CFA conducted was in two stages, the study first extracted the factor structure of research framework using an EFA. An EFA was conducted to find out the underlying dimensions of technological capability, technological competence, policy implementation, factor affecting, interest, interaction, environmental issues, and awareness of the solar energy technologies. Table 1 presents the results of the EFA, the extracted structure, total variance explained and the reliability computed through Cronbach alpha for each factor. As a result of the EFA conducted, five (5) constructs were extracted with a total variance explained as 63.28 percent. The Cronbach alpha values for the underlying constructs range from 0.793 to 0.941 suggesting satisfactory levels of construct reliability, since for Cronbach alpha values greater than 0.70, the scale is accepted as reliable (Hair et al., 2010). The second stage of the CFA was to obtain a good fit of goodness that shows the quality of the whole model.

Table 1: EFA for Technological Capability in Nigerian Solar Industry

	Component				
	1	2	3	4	5
Technological competence (tcomp)					
Parabolic trough collectors	.772				
Module	.765				
Solar glass production	.763				
Power towers	.754				
Dish-stirling engine systems	.748				
Materials For Reinforcement Quality	.724				
Solar battery	.679				
Heat exchanger	.679				
Heat transfer fluids	.667				
Hybrid system	.650				
Storage system	.640				
Project Quality Control	.638				
Recycling/ Re-use of the modules	.636				
Electrical control system	.611				
Policy Implementation (timpg)					
Periodic review of the renewable energy master plan		.828			
Link industrial sector to energy R&D		.816			
Availability of funding to research institutes		.799			
Development of research portfolios		.783			
Conduction of National solar radiation database		.768			
Development and promotion of local capability		.763			
Organisation of On-the-Job training		.752			
Organisation of training and re-training workshops		.750			
Compilation of directory of all policy		.750			
Production of comprehensive business plan		.749			
Organisation of training on the preparation		.738			
Inventory of locally manufactured		.732			

Factor Affecting (tfact)					
Size of economy and growth rate			.838		
Organisation structure			.803		
Organisation strategy			.801		
Company's culture			.796		
Level of Interest			.791		
Inward/outward looking trade regime			.789		
Financial and fiscal policies of government			.764		
Technology used			.748		
Factor market conditions			.747		
Learning and Intelligence gathering			.723		
Interest rate concessions			.699		
Technological capability (tcmp)					
Capability to develop and maintain the distribution channel for the product or service				.868	
Capability to supply the PV/CSP product or service				.805	
Capability to plan, monitor and Coordinate				.804	
Capability to plan, monitor and coordinate service capacity				.777	
Capability to identify, assess, Negotiate				.750	
Capability for planning, monitoring and coordinating resource				.749	
Capability to sell Solar PV technology				.743	
Capability to provide technical advice to customers				.736	
Capability to perform civil Construction				.718	
Capability to identify customers, Bid				.699	
Capability for carrying out preventive				.612	
Interaction (tintr)					
Interaction with co-contractors during a project execution					.757
On secondment to another university					.714
Supervisor to owner of a private firm					.708
On secondment to Research Institute/Ministry					.708
In an organised workshops, trainings and conferences					.686
Knowledge obtained from local suppliers					.659
Foreign firms					.636
Use of other universities laboratory					.635
Universities					.602
Research Institutes					.602
Banks					.591
Cronbach α	.890	.940	.941	.940	.793

KMO= 0.804; Bartlett's Test of Sphericity: Chi-Square=13757.788, df=3003, Sig.=.000; TVE=63.28 percent.

According to the standardized estimates obtained with AMOS software, the measurement model provides a reasonable fit to the data ($\chi 2$ = 4188.399; df = 2464; comparative fit index (CFI) = 0.953; root mean square error of approximation (RMSEA) = 0.051). The traditionally reported fit indexes are within the acceptable range. Also, the reliability of those measures was calculated with Bagozzi and Yi's formula for composite reliability index and Fornell and Lacker's for average variance extracted index found in Hair et al. (2010). For all the measures both indices are higher than the evaluation criteria of 0.6 for composite reliability and 0.5 for average variance extracted. Composite reliabilities ranged from 0.80 to 0.94 and average variance extracted is between 0.51 and 0.57 (Table 2).

Furthermore, discriminant validity is indicated, as the average for every construct is higher than the square estimated correlation parameter between each two constructs (Aragon et al., 2014). As shown in Table 2, the square root of the average variance extracted of each construct exceeds the highest correlation among other constructs. Based on the recommended criterion Fornell and Larcker in Aragon et al. (2014), discriminant validity was confirmed since the square root of average variance extracted for each construct is greater than the shared variance with other constructs. Furthermore, the results of the common method bias through the common latent factor (CLF) approach proved negative. There was no large difference greater than 0.20 when the standardized regression weights with CLF were compared with standardized regression weights without CLF (Table 3). Hence, there was no need to include the CLF in the SEM.

Table 2: Construct Validity and Reliability Analysis

	CR	AVE	tawn	tcomp	timpg	tfact	tcmp	tints	tintr	Tenvt
Tcomp	0.935	0.510	0.104	0.714						
Timpg	0.941	0.570	-0.223	0.317	0.755					
Tfact	0.936	0.573	0.263	0.260	-0.075	0.757				
Tcmp	0.936	0.573	-0.001	0.525	0.221	0.076	0.757			
Tintr	0.882	0.517	0.154	0.310	0.204	0.121	0.179	0.378	0.719	

Table 3: Compared Standardized Regression Weights

Variable			Estimate (CLF)	Estimate (No CLF)	Delta
comp12	<---	tcomp	0.772	0.773	0.001
comp7	<---	tcomp	0.632	0.681	0.049
comp6	<---	tcomp	0.61	0.584	-0.026
comp13	<---	tcomp	0.814	0.857	0.043
comp14	<---	tcomp	0.746	0.748	0.002
comp23	<---	tcomp	0.684	0.702	0.018
comp11	<---	tcomp	0.69	0.653	-0.037
comp21	<---	tcomp	0.768	0.82	0.052
comp15	<---	tcomp	0.706	0.733	0.027
comp10	<---	tcomp	0.602	0.671	0.069
comp16	<---	tcomp	0.709	0.685	-0.024
comp22	<---	tcomp	0.705	0.711	0.006
comp9	<---	tcomp	0.627	0.689	0.062
comp17	<---	tcomp	0.659	0.649	-0.010
impg10	<---	timpg	0.786	0.799	0.013
impg6	<---	timpg	0.8	0.819	0.019
impg2	<---	timpg	0.77	0.79	0.020
impg4	<---	timpg	0.76	0.79	0.030
impg8	<---	timpg	0.745	0.769	0.024
impg3	<---	timpg	0.712	0.715	0.003
impg12	<---	timpg	0.761	0.711	-0.050
impg11	<---	timpg	0.723	0.72	-0.003
impg9	<---	timpg	0.694	0.718	0.024
impg7	<---	timpg	0.714	0.74	0.026
impg14	<---	timpg	0.777	0.677	-0.100
impg5	<---	timpg	0.742	0.8	0.058
facth	<---	tfact	0.798	0.809	0.011
facte	<---	tfact	0.785	0.797	0.012
factd	<---	tfact	0.84	0.85	0.010
factb	<---	tfact	0.766	0.789	0.023
factg	<---	tfact	0.785	0.791	0.006
facti	<---	tfact	0.755	0.751	-0.004
factj	<---	tfact	0.669	0.698	0.029
facta	<---	tfact	0.764	0.782	0.018
factl	<---	tfact	0.671	0.683	0.012
factf	<---	tfact	0.755	0.741	-0.014
factk	<---	tfact	0.588	0.602	0.014
cmp9	<---	tcmp	0.856	0.864	0.008
cmp21	<---	tcmp	0.791	0.821	0.030
cmp10	<---	tcmp	0.787	0.804	0.017
cmp8	<---	tcmp	0.779	0.779	0.000

cmp20	<---	tcmp	0.694	0.684	-0.010
cmp12	<---	tcmp	0.768	0.779	0.011
cmp11	<---	tcmp	0.807	0.829	0.022
cmp22	<---	tcmp	0.695	0.684	-0.011
cmp7	<---	tcmp	0.713	0.709	-0.004
cmp17	<---	tcmp	0.641	0.663	0.022
cmp15	<---	tcmp	0.648	0.68	0.032
intr5	<---	tints	0.872	0.868	-0.004
intr1	<---	tints	0.83	0.823	-0.007
intr13	<---	tints	0.848	0.847	-0.001
intr14	<---	tints	0.824	0.829	0.005
intr2	<---	tints	0.733	0.732	-0.001
intr6	<---	tints	0.771	0.769	-0.002
intr7	<---	tints	0.612	0.614	0.002
intr15	<---	tints	0.635	0.641	0.006
intr10	<---	tints	0.653	0.656	0.003
intr9	<---	tints	0.642	0.649	0.007
intr3	<---	tints	0.519	0.525	0.006

Plate 1 shows the structural equation modelling. The SEM provides the study with the model fitness and the path analyses of variables and the constructs. The results presented in Table 4 show that the model fitness is within the acceptable range as reported by (Hair et al., 2010) Likewise, the path analyses results show that significant causal effect relationships with technological competence and policy implementation, factor affecting technological capabilities, and interaction among the stakeholders. But only technological competence is significantly a causal effect for technological capability (Table 5). These results imply that quality outputs are expected from our knowledge institutions for technological capability to be built and sustained in the country.

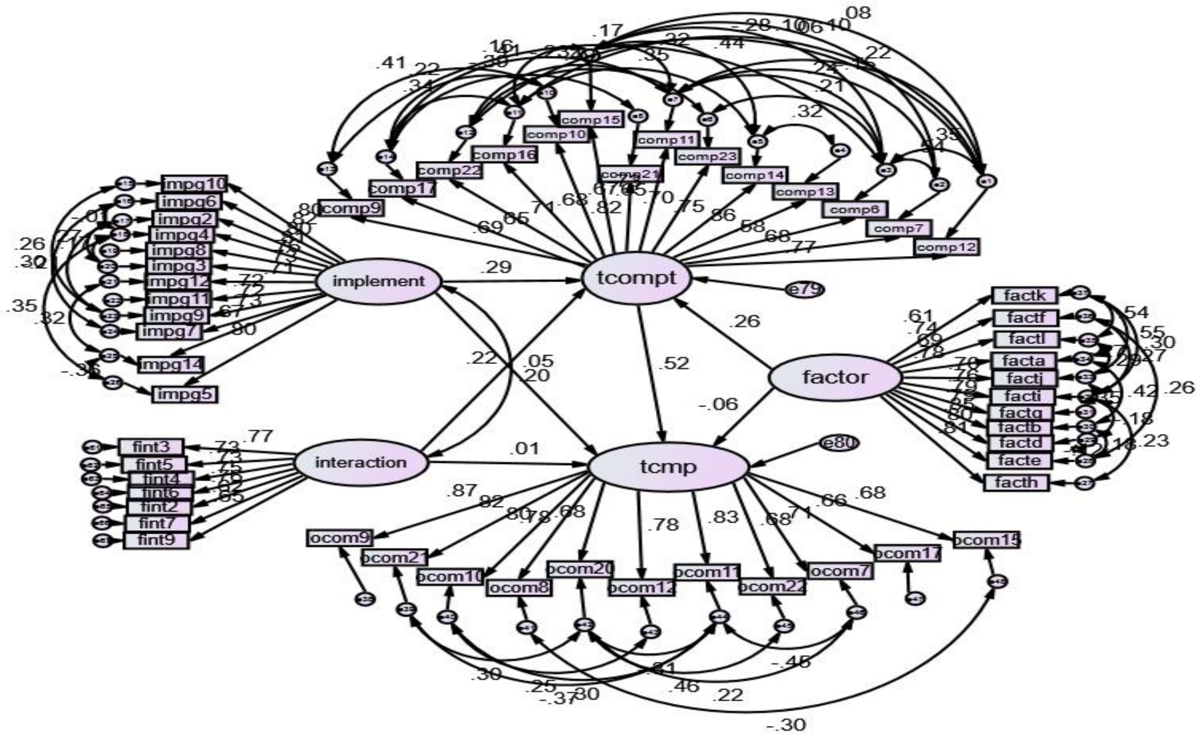

Plate 1: SEM with Standardized Regression Weights

Table 4: Goodness of Fit Indexes

Variable	**Result**	**Acceptable Range Hair *et al*. (2010)**
Chi-square	2619.492	-
Probability	0.001	-
CMIN/DF	1.915	2.000
RMSEA	0.068	<1.000
CFI	0.959	>0.900

Table 5: Path Analysis with AMOS-SEM

Variable			**Estimate**	**S.E.**	**C.R.**	**P**	**Result**
tcompt	<---	implement	0.341	0.085	4.001	0.001	causal
tcompt	<---	interaction	0.230	0.077	3.003	0.003	causal
tcompt	<---	factor	0.172	0.047	3.669	0.001	causal
tcmp	<---	interaction	0.010	0.047	0.202	0.840	no causal
tcmp	<---	implement	0.038	0.053	0.718	0.473	no causal
tcmp	<---	tcompt	0.334	0.054	6.212	0.001	causal
tcmp	<---	factor	-0.024	0.029	-0.822	0.411	no causal

Conclusion

The study concluded that the paths of interactions among the stakeholders, factor affecting technological capability and government policy implementations could only have significant relationships with technological capability of the solar energy firms through the mediated effects of the technological competence of the universities.

Based on the findings from the study, the following recommendations were proposed: there must be collective efforts from stakeholders in the national system of innovation in supporting R&D on solar energy; and a mutualism symbiotic relationship between the university faculty members and the solar energy firms in the country in order to build a sustainable technological capability in the solar energy industry.

References

Aeron, P. and Jain, R. (2015). A Study of Technological Capability among Product Based Telecom Start-Ups in India: Role of Knowledge, Learning and Brocolage. Indian Institute of Management Research and Publications Working Paper No. 2015-04-02.

Ajayi, O. O. and Ajayi, O. O. (2013). Nigeria's Energy Policy: Inferences, Analysis and Legal Ethics Toward Renewable Energy Development. *Energy Policy*, 60: 61–67.

Ajayi, O. O., Fagbenle, R. O., Katende, J. and Okeniyi, J. O. (2011). Availability of Wind Energy Resource Potential for Power Generation at Jos, Nigeria. *Frontiers of Energy*, 5(4): 376–385.

Akinbami, J. F. K. (2001). Renewable Energy Resources and Technologies in Nigeria: Present Situation, Future Prospects and Policy Framework. *Mitigation and Adaptation Strategies for Global Change*, 6(2):155–82.

Akuru, U. B. and Okoro, O. I. (2010). Renewable Energy Investment in Nigeria: A Review of the Renewable Energy Master Plan. Proceedings of the Energy Conference and Exhibition (EnergyCon), 2010 IEEE International, USA.

Aragon, M. I. B., Jimenez, D. J. and Valle, R. S. (2014). Training and Performance: The Mediating Role of Organizational Learning. Business Research Quarterly. 17: 161-173.

Barney, J. (2001). Is the Resource-Based View A Useful Perspective for Strategic Management Research? Yes. *Academic of Management Review*, 2(1): 41-56.

Bell, M. and Figueiredo, P. N. (2012). Innovation Capability Building and Learning Mechanisms in Latecomer Firms: Recent Empirical Contributions and Implications for Research. *Canadian Journal of Development Studies*, 33(1): 14-40.

Day, G. S. (1994). The Capabilities of Market-Driven Organizations. *Journal of Marketing*. 58: 37-56.

DiStefano, C., Zhu, M. and Mîndrilă, D. (2009). Understanding and Using Factor Scores: Considerations for the Applied Researcher. Practical Assessment, Research and Evaluation, 14(20): 1-11.

Dosi, G. (1988). Sources, Procedures, and Microeconomic Effects of Innovation. Journal of Economic Literature. 26: 1120-1171.

Duysters, G. and Lokshin, B. (2011). Determinants of Alliance Portfolio Complexity and Its Effect on Innovative Performance of Companies. *Journal of Product Innovation Management*. 28: 570-585.

Egbetokun, A. A. (2015a). The More the Merrier? Network Portfolio Size and Innovation Performance in Nigerian Firms. *Technovation*, 43-44, 17-28.

Egbetokun, A. A. (2015b). Interactive Learning and Firm-Level Capabilities in Latecomer Settings: The Nigerian Manufacturing Industry. *Technological Forecasting and Social Change*, 99(1): 231-241.

Energy Commission of Nigeria- ECN (2012). Renewable Energy Master Plan-updated. Abuja, Nigeria.

Energy Commission of Nigeria- ECN (2014). National Energy Master Plan. Abuja, Nigeria.

Freling, R. and Lahl, J. (2005). Renewable Energy Technology: Optimizing Energy Sources for the Development of Millennium Project Villages: Solar Electric Light Fund (SELF). Washington DC, USA.

Goldstein, D. and Hilliard, R. (2008). Organisational Capabilities for Sustainable Production. DIME International Conference: 'Innovation, Sustainability, and Policy' September, Bordeaux, France.

Hair, J. F., Black, W. C., Babin, B. J. and Anderson, R. E. (2010). Multivariate Data Analysis. Seventh Edition, Pearson Prentice Hall, Upper Saddle River, New Jersey, USA.

Handbook of Renewable Energy Technology (2011). Zobaa, A. F. and Bansal, R. C. (Eds.), World Scientific Publishing, Danvers, United State of America.

Hermann, S. (2001). Solar Manifesto. James and James Limited, London, 1–22.

Huenteler, J. Niebuhr, C. and Schmidt, T. S. (2014). The Effect of Local and Global Learning on the Cost of Renewable Energy in Developing Countries. Journal for Cleaner Production. In Press: 1-16. http://dx.doi.org/10.1016/j.jclepro.2014.06.056

Iammarino, S., Padilla, R. and von Tunzelmann, N. (2008). Technological Capabilities and Global–Local Interactions: The Electronics Industry in Two Mexican Regions. *World Development*, 36 (10): 1980–2003.

Iammarino, S., Piva, M., Vivarelli, M. and von Tunzelmann, N. (2012). Technological Capabilities and Pattern of Innovative Cooperation of Firms in the UK Regions. *Regional Studies*, 46(10): 1283-1301.

International Energy Agency- IEA (2011). CO_2 Emission from Fuel Combustion: Highlights. International Energy Agency, Paris.

IRENA, (2015). Renewable Energy Prospects: United Arab Emirates, Re-Map 2030 Analysis IRENA. Abu Dhabi. www.irena.org/remap.

Israel, G. D. (2012). Determining Sample Size, Program Evaluation and Organizational Development. IFAS, University of Florida, June PEOD-6, United States America.

Jekayinfa, S. O. and Omisakin, O. O. (2005). The Energy Potential of some Agricultural Wastes as Local Fuel Materials in Nigeria, Agricultural Engineering International: *The CIGR E-Journal of Scientific Research and Development*, 3: 33-44.

Karadag, E. (2012). Basic Features of Structural Equation Modelling and Path Analysis with its Place and Importance in Educational Research Methodology. *Bulgarian Journal of Science and Education Policy*, 6(1): 194-212.

Kline, R. B. (2011). Principles and Practice of Structural Equation Modelling. Third Edition, The Guilford Press, New York.

Ladan, M. T. (2009). Policy, Legislative and Regulatory Challenges in Promoting Renewable Energy. In: *Monograph 167 Environmental Governance and Climate Change in Africa: Legal Perspectives*, Mwebaza, R. and Kotze, L. J. (Eds.), 93-115.

Laursen, K. and Salter, A. (2004). Searching High and Low: What Types of Firms use Universities as a Source of Innovation?. *Research Policy*, 33(1): 1201-1215.

Leeuw, T., Lokshin, B. and Duysters, G. (2014). Returns to Alliance Portfolio Diversity: The Relative Effects of Partner Diversity on Firm's Innovative Performance and Productivity. *Journal of Business Research*. 67:1839–1849.

Leggett, J. A., Logan, J. and Mackey, A. (2008). China's Green House Gas Emissions and Mitigation Policies. Congressional Research Service Report for Congress.

Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal*. 13: 111-125.

Nelson, R. R. and Winter, S. G. (1982). An Evolutionary Theory of Economic Behavior and Capabilities, Cambridge, Harvard University Press, 195–307.

Ockwell, D., Haum, R., Mallett, A., Watson, J. (2010). Intellectual Property Rights and Low Carbon Technology Transfer: Conflicting Discourses of Diffusion and Development. *Global Environmental Change*, 20: 729–738.

Ogbimi, F. E. (2007). Solution to Mass Unemployment in Nigeria. Third Edition, Society for Linking Education and Problems, Ile-Ife, Nigeria, 7-103.

Oladeji, J. T. (2009). Energy and Power Development: Renewable and Decentralized Energy for Remote Communities. Proceedings of 22nd AGM and International Conference of NIMechE, Osogbo, October 21-23, 232-234.

Oyelaran-Oyeyinka, B. (2003). Knowledge Networks and Technological Capabilities in the African Manufacturing Cluster. *Science Technology Society*, 8(1): 1-23.

Panda, H. and Ramanathan, R. (1996). Technological Capability Assessment of a Firm in the Electricity Sector. *Technovation*. 16(10): 561-588.

Penrose, E. T. (1959). The Theory of the Growth of the Firm, Oxford, Blackwell.

Saifuddin N., Bello S., Fatihah, S. and Vigna, K. R. (2016). Improving Electricity Supply in Nigeria: Potential for Renewable Energy from Biomass. *International Journal of Applied Engineering Research*, 11(14): 8322-8339.

Shaaban, M. and Petinrin, J. O. (2014). Renewable Energy Potentials in Nigeria: Meeting Rural Energy Needs. *Renew Sustain Energy Reviews*, 29: 72–84.

Teece, D. J., Pisano, G. and Shuen, A. (1990). Firm Capabilities, Resources and the Concept of Strategy. Consortium on Competitiveness and Cooperation Working Paper, Berkley, USA.

Uduma, K. and Arciszeswki, T. (2010). Sustainable energy development: The key to a stable Nigeria. *Sustainability*, 2: 1558-1570.

von Hippel, E. (1994). Sticky Information and the Locus of Problem Solving: Implications for Innovation. *Management Science*, 40(4): 429–439.

von Tunzelmann, N. and Wang, Q. (2003). An Evolutionary View of Dynamic Capabilities. *Economie Appliquée*, 6: 33–64.

Wen, D. J. (2009). Climate Change and China: Technology, Market and Beyond. Occasional Paper: 6, Focus on the Global South, 49-68.

Yamane, Taro. 1967. Statistics: An Introductory Analysis, 2nd Ed., New York: Harper and Row.