Role of government towards adoption of cleaner technologies for climate proactivity

A survey-based empirical study of Indian firms

Santanu Kumar Satapathy
National Institute of Industrial Engineering (NITIE), Mumbai, India
Shirish Sangle
Sustainable Business, National Institute of Industrial Engineering (NITIE), Mumbai, India, and
Seema Unnikrishnan
National Institute of Industrial Engineering (NITIE), Mumbai, India

Abstract

Purpose – There is a need for considerable attention on the adoption of cleaner technologies (CT) by firms for climate proactivity for developing countries such as India. Literature survey suggests that government, market and civil society are the key drivers of CT adoption (CTA) in developing countries. The purpose of this paper is to investigate the mediating and moderating role of the government in CTA for climate proactivity.
Design/methodology/approach – The data collected from a survey of Indian firms were analyzed through exploratory factor analysis and multiple regression analysis to examine the mediating and moderating role of the government.
Findings – The empirical outcome was compared with the current government policies to summarize the research findings.
Research limitations/implications – There is scope of future research to examine the moderating and mediating role of market and civil society in CTA for climate proactivity.
Practical implications – The study will provide significant insight into various stakeholders associated with the CTA such as government, technology manufacturers, marketing community, environmental professionals and associated researchers. The research model will be useful for policymakers, managers and researchers for understanding CTA in the Indian context.
Social implications – The output model will be useful for the government to formulate forward-looking strategies toward the adoption of CT by industries for climate proactivity.
Originality/value – Unlike previous studies in which the government was recognized as a key driver of CTA, this study makes an attempt to test the moderating/mediating role of government in CTA in India. The findings of the study are supported by adequate empirical evidence.

Keywords Government policy, Cleaner technologies adoption, Climate proactivity, Indian firms, Moderating and mediating role

Paper type Research paper

1. Introduction

What is the role of government toward the adoption of cleaner technologies (CTs) by firms in India? While many studies have been carried out in developed countries on CT adoption (CTA), very less research is evident on developing countries such as India. In the early 1970s, most of the developed countries such as USA and Canada established stringent environmental regulations to address the concern of environmental pollution and the threat of climate change. This resulted in an increase in their pollution abatement investments significantly. For example pollution abatement expenditure of USA was increased by 137 percent over the period 1979-1994 (Berman and Bui, 2001). Similarly, Canada had to increase its pollution abatement expenditure by 27 percent during 1995-2002 to meet the new environmental norms (Statistics Canada, 2004). A recent study

World Journal of Science, Technology and Sustainable Development
Vol. 14 No. 1, 2017
pp. 29-49

2042-5945
DOI 10.1108/WJSTSD-02-2016-0027

finds that CT diffusion in India is only 12 percent compared with 59 percent by China (Dechezleprêtre *et al.*, 2009).

CTs use lesser natural resources and have reduced environmental impact (OECD, 2014; Truffer, 2012) compared with the conventional technologies. Current studies show that technological innovation is strongly focusing on the development of CTs for various applications (Jacobsson and Bergek, 2011). Despite the urgent need for CTA, very few studies have been carried out in the developing countries pertaining to technological innovation, which limits access to the clean-tech potential in emerging economies such as India and China (Bai *et al.*, 2009; Binz *et al.*, 2014, 2012; Gosens and Lu, 2013; Hansen and Nygaard, 2013; van Alphen *et al.*, 2008; Vasseur *et al.*, 2013).

Multinational companies operating in the regions of negligent environmental compliance requirement, but with presence in the mature global marketplaces with a demand for environment-friendly goods, are more inclined toward the adoption of CTs (Luken and Van Rompaey, 2008; Calleja *et al.*, 2002; Luukkanen, 2003).

As developing countries such as India, China and Africa are rapidly industrializing, it is important for them to develop and adopt CT right from the design stage of new projects. Since the Rio Conference of 1992, environmental performance of the industries in developing countries has achieved major improvements. Between 1990 and around 2002, developing countries have fared better in terms of reducing water pollution and energy conservation. Developing countries have achieved a 27 percent reduction in energy intensity and a 49 percent reduction in water pollutant intensity during this period. In contrast, the developed countries have achieved only about an 8 percent reduction in energy intensity and a 29 percent reduction in water pollutant intensity during the same period (Luken and Castellanos-Silveria, 2006). However, despite this, developed countries remain better placed in terms of pollution reduction compared with their counterparts in developing countries. The energy use, water use, water pollutant and carbon dioxide emission of industries in developing countries remain almost three times, more than 11 times, six times and four times higher, respectively (Luken *et al.*, 2008). The gap needs to be analyzed by the governments of developing countries and the factors need to be identified to step up the speedy adoption of CT.

Developing countries will be the most impacted by the climate change effects; in particular, the poor populations will suffer the most because of their inability to sufficiently adapt to the change (World Bank Report, 2013). Therefore, climate change offers ample opportunity for the developing countries to formulate their own strategy to promote local cleaner industries that can lead to economic, social and environmental benefits. CTA is extremely essential to tackle the issues arising from environmental pollution resulting in climate change. A study of past research work on CTA indicates that ample research has been carried out on the adoption of CT at factory as well as sector levels (Montalvo, 2002; Wijk *et al.*, 2001). As it is evident that widespread adoption of CT will help mitigate the climate change effects, it is essential to determine the factors affecting CTA for climate variability (Sangle, 2011).

1.1 Need and significance

Technology and human activities are the pivotal causative agents of climate change. Literature survey suggests that a reduction in GHG emissions can only be achieved through adoption of CT by companies and eco-friendly technology-based product adoption by individuals. As India is becoming a major player in the global economy in the twenty-first century, it is necessary that it takes steps to address the climate change issue through policies and regulations. Investing in CTs holds the greatest promise toward addressing these challenges while generating superior returns and job creation. As a rising economy of the twenty-first century, India is under global pressure to reduce its GHG emissions while

achieving economic growth. Hence, in view of the above scenarios, the present research study aims to identify the role of civil society, government and market in the adoption of CTs by companies and to determine the determinants of technology-based product adoption by consumers in the context of climate change.

Very few studies (e.g. Luken *et al.*, 2008) have shed light on the role of civil society, government and market in promoting CTs. Also, it may be perceived from the literature study that only some studies have reported on the adoption of CTs in the context of climate change. Only a few studies are reported (e.g. Montalvo, 2008; World Bank Report, 2000) in the literature with respect to the adoption of CT in India.

1.2 Objective of the study

The aim of the proposed research work is to study the mediating and moderating role of government in firms, technology and stakeholders toward the adoption of CTs for climate proactivity.

2. Conceptual background for CTA by companies

With growing global attention toward environmental concerns during the end years of the twentieth century, it was also eminently clear that technical improvements are the key approaches for providing environmental and social sustainability. Various studies have been carried out in the past 20 years in the field of CTA in different countries. This section summarizes the key determinants responsible for CTA, mainly in the developing countries. A review carried out by Montalvo (2008) classifies the various factors affecting CTA. These factors are environmental regulations, economics, markets, pressure from community and society, social status, technical expertise and organizational abilities. The elements reported in the empirical studies could be drivers and (or) barriers of CTA on the basis of the conditions, period and perspectives in which they are considered.

The literature shows that government policies and implementation of the regulations are one of the key drivers of environmentally accountable performance by the industries (Battisti, 2008; Clayton *et al.*, 1999; Vollebergh and van der Werf, 2014). A few studies also report that government policies are not the promoters of pollution prevention at source (Rothwell, 1992; Granderson, 1999) and it was also found that the government regulations are not intended to encourage industries to develop and adopt CTs (CSIS, 1997; Huhtala, 2003; Government of India (GOI), 2014; Groba and Breitschopf, 2013; Kalamova *et al.*, 2013). Cleaner production has a large potential to influence the economic aspect of firms. As there is an urgent requirement for the replacement of older technologies with state-of-the-art new technology, the economy of the twenty-first century will be dependent on technology adoption for long-term sustainable growth (CSIS, 1997; PCSD, 1999). Market plays an important role in the adoption of CT. Past studies have evidenced that environmental problems have resulted in market failure; this is because of the fact that many countries do not accept products that are harmful to the environment (Pearce and Turner, 1991; Tietenberg, 1992). Pressure from communities and society is one of the major attributers for the adoption of CT by the industries. Better social image and public acceptability pertaining to ecological aspects are drivers that motivate the firms to aim for cleaner production (Steger, 1993; Jurgen and Holliday, 2002). Hence, pressure from community, consumer demand and NGOs are all drivers of ecological safeguard (Visser *et al.*, 2008; Dillon and Baram, 1993; Duffy *et al.*, 1999; Hart and Ahuja, 1996; Rondinelli and Vastag, 1996; Hartman and Stafford, 1997; Luukkanen, 2003). The attitudes and social values are supplemented by the fact that the decision to adopt CTs is influenced by the positive approach, philosophy and personality of senior executives of the firm (Calleja *et al.*, 2002; Duffy *et al.*, 1999; Steger, 1993; Everett *et al.*, 1993; Andrews, 1998).

Technological opportunities and capabilities are important in adopting new pollution prevention technologies. It is evident that a lack of cleaner production/design experts (Tukker *et al.*, 2000), lack of capacity enhancement at the firm level (Koefoed and Buckley, 2008; Huhtala, 2003) and the lack of expertise in cleaner production project implementation (Staniskis and Stasiskiene, 2003; del Río *et al.*, 2013) collectively affect the adoption of new cleaner production processes and technologies innovation (Plotnikova *et al.*, 2015). Organizational capabilities such as unlearning old skills, acquiring new skills, ability to collaborate with suppliers and engaging with the customers are very critical for firm-level CTA (Roome, 1994; Murphy and Gouldson, 2000; Florida, 1996; Van Dijken *et al.*, 1999; Kerndrup *et al.*, 1999; Duffy *et al.*, 1999; Eder's, 2003; del Río *et al.*, 2013).

A study by Adeoti (2002) covering 122 plants in the food, beverage and textiles sub-sectors in Nigeria shows that government regulation is a key promoter of EST[1] (PAT & CT) adoption. As per his study, the major driver for pollution prevention (CTA) is plant size and plant internal capacity, whereas environmental policy is a very insignificant variable. According to Luken and Van Rompaey (2008), high production cost, current environmental laws and expected future environmental rules are the three most important drivers for adopting EST in the developing countries. Adeoti (2002), however, reported a different study outcome on this. Adeoti found that environmental regulation, accident prevention and improving environmental image are the three key drivers for EST adoption. Similarly, according to the study by Luken and Van Rompaey (2008), high cost of implementation, unavailability of alternative technology and deficiency of technical skills are the three most important barriers for EST adoption in developing countries. Again, Adeoti (2002) reported a different opinion on the barriers. According to Adeoti, high capital cost of pollution control equipment, no convincing reason to spend in EST and absence of awareness of EST are the three most important obstacles to EST adoption.

Most of the studies in the developing countries investigated the influence of regulatory pressure on the compliance of environmental norms and adoption of the CTs/EST. The studies focused on two factors, i.e., contextual (external, such as pressure from community and market) and plant-specific (internal, such as skills, organizational capability and cost). The research on CTA in the developing countries is focused on either contextual or plant-specific factors or the combination of the two factors (Hettige *et al.*, 1996; Aden *et al.*, 1999; Aden and Rock, 1999; Seroa da Motta, 2006; Gangadharan, 2006; Wang and Wheeler, 2000; Adeoti, 2002; Blackman and Kildegaard, 2004; Montalvo, 2003; Wheeler and Martin, 1991; Reppelin-Hill, 1999; Veugelers, 2012).

2.1 Development of hypotheses

The literature sited in the previous section suggests that government acts as a driver for CTA. One key finding of a survey conducted by Montalvo (2008) was that government policies are one of the main drivers of CTA in industry. The framework by Sangle (2011) brings together the technology, firm and stakeholder for CTA for climate proactivity. The World Bank "New Model" mentions that "Government is more like a mediator rather than a dictator, because it exerts influence through numerous channels," and suggests more empirical research in this direction (World Bank Report, 2003). Therefore, this research study makes an attempt to empirically determine the role of government as moderator and (or) mediator toward CTA for climate proactivity.

Venkatraman (1989) identifies six models of fit: mediation, moderation, matching, gestalts, profile deviation and co-variation. The mediation and moderation models of fit are suitable for the current purpose because they are capable of conceptualizing the fit between two constructs and can be anchored to performance. To understand the role of

government as moderator or mediator, the following hypotheses have been proposed for empirical validation.

Moderation can be described as the scenario wherein a third variable governs the impact of a predictor variable on the criterion variable, Venkatraman (1989). To investigate the moderating role of government on firm, technology and stakeholder in CTA for climate proactivity, the following three hypotheses are proposed. Governemt will be tested as moderator, firm, technology and stakeholder are independent variables and CTA for climate proactivity is the dependent variable:

H1. Government plays a moderating role between firm and CTA for climate proactivity.

H2. Government plays a moderating role between technology and CTA for climate proactivity.

H3. Government plays a moderating role between stakeholder and CTA for climate proactivity.

Mediating role indicates the existence of a significant intervening mechanism between an antecedent variable and the consequent variable, Venkatraman (1989). As government intervention is key to CTA (Montalvo, 2008; World Bank Report, 2003), we propose the following three hypotheses to investigate the mediating role of government on firm, technology and stakeholder in CTA for climate proactivity. Government will be tested as mediator, firm, technology and stakeholder are independent variables and CTA for climate proactivity is the dependent variable:

H4. Government plays a mediating role between firm and CTA for climate proactivity.

H5. Government plays a mediating role between technology and CTA for climate proactivity.

H6. Government plays a mediating role between stakeholder and CTA for climate proactivity.

The six hypotheses proposed above are presented in Figures 1-6, respectively.

3. Research methodology

In this section, the questionnaire design, data collection and data analysis techniques used for the study have been detailed; also, potential biases and their removal techniques have been briefly summarized.

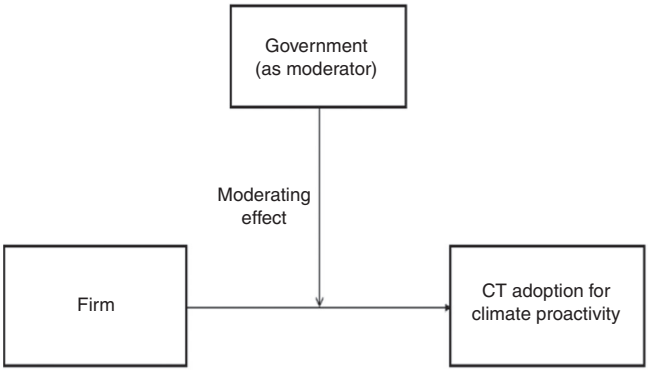


Figure 1.
H1 – moderating role of the government between firm and CT adoption for climate proactivity

Unit of analysis shall be "firms/organizations" for CTA. As the case may be, it can be the complete organization or sub-part of an organization where the strategy under consideration has been in practice. The role of government, market and civil society in adoption or non-adoption of clean technology in the context of climate change was discussed among the middle to top management staff.

3.1 Questionnaire design

As this research is exploratory in nature, a questionnaire-based survey was chosen as an appropriate approach (Bailey *et al.*, 1995). Primarily, such a method of data collection has multiple benefits of being a relatively faster, cost-effective easy of analysis (Bowling, 1997).

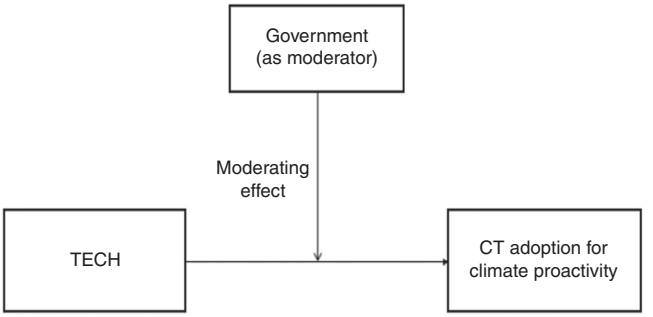


Figure 2.
H2 – moderating role of the government between technology and CT adoption for climate proactivity

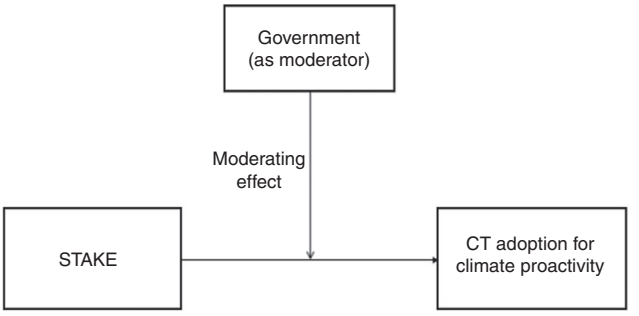


Figure 3.
H3 – moderating role of the government between stakeholder and CT adoption for climate proactivity

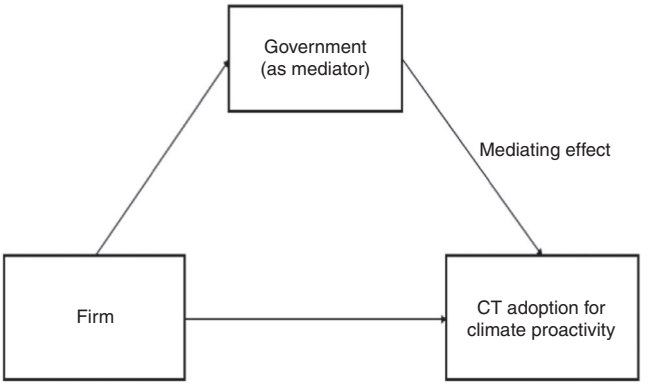


Figure 4.
H4 – mediating role of the government between firm and CT adoption for climate proactivity

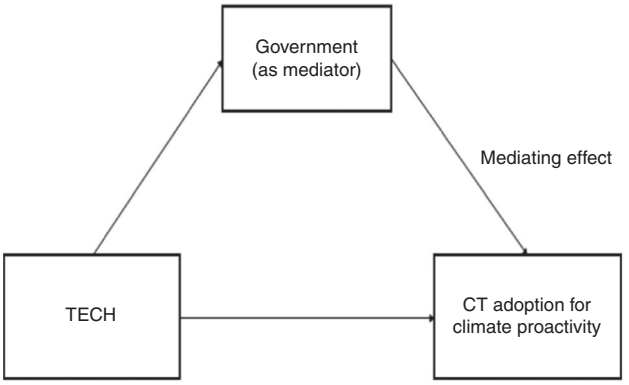


Figure 5.
H5 – mediating role of the government between technology and CT adoption for climate proactivity

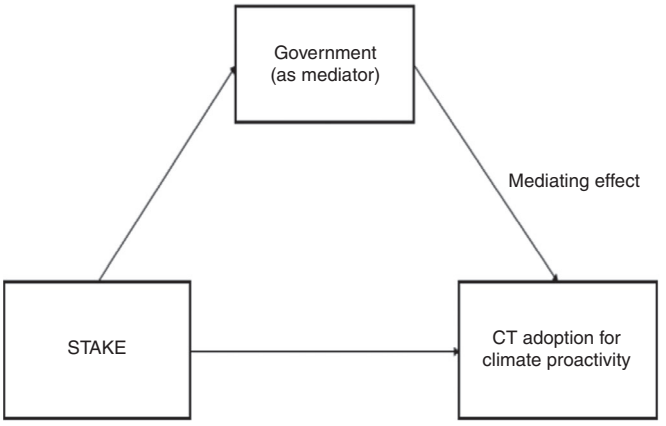


Figure 6.
H6 – mediating role of the government between stakeholder and CT adoption for climate proactivity

A literature survey was conducted to confirm the determinants/variables for questionnaire preparation. On the basis of the literature survey, research gap and the objective of the research work, a questionnaire design was used to conduct the primary survey for empirical analysis. Due attention was paid to make the questions respondent-centric and easy to understand. The language of the questionnaire was "English" because the target respondents were well versed with the language. The language and words were kept simple and straightforward to ensure that the respondents understood it easily. Care was taken to minimize the social desirability bias while designing the questions. A draft questionnaire was prepared on the basis of the literature survey and in line with the research objectives. A focus group discussion was carried out with a few experts to understand the gaps in the questionnaire. During the focus group discussion, a few questions were modified while a few repetitive or irrelevant ones were removed. As per the research objective, the questionnaire was designed focusing on the selected five factors, i.e., government, CTs, stakeholders, organizations and climate proactivity. The questionnaire was finalized and a pilot study was carried out to collect 185 samples. Pilot study responses were analyzed and further minor corrections were made for the final survey.

3.2 Scale used for the survey

A seven-point Likert scale was used in the pilot survey, with 1 indicating strongly disagree and 7 indicating strongly agree (Table I).

Named after its developer, Rensis Likert, this is a widely used rating scale that requires the respondents to indicate the degree of agreement or disagreement with each of a series of statements about the stimulus objects (Likert, 1932). The Likert scale has several advantages. It is easy to construct and administer. Respondents easily understand how to use the scale, making it suitable for mail, telephone, personal or electronic interviews.

3.3 Data collection

The data were collected in an electronic format (i.e. online questionnaire) for the study. The data were fed into Microsoft Office Excel 2007. Pilot testing of the data was carried out through exploratory factor analysis (EFA) using principle component analysis in SPSS version 20. The results of the factor analysis have been discussed in the following section. The EFA data were further used for multiple regression (MR) analysis in SPSS version 20. The following steps were followed for the research work and to validate the research models.

In total, 242 questionnaires were received within six weeks of the questionnaire being sent to different industries across India. Of the 242 respondents, 148 (61 percent) were from large-scale and 94 (39 percent) respondents were from small- and medium-scale industries (SMEs). In total, 75 (31 percent) respondents were from the organizations publishing sustainability report as per GRI guidelines, whereas the rest of the 167 respondents (69 percent) were not publishing any non-financial report. In total, 94 percent (228) of the respondents were private firms whereas 6 percent (14) of the respondents were from government/PSU firms. In total, 175 (72 percent) responses were from middle and senior employees, whereas 67 (28 percent) responses were from junior managers with more than eight years of experience and working in corporate headquarters. In total, 205 (85 percent) respondents were from ISO 14001-certified companies whereas 37 (15 percent) responses were from non-EMS-certified companies. Overall, 242 positive replies were received, yielding a 76 percent response rate. The survey cannot be considered biased following Moser and Kalton (1971), who hold that the results of a postal survey are biased if the return rate is lower than the range 30-40 percent.

3.4 Data analysis

The study utilizes factor analysis to support the factor structure of the variables and to ascertain that the variables used in the study were conceptually different. EFA using principal component analysis with varimax rotation was carried out to achieve a simple data structure. Further, MR analysis was carried out to verify the factor structure of the observed variables.

MR is a statistical technique that simultaneously develops a mathematical relationship between two or more independent variables and an interval-scaled dependent variable. This technique is used to test the moderating and mediating role of a variable in the study. This method has been used in the present study to ascertain the moderating/mediating role of government in CTA for climate proactivity. Further, the Sobel (1982) test was carried out to confirm the significance of the mediation effect.

The data collected were processed in the SPSS software for EFA, followed by MR analysis. The results of the EFA and MR analysis are explained below.

Table I. Seven-point Likert scale

	Disagree		–		Agree	
Extremely	Quite	Slightly	Uncertain	Slightly	Quite	Extremely
1	2	3	4	5	6	7

3.4.1 EFA. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy measure was found to be greater than 0.5, i.e., 0.690, which indicates that the sample is adequate for the given number of variables used for the factor analysis (Hutcheson and Sofroniou, 1999).

Table II shows the KMO and Bartlett's test of sphericity values from SPSS.

Cronbach's α (Cronbach, 1951), which quantifies the degree of internal consistency (reliability) of a set of items, was calculated for each subscale as well as the overall scale. In general, a Cronbach's α value of at least 0.7 is the criterion used to establish an acceptable level of reliability. Cronbach's α values are presented in Table III.

It may be observed from the cumulative percent column that the five factors extracted together accounted for 57.775 percent of the total variance. This is remarkable because the EFA could able to economize on the number of variables from the original 17 to 5 underlying factors. The total variance explained is shown in Table IV.

In Table V, the rotated factor matrix has been reported; from this, the following observations can be made.

International norms, international support, policy and regulation and incentives and recognition are the variables related to government. Hence, these factors are collectively named as GOVT. Economic risk (ECO), organizational learning, strategic alliance and collaboration capability (COL) are the variables related to firm. This factor is, therefore, named as FIRM. High capital cost, research and development and awareness (AWA) are the variables related to technology. Hence, these are named as TECH. Community (COM), social media and industry association are the variables related to stakeholders. These factors are, therefore, named as STAKEH. CTA1, CTA2 and CTA3 are the factors related to CTA for climate proactivity. Hence, these three factors were named as CTA.

Table II. KMO and Bartlett's test of sphericity

KMO and Bartlett's test		
Kaiser-Meyer-Olkin measure of sampling adequacy		0.690
Bartlett's test of sphericity	Approx. χ^2	995.963
	df	136
	Sig.	0.000

Table III. Reliability statistics

Variables	Cronbach's α	No. of items
Firm	0.800	4
Government	0.807	4
Technology	0.749	3
Stakeholder	0.758	3
Climate proactivity	0.723	3

Table IV. Total variance explained

Total variance explained			
		Rotation sums of squared loadings	
Component	Total	% of variance	Cumulative %
1	2.648	15.579	15.579
2	2.609	15.347	30.926
3	1.674	9.845	40.771
4	1.464	8.609	49.380
5	1.427	8.395	57.775

Variables	Component 1	2	3	4	5
Economic risk (ER)	*0.766*	0.124	0.064	0.096	−0.035
Organizational learning (OL)	*0.779*	0.168	0.011	−0.154	0.061
Strategic alliance (SA)	*0.769*	0.120	−0.137	−0.138	−0.034
Collaboration capability (COL)	*0.815*	0.044	−0.062	0.034	0.147
High capital cost (CC)	0.040	−0.046	*0.652*	−0.068	−0.106
Research and development (RD)	−0.209	0.019	*0.728*	−0.090	−0.147
Awareness (AWA)	0.025	0.162	*0.645*	0.220	0.133
Community (COM)	0.031	−0.050	0.258	*0.574*	0.028
Social media (SM)	−0.014	−0.038	−0.317	*0.586*	0.001
Industry association (IA)	−0.218	0.227	0.015	*0.622*	0.165
International norms (IN)	0.154	*0.829*	0.147	0.099	−0.080
International support (IS)	0.098	*0.831*	0.202	0.030	−0.058
Policy and regulation (PR)	0.021	*0.745*	−0.048	0.071	−0.061
Incentives and recognition (IR)	0.233	*0.692*	−0.158	−0.105	−0.018
CTA1	0.114	−0.196	−0.117	0.248	*0.618*
CTA2	−0.041	−0.108	0.049	−0.431	*0.680*
CTA3	0.039	0.029	−0.059	0.124	*0.681*

Table V.
Rotated component matrix

Convergent validity was checked and it was found that the factors are highly correlated. Also, divergent validity confirmed that there was no cross loadings for any of the 17 variables.

3.4.2 MR analysis of the factors from the EFA study. On the basis of the above inferences from the EFA study, all the factors, i.e., firm, technology, stakeholder, government and CTA for climate proactivity were identified for MR analysis. MR considering the variables are grouped under the factors identified in the above EFA.

3.4.2.1 Moderating role of government. To establish moderation, it must be shown that a moderator interacts with an independent (initial) variable to yield a dependent (final) variable (Baron and Kenny, 1986). Statistically, a moderator exists when there is a significant interaction. A moderator may increase the strength, decrease the strength or alter the direction of a relationship. The following sections discuss the moderating role of Government clarified through MR analysis.

The MR output is shown in Table VI; it shows a standardized regression value with CTA as a dependent variable. The direct relation between FIRM and CTA is significant ($\beta = 0.172$ and $p = 0.028$) and the direct relation between GOVT and CTA is significant ($\beta = -0.215$ and $p = 0.001$), but negative. The combined interaction of FIRM and GOVT with CTA is not significant ($\beta = 0.084$ and $p = 0.264$), which explains that GOVT is not acting as a moderator between FIRM and CTA.

The MR output is shown in Table VII; it shows a standardized regression value with CTA as a dependent variable. The direct relation between TECH and CTA is not significant ($\beta = -0.105$ and $p = 0.123$) and the direct relation between GOVT and CTA is significant

Model 1	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	−0.021	0.066		−0.316	0.752	
ZFIRM	0.172	0.078	*0.172*	2.205	*0.028*	0.655
ZGOVT	−0.215	0.066	*−0.215*	−3.257	*0.001*	0.916
ZFIRM X ZGOVT	0.074	0.066	0.084	1.120	0.264	0.705

Table VI.
Multiple regression between firm and government

($\beta = -0.161$ and $p = 0.012$), but negative. The combined interaction of TECH and GOVT with CTA is not significant ($\beta = -0.059$ and $p = 0.383$), which explains that GOVT is not acting as a moderator between TECH and CTA.

The MR output is shown in Table VIII, which shows the standardized regression value with CTA as a dependent variable. The direct relation between STAKE and CTA is not significant ($\beta = 0.070$ and $p = 0.276$), whereas the direct relation between GOVT and CTA is significant ($\beta = -0.175$ and $p = 0.007$) although negative. The combined interaction of STAKE and GOVT with CTA is not significant ($\beta = -0.055$ and $p = 0.388$), which explains that GOVT is not acting as a moderator between STAKE and CTA.

The R^2 values for the above three outputs of the moderation study are 0.050, 0.049 and 0.038, respectively.

3.4.2.2 Mediating role of government. Mediation is the mechanism that underlies the relationship between an independent (initial) and a dependent (outcome) variable by the involvement of a third explanatory (intervening/mediating) variable (Baron and Kenny, 1986). The following sections discuss the moderating role of government through MR analysis.

The MR output shown in Table IX has a standardized regression value with GOVT as the dependent variable. The direct relation of FIRM ($\beta = 0.310$ and $p = 0.000$), TECH ($\beta = 0.133$ and $p = 0.032$) and STAKE ($\beta = 0.114$ and $p = 0.067$) with GOVT is significant sand positive.

MR output is shown in Table X as having a standardized regression value with CTA as a dependent variable. The direct relation of FIRM ($\beta = 0.057$ and $p = 0.384$) and STAKE ($\beta = 0.063$ and $p = 0.329$) with CTA is insignificant. The direct relation of TECH ($\beta = -0.135$ and $p = 0.037$) with CTA is significant, but negative.

Model 2	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	0.006	0.063		0.096	0.924	
ZTECH	−0.105	0.068	−0.105	−1.549	0.123	0.861
ZGOVT	−0.161	0.064	*−0.161*	−2.530	*0.012*	0.990
ZTECH X ZGOVT	−0.065	0.074	−0.059	−0.875	0.383	0.866

Table VII. Multiple regression between technology and government

Model 1	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	0.005	0.064		0.071	0.944	
ZSTAKE	0.070	0.064	0.070	1.092	0.276	0.994
ZGOVT	−0.175	0.064	*−0.175*	−2.736	*0.007*	0.987
ZSTAKE X ZGOVT	−0.058	0.067	−0.055	−0.865	0.388	0.993

Table VIII. Multiple regression between stakeholder and government

Model 1	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	−3.969E-015	0.061		0.000	1.000	−3.969E-015
ZFIRM	0.310	0.062	0.310	4.995	0.000	0.310
ZTECH	0.133	0.062	0.133	2.159	0.032	0.133
ZSTAKE	0.114	0.062	0.114	1.843	0.067	0.114

Table IX. Interaction between independent variables and mediator

The standardized MR output in Table XI shows that the direct relation of GOVT ($\beta = -0.174$ and $p = 0.007$) with CTA as a dependent variable is significant, but negative.

The R^2 values for the above three outputs of the mediation study are 0.108, 0.027 and 0.030, respectively.

4. Results and discussion

The statistical outcomes of the study are discussed in this section, correlating the same with the literature study. Also, the policy implications of the research findings are discussed in this section.

As shown in Figure 1 and explained in Table VI, this study does not support the moderating role of government for CTA by the firms for climate proactivity, i.e., *H1* is not supported. This implies that existing government mandates are only followed for compliance purposes and, with no legal compulsion, the government is not influencing the firms to go beyond compliance. The result of the mediating role of government shown in Figures 4, 7 and 8 is explained in Tables IX-XI. MR analysis shows a significant mediation effect whereas the Sobel test confirms the mediating role of the government between firm and CTA for climate proactivity. Hence, *H4* is supported. This indicates that for CTA by firms, government policies are rather essential. The direct interaction between firm and CTA is not significant, but with the mediation of the government, it acquires significance. Empirical studies have established that regulatory pressure is a major element in firm's environmental performance (Luken and Van Rompaey, 2008).

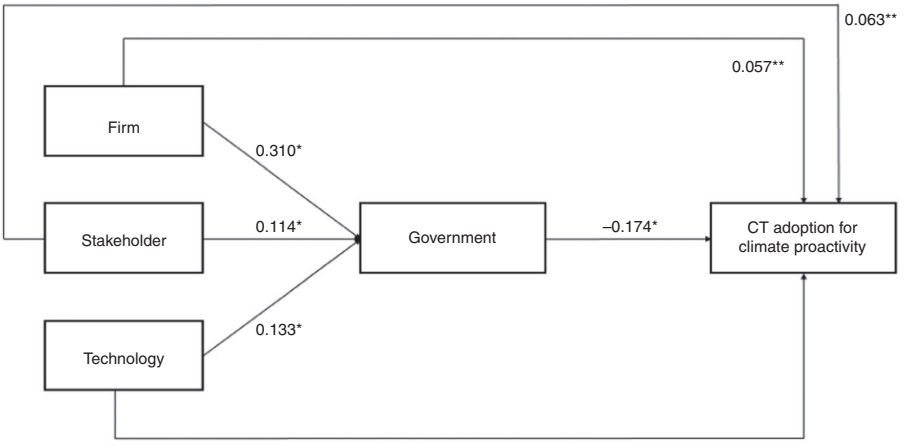
The mediation result shows that the interaction between government and CTA is significant, but negative. This means that government policies are not promoting CTA for climate proactivity. This result is supported by various studies carried out previously in the area of CTA. According to a survey conducted by Montalvo (2008), studies by various authors agree on the fact that the design and enforcement of the environmental policies are not favouring the adoption of CTs in industries (CSIS, 1997; PCSD, 1999; Huhtala, 2003). The negative result is also supported by Reijnders L. (2003), whose study states that present government regulation will progressively become outdated, counterproductive and incapable of motivating CTA. As per the study by the World Bank Report (2000), most of the manufacturing companies in the developing countries have complied or even overcomplied with the prescribed environmental norms. Even after complying with the environmental norms, the adoption of CTs is extremely slow in developing countries. This indicates the inadequacy of the present environmental laws in promoting CTA. This result is also supported by one recent study carried out in India. The MoEFCC (then MoEF),

Table X.
Interaction between independent variables and dependent variable

Model 1	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	−1.958E-015	0.064		0.000	1.000	−1.958E-015
ZFIRM	0.057	0.065	0.057	0.872	0.384	0.057
ZTECH	−0.135	0.064	−0.135	−2.098	0.037	−0.135
ZSTAKE	0.063	0.064	0.063	0.978	0.329	0.063

Table XI.
Interaction between dependent variable and mediator

Model 1	Unstandardized coefficients *B*	SE	Standardized coefficients *β*	*t*	Sig	Collinearity statistics Tolerance
Constant	−2.333E-015	0.063		0.000	1.000	−2.333E-015
ZGOVT	−0.174	0.064	−0.174	−2.739	0.007	−0.174



Notes: *, significant; **, not significant

Figure 7.
Mediating role of the government with all the variables

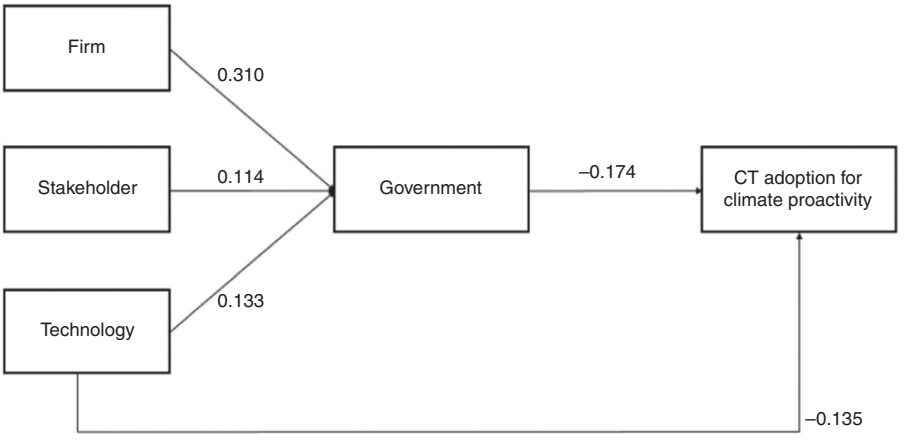


Figure 8.
Mediating role of the government with only significant variables

Government of India (GOI), set up a high-level committee in 2014 to review all the environmental laws and ascertain the gaps in government policies. To drive a paradigm shift in technology adoption, this committee recommended a reworking of the existing standards and revising a system of financial penalties and rewards to create a market-related incentive system to encourage "green projects" (GOI, 2014). Similarly, a study by World Bank in 2014 suggested that for faster adoption of CT among the SMEs in developing countries, legal and regulatory framework is a key support area. The study states that by enabling an overall framework for clean technology, SMEs can be strengthened. This framework can be formulated by implementing a number of legal and regulatory policies, including sector-specific tax incentives, cap-and-trade emission schemes, emission reduction credits, taxation on pollution or natural resource use, import tax reductions or waivers and incentives to attract skilled labor. These can be designed to create business incentives and/or obligations that address both the supply and the demand side of clean technology markets.

The moderating role of government between technology and CTA is not supported in this study, i.e., *H2* is not supported. This indicates that the government is not influencing

technology adoption beyond the policy implications. The moderating effect is shown in Figure 2 and explained in Table VII. The MR analysis and the Sobel test confirm that there is a partial mediation of government between technology and CTA, i.e., *H5* is supported. The mediation results are explained in Tables IX-XI. The mediating effect is shown in Figures 5, 7 and 8. The interaction of technology through government ($0.133 \times -0.174 = -0.023$) is more significant compared with the direct interaction between technology and CTA (−0.315). This indicates that the government has less influence on technology compared with its influence on firms for CTA.

The partial mediation implies that government policies do not have direct control over technology innovation. This is true because governments do not have direct command over CT. On the basis of the government policies, technology manufacturers carry out the required R&D, manufacture the desired product and ensure necessary marketing to convince the firms for adoption of new technology. Apart from the regulatory requirement, adoption of new technology depends on various factors such as future stringent environmental norms, capital investment, technological capabilities, organizational capabilities, awareness on new technology, environmental image, supply chain demand and commitment to go beyond compliance (Sangle, 2011; Hilliard, 2006; del Rio Gonzalez, 2005; Montalvo, 2003; Luken *et al.*, 2008; Kemp and Volpi, 2008).

As discussed in the initial part of this section, CTA in developing countries such as India is currently perceived as beyond compliance. Hence, as the mediation result shows, CTA has a direct interaction with technology, with partial mediation by government. This result is justified because there are various firm-specific factors that influence the CTA decision along with anticipated stringent legal requirements. There are few government policies (e.g. NAPCC, National Environmental Policy) that recommend firms for various types of technology adoption, but as these are voluntary guidelines, firms barely implement them. Hence, with reference to the discussion, it can also be stated that "until there are adequate regulations for CTA, the Government role will be limited on the Technological front for the Adoption of CTs for climate proactivity."

This study did not support the moderating role of government between stakeholders and CTA, i.e., *H3* is not supported. This indicates that government is not influencing the stakeholders to intervene in favor of CTA by companies. The relation is presented in Figure 3 and the moderating results are presented in Table VIII. The mediation of government between stakeholder and CTA is significant, but the Sobel test does not confirm the mediation. Hence, *H6* is not supported. The mediation results are explained in Tables IX-XI. The mediating effect is shown in Figures 6-8. This implies that the Indian government is neither moderating nor mediating the stakeholders for CTA for climate proactivity.

A literature study on CTA identifies the stakeholders as an important determinant of environmental performance. Local communities, consumer groups and NGOs have been sensible "watchdogs" and are all promoters of environmental protection (Dillon and Baram, 1993; Duffy *et al.*, 1999; Hart and Ahuja, 1996; Hartman and Stafford, 1997; Luukkanen, 2003; Rondinelli and Vastag, 1996; Visser *et al.*, 2008). However, very few studies have examined the influence of this pressure on the type of technological change brought about. As one of the few to examine the effect of stakeholder pressure on technology adoption by firms, Montalvo (2003) found that community pressure is not sufficient to foster the willingness of a firm to undertake technology change to reduce pollution. This substantiates our finding on the moderating and mediating role of government between stakeholder and CTA.

The above standardized MR output is represented in Figure 7 with all the significant and non-significant factors. In Figure 8, only the significant factor has been incorporated into the model. In both the models represented below, firm, stakeholder and technology are independent variables whereas government and CTA are dependent variables.

5. Conclusions, limitations and future research directions

The empirical findings discussed in Section 4 lead to the following conclusions.

While testing the moderating role, three important points were evident. First, there is a significant direct and positive interaction between FIRM and CTA. This implies that when there is no legal obligation, it is up to the organizations to decide whether or not to go for the advanced pollution control technologies. Second, it is observed that there is no significant relation between TECH and CTA. This indicates that variables such as high capital cost, research and development and awareness are not significantly influencing CTA unless there is legal compulsion. Third, STAKEH and CTA also do not have a significant direct interaction. This indicates that the stakeholders (community, social media and industry associations) in India do not exert sufficient pressure on industries for CTA.

Government is strongly mediating between FIRM and CTA for climate proactivity.

A very recent gazette notification by the GOI (Environment (Protection) Amendment Rules, 2015) helps substantiate this study finding. Currently, there are no statutory limits for the stack emissions, except for particulate matter. The gazette notification by GOI, dated December 8, 2015, introduces specific limits for stack emissions (SO2, NOx and Mercury) in thermal power plants (TPPs). Also, the notification introduces specific water consumption limits for the TPPs. TPPs have been asked to comply with this new requirement by December 2017. Industries will have to install advanced technologies such as flue gas desulfurization, low NOx burners and water recycling plants to meet the new compliance requirements. Without the statutory requirements, hardly any industry has opted for the advanced technologies, but with the new law in force, industries are bound to adopt new pollution prevention technologies. This not only enforces CTA by industries but also promotes CT innovation and engagement of stakeholders in this direction.

This helps strengthen this study's finding that the government in India has a very influential mediating role in CTA. Government policies will have an immediate effect on the CTA strategy.

The study finding indicates that although government mediates CTA, the government policies are not adequate for faster CTA for climate proactivity. As described in the introduction section, stringent environmental norms have improved the CTA in other countries such as USA and Canada; our study findings have following policy implications for faster adoption of CTs.

The key policy implications from this research are as follows: the government needs to have in place new policies that will promote CTA by firms, the government needs to establish a continuous dialogue with technology manufacturers and incentivize new technologies to help firms in addressing hurdles such as high capital cost, technological awareness and organizational capability and the government must partner with various stakeholders (e.g. local community, media and NGOs), and make use of these valued resources to create a positive influence on the firms for adoption of new and CTs.

A few implications for the managers are discussed in this section. First, as government policies take time in terms of amendment and implementation, industries should lead the CTA process without waiting for government actions. Second, industries can collaborate among themselves to explore and adopt CT for climate proactivity. For example, Responsible Care (RC) is a chemical industry initiative that calls on companies to demonstrate their commitment to improve all aspects of performance, which relate to protection of health, safety and environment. In India, the Indian Chemical Council is at the forefront in promoting the RC initiatives. Other sectors can combine themselves to drive emission reduction programs specific for their sector through CTA. Third, large corporate houses with experience in advanced technologies can support the SMEs through knowledge sharing and help them take advantage of CTA.

A limitation of this study is that it has only tested the moderating and mediating role of the government toward CTA. Further research can be carried out to determine the

moderating and mediating role of stakeholders, technology and firms in formulating the CTA strategy.

Another limitation is that the respondents did not include policymakers such as Pollution Control Boards) and government institutes such as the Confederation of Indian Industry, the Federation of Indian Chambers of Commerce & Industry, The Associated Chambers of Commerce and Industry of India (ASSOCHAM), etc. Future studies can be carried out by including these stakeholders.

Global GHG Emission by economic sector shows that approximately a quarter (24 percent) of the total GHG emission is from agriculture, forestry and other land use. Specific research needs to be carried out to explore how CTs can be useful in reducing these GHG emissions. This seems to be a rather unexplored area in developing countries.

In the COP 21 held at Paris December 2015, it was evident that India is facing pressure from various international communities to adopt definite targets toward emission reduction to address the global climate change (India's Intended Nationally Determined Contribution, 2015 agreement). Hence, more studies should include climate change or climate proactivity (as done in this study and in the study by Sangle, 2011) as a key variable for understanding CTA in the industrial as well as other areas.

This study differs from all the previous research work by introducing a new dimension into the CTA research. Instead of researching further on the government's role as driver, this study investigates the moderating and mediating role of the government in CTA for climate proactivity. This is a major contribution of this research work and it can be applied to various researches in the area of environment and sustainability.

Note

1. Pollution abatement technologies (PATs) are added at the end of the production process to treat pollutants generated in the process. Pollution prevention or cleaner technologies (CTs) are the intermediate part of production processes and prevent the generation of pollutants from the process. The combination of PAT and CT is represented as environmentally sound technology (EST) (Luken *et al.*, 2008).

References

Aden, J. and Rock, M. (1999), "Initiating environmental behavior in manufacturing plants in Indonesia", *Journal of Environment and Development*, Vol. 8 No. 4, pp. 357-375.

Aden, J., Ahn, K. and Rock, M. (1999), "What is driving the pollution abatement expenditure behavior of manufacturing plants in Korea?", *World Development*, Vol. 27 No. 7, pp. 1203-1214.

Adeoti, J. (2002), *Technology and the Environment in Sub-Saharan Africa, Emerging Trends in the Nigerian Manufacturing Industry*, Ashgate Publishing, Burlington, VT.

Andrews, C.J. (1998), "Environmental business strategy: corporate leaders' perceptions", *Society and Natural Resources*, Vol. 11 No. 5, pp. 531-540.

Bai, X., Wieczorek, A.J., Kaneko, S., Lisson, S. and Contreras, A. (2009), "Enabling sustainability transitions in Asia: the importance of vertical and horizontal linkages", *Technological Forecasting and Social Change*, Vol. 76 No. 2, pp. 255-266.

Bailey, V., Bemrose, G., Goddard, S., Joslyn, E. and Mackness, J. (1995), *Essential Research Skill*, Collins Educational, London, pp. 60-62.

Baron, R.M. and Kenny, D.A. (1986), "The moderator – mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations", *Journal of Personality & Social Psychology*, Vol. 51, pp. 1173-1182.

Battisti, G. (2008), "Innovations and the economics of new technology spreading within and across users: gaps and way forward", *Journal of Cleaner Production*, Vol. 16 No. 1, S1, pp. 22-31.

Berman, E. and Bui, L.T.M. (2001), "Environmental regulation and productivity: evidence from oil refineries", *The Review of Economics and Statistics*, Vol. 83 No. 3, pp. 498-510.

Binz, C., Truffer, B. and Coenen, L. (2014), "Why space matters in technological innovation systems-mapping global knowledge dynamics of membrane bioreactor technology", *Research Policy*, Vol. 43 No. 1, pp. 138-155.

Binz, C., Truffer, B., Li, L., Shi, Y. and Lu, Y. (2012), "Conceptualizing leapfrogging with spatially coupled innovation systems: the case of onsite wastewater treatment in China", *Technological Forecasting and Social Change*, Vol. 79 No. 1, pp. 155-171.

Blackman, A. and Kildegaard, A. (2004), "Clean technology change in developing country industrial clusters: Mexican leather tanning", Discussion Paper No. 03-12 rev. Resources for the Future, Washington, DC.

Bowling, A. (1997), *Measuring Health: A Review of Quality of Life Measurement Scales*, 2nd ed., Open University Press, Buckingham.

Calleja, I., Lindblom, J. and Wolf, O. (2002), "Clean technologies in Europe: diffusion and frontiers", The IPTS Report No. 69, JRC-IPTS, Sevilla.

Clayton, A., Spinardi, G. and Williams, R. (1999), "What shapes the implementation of cleaner technology?", *Policies for Cleaner Technology*, Earthscan, London, pp. 218-265, available at: www.researchgate.net/profile/Carlos_Montalvo2/publication/223073592_General_wisdom_concerning_the_factors_affecting_the_adoption_of_cleaner_technologies_a_survey_1990-2007/links/54d4c4ae0cf2970e4e639ba2.pdf

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16 No. 3, pp. 297-334.

CSIS (1997), *The Environmental Protection System in Transition*, Center for Strategic and International Studies (CSIS) Press, Washington, DC.

Dechezleprêtre, A., Glachant, M. and Meniere, Y. (2009), "Technology transfer by CDM projects: a comparison of Brazil, China, India and Mexico", *Energy Policy*, Vol. 37 No. 2, pp. 703-711.

del Rio Gonzalez, P. (2005), "Analyzing the factors influencing clean technology adoption: a study of the Spanish Pulp & paper industry", *Business Strategy and the Environment*, Vol. 14 No. 1, pp. 20-37.

del Río, P., Peñasco, C. and Romero-Jordán, D. (2013), "Distinctive features of environmental innovators: an econometric analysis", *Business Strategy and the Environment*, Vol. 24 No. 6, pp. 361-385.

Dillon, P. and Baram, M.S. (1993), "Forces shaping the development of product stewardship in the private sector", in Fisher, K. and Schot, J. (Eds), *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications*, Island Press, Washington, DC, pp. 329-342.

Duffy, N., Ryan, B., Baas, L., Boons, F., Hansen, O.L. and Spinardi, G. (1999), "Pharmaceutical sector", in Clayton, A., Spinardi, G. and Williams, R. (Eds), *Policies for Cleaner Technology*, Earthscan, London, pp. 107-129.

Eder, P. (2003), "Expert inquiry on innovation options for cleaner production in the chemical industry", *Journal of Cleaner Production*, Vol. 11 No. 4, pp. 347-364.

Environment (Protection) Amendment Rules (2015), *Ministry of Environment, Forest and Climate Change (MOEF&CC)*, Gazette Notification No – 2620, Government of India, New Delhi, December 7.

Everett, M., Mark, J.E. and Toward, O.R. (1993), "Greening in the executive suite", in Fisher, K. and Schot, J. (Eds), *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications*, Island Press, Washington, DC, pp. 68-78.

Florida, R. (1996), "Lean and green: the move to environmentally conscious manufacturing", *California Management Review*, Vol. 39 No. 1, pp. 80-05.

Gangadharan, L. (2006), "Environmental compliance by firms in the manufacturing sector in Mexico", *Ecological Economics*, Vol. 59 No. 4, pp. 477-486.

Gosens, J. and Lu, Y. (2013), "From lagging to leading? Technological innovation systems in emerging economies and the case of Chinese wind power", *Energy Policy*, Vol. 60, pp. 234-250.

Government of India (GOI) (2014), "Report high level committee to review various acts administered", Ministry of Environment, Forest & Climate Change, New Delhi, p. 95.

Granderson, G. (1999), "The impact of regulation on technical change", *Southern Economic Journal*, Vol. 65 No. 4, pp. 807-822.

Groba, F. and Breitschopf, B. (2013), "Impact of renewable energy policy and use on innovation: a literature review", Discussion Paper No. 1318, Deutsches Institut fur Wirtschaftsforschung (DIW Berlin), Berlin.

Hansen, U.E. and Nygaard, I. (2013), "Transnational linkages and sustainable transitions in emerging countries: exploring the role of donor interventions in niche development", *Environmental Innovation and Societal Transitions*, Vol. 8, pp. 1-19.

Hart, S. and Ahuja, G. (1996), "Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance", *Business Strategy and the Environment*, Vol. 5 No. 1, pp. 30-37.

Hartman, C. and Stafford, E. (1997), "Green alliances: forging corporate e environmental group collaborative relationships", *Paper Presented at the GIN Conference*, *Santa Barbara, CA*, available at: http://shodhganga.inflibnet.ac.in/bitstream/10603/18813/18/18_references.pdf

Hilliard, R.M. (2006), "The role of organizational capabilities in cleaner technology adoption: an analysis of the response of the pharmaceutical manufacturing sector in Ireland to IPC licensing regulations", *European Environment*, Vol. 16 No. 6, pp. 336-349.

Hettige, H., Huq, M., Pargal, S. and Wheeler, D. (1996), "Determinants of pollution abatement in developing countries: evidence from South and Southeast Asia", *World Development*, Vol. 24 No. 12, pp. 1891-1904.

Huhtala, A. (2003), "Promoting financing of cleaner production investments UNEP experience", *Journal of Cleaner Production*, Vol. 11 No. 6, pp. 615-618.

Hutcheson, G. and Sofroniou, N. (1999), *The Multivariate Social Scientist*, Sage Publications, London.

Jacobsson, S. and Bergek, A. (2011), "Innovation system analyses and sustainability transitions: contributions and suggestions for research", *Environmental Innovation and Societal Transitions*, Vol. 1 No. 1, pp. 41-57.

Jurgen, D. and Holliday, C. (2002), "Innovation, technology, sustainability and society", World Business Council for Sustainable Development, Earthprint, Hertfordshire.

Kalamova, M., Johnstone, N. and Haščič, I. (2013), "Implications of policy uncertainty for innovation in environmental technologies: the case of public R&D budgets", in Constantini, V. and Mazzanti, M. (Eds), *The Dynamics of Environmental and Economic Systems*, Springer, Berlin and Heidelberg, pp. 99-116.

Kemp, R. and Volpi, M. (2008), "The diffusion of clean technologies: a review with suggestions for future diffusion analysis", *Journal of Cleaner Production*, Vol. 16 No. S1, pp. S14-S21.

Kerndrup, S., Baas, L., Nielsen, U. and Haas, J.S. (1999), "Electroplating", in Clayton, A., Spinardi, G. and Williams, R. (Eds), *Policies for Cleaner Technology*, Earthscan, London, pp. 204-217.

Koefoed, M. and Buckley, C. (2008), "Clean technology transfer: a case study from the South African metal finishing industry, 2000-2004", *Journal of Cleaner Production*, Vol. 16 No. 1, S1, pp. 78-84.

Likert, R. (1932), *A Technique for the Measurement of Attitudes*, McGraw-Hill, New York.

Luken, R. and Van Rompaey, F. (2008), "Drivers for and barriers to environmentally sound technology adoption by manufacturing plants in nine developing countries", *Journal of Cleaner Production*, Vol. 16 No. S1, pp. S67-S77.

Luken, R. and Castellanos-Silveria, F. (2006), "Industry and sustainable development: a global comparison", report prepared for UNIDO for the Fourteen Session of the Commission on Sustainable Development, UNIDO, Vienna.

Luken, R., Van Rompaey, F. and Zigova, K. (2008), "The determinants of EST adoption by manufacturing plants in developing countries", *Ecological Economics*, Vol. 66 No. 1, pp. 141-152.

Luukkanen, J. (2003), "Green paper with green electricity? Greening strategies of Nordic pulp and paper industry", *Energy Policy*, Vol. 31 No. 7, pp. 641-655.

Montalvo, C. (2002), *Environmental Policy and Technological Innovation, Why do Plants Adopt or Reject New Technologies?*, Edward Elgar Publishing Co, Cheltenham.

Montalvo, C. (2003), "Sustainable production and consumption systems – cooperation for change: assessing and simulating the willingness of the firm to adopt/develop cleaner technologies: the case of the In-Bond industry in northern Mexico", *Journal of Cleaner Production*, Vol. 11 No. 4, pp. 411-426.

Montalvo, C. (2008), "General wisdom concerning the factors affecting the adoption of cleaner technologies: a survey 1990-2007", *Journal of Cleaner Production*, Vol. 16 No. S1, pp. S7-S13.

Moser, C.A. and Kalton, G. (1971), *Survey Methods in Social Investigation*, Heinemann Educational, London.

Murphy, J. and Gouldson, A. (2000), "Environmental policy and industrial innovation: integrating environment and economy through ecological modernization", *Geoforum*, Vol. 31 No. 1, pp. 33-44.

OECD (2014), "Glossary of statistical terms, definition of clean technology", available at: https://stats.oecd.org/glossary/detail.asp?ID=2988 (accessed May 12, 2015).

PCSD (1999), *Towards a Sustainable America: Advancing Prosperity, Opportunity and A Healthy Environment for the 21st Century*, President's Council on Sustainable Development, US/Government Printing Office, Washington, DC.

Pearce, D.W. and Turner, R.K. (1991), *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, New York, NY.

Plotnikova, I., Korneva, O. and Ustuizhanina, A. (2015), "Barriers to innovation in the implementation of the investment strategy: an empirical study", *Procedia – Social and Behavioral Sciences*, Vol. 166, pp. 369-377.

Reijnders, L. (2003), "Policies influencing cleaner production: the role of prices and regulation", *Journal of Cleaner Production*, Vol. 11 No. 3, pp. 333-338.

Reppelin-Hill, V. (1999), "Trade and environment: an empirical analysis of the technology effect in the steel industry", *Journal of Environmental Economics and Management*, Vol. 38 No. 3, pp. 283-301.

Rondinelli, D. and Vastag, G. (1996), "International environmental standards and corporate policies", *California Management Review*, Vol. 39 No. 1, pp. 106-122.

Roome, N. (1994), "Business strategy, R&D management and environmental imperatives", *R&D Management*, Vol. 24 No. 1, pp. 65-82.

Rothwell, R. (1992), "Industrial innovation and government environmental regulations: some lessons from the past", *Technovation*, Vol. 12 No. 7, pp. 447-458.

Sangle, S. (2011), "Adoption of cleaner technology for climate proactivity: a technology-firm-stakeholder framework", *Business Strategy and The Environment*, Vol. 20 No. 6, pp. 365-378.

Seroa da Motta, R. (2006), "Analyzing the environmental performance of the Brazilian industrial sector", *Ecological Economics*, Vol. 57 No. 2, pp. 269-281.

Sobel, M.E. (1982), "Asymptotic confidence intervals for indirect effects in structural equation models", in Leinhart, S. (Ed.), *Sociological Methodology*, Jossey-Bass, San Francisco, CA, pp. 290-312.

Staniskis, J.K. and Stasiskiene, Z. (2003), "Promotion of cleaner production investments: international experience", *Journal of Cleaner Production*, Vol. 11 No. 6, pp. 619-628.

Statistics Canada (2004), *Environmental Protection Expenditures in the Business Sector (2002), 16F0006XIF*, Ottawa.

Steger, U. (1993), "The greening of the board room: how German companies are dealing with environmental issues", in Fisher, K. and Schot, J. (Eds), *Environmental Strategies for Industry: International Perspectives on Research Needs and Policy Implications*, Island Press, Washington, DC, pp. 63-78.

Tietenberg, T.H. (1992), *Environmental Policy Innovation*, Edward Elgar, Aldershot.

Truffer, B. (2012), "The need for a global perspective on sustainability transitions", *Environmental Development*, Vol. 3 No. 1, pp. 182-183.

Tukker, A., Haag, E. and Eder, P. (2000), "European state of the art. Part I: comparative analysis and conclusions", An ESTO Project Report Prepared for the European Commission, Joint Research Centre, Institute for Prospective Technological Studies/REP, Seville.

van Alphen, K., Hekkert, M.P. and van Sark, W.G.J.H.M. (2008), "Renewable energy technologies in the Maldives-realizing the potential", *Renewable & Sustainable Energy Reviews*, Vol. 12 No. 1, pp. 162-180.

Van Dijken, K., Prince, Y., Wolters, T., Frey, M., Mussati, G., Kalf, P., Hansen, O., Kerndrup, S., Sondergard, B., Rodrigues, E.L. and Meredith, S. (Eds) (1999), *The Adoption of Environmental Innovations by Small and Medium-Sized Enterprises: The Dynamics of Innovation as Interplay between Business Competence, Environmental Orientation and Network Involvement*, Kluwer Academic Press, Dordrecht.

Vasseur, V., Kamp, L.M. and Negro, S.O. (2013), "A comparative analysis of photovoltaic technological innovation systems including international dimensions: the cases of Japan and the Netherlands", *Journal of Cleaner Production*, Vol. 48, pp. 200-210.

Venkatraman, N. (1989), "The concept of fit in strategy research: toward verbal and statistical correspondence", *Academy of Management Review*, Vol. 14 No. 3, pp. 423-444.

Veugelers, R. (2012), "Which policy instruments to induce clean innovating?", *Research Policy*, Vol. 41 No. 10, pp. 1770-1778.

Visser, R., Jongen, M. and Zwetsloot, G. (2008), "Business-driven innovations towards more sustainable chemical products", *Journal of Cleaner Production*, Vol. 16 No. 1, S1, pp. 85-94.

Vollebergh, H.R.J. and van der Werf, E. (2014), "The role of standards in Eco-innovation: lessons for policymakers", *Review of Environmental Economics Policy*, Vol. 8 No. 2, pp. 230-248, doi: 10.1093/reep/reu004.

Wang, H. and Wheeler, D. (2000), *Endogenous Enforcement and Effectiveness of China's Pollution Levy System*, World Bank, Washington, DC.

Wheeler, D. and Martin, P. (1991), "Prices, policies and the international diffusion of clean technology", in Low, P. (Ed.), *International Trade and the Environment*, World Bank, Washington, DC, pp. 197-224.

Wijk, J., Engelen, R.F.J.M. and Ros, J.P.M. (2001), "Model for effectiveness of policy instruments for the energy-saving in industry (MEI-Energy)", RIVM Rapport No. 778011004, Dutch National Institute for Public Health and the Environment, Bilthoven.

World Bank Report (2000), *Greening Industry: New Roles for Communities, Markets and Governments*, The World Bank, Oxford University Press, New York, Washington, DC.

World Bank Report (2013), "Turn down the heat: climate extremes, regional impacts, and the case for resilience", The World Bank, Washington, DC.

World Bank Report (2003), *Greening Industry: New Roles for Communities, Markets and Governments*, The World Bank, Washington, DC.

Web reference

http://documents.worldbank.org/curated/en/2013/06/17862361/turndownheat-climate-extremes-regional-impacts-case-resilience-full-report (accessed March 15, 2015).

Further reading

Bruin, J. (2006), "Newtest: command to compute new test", UCLA: Statistical Consulting Group, Los Angeles, available at: www.ats.ucla.edu/stat/stata/ado/analysis/ (accessed May 2, 2015).

Intergovernmental Panel on Climate Change (IPCC) (2014), Fifth Assessment Report 2014, Geneva, available at: www.ipcc.ch (accessed March 15, 2015).

Tavakol, M. and Dennick, R. (2011), "Making sense of Cronbach's alpha", *International Journal of Medical Education*, Vol. 2011 No. 2, pp. 53-55.

About the authors

Santanu Kumar Satapathy is a Fellow (PhD) Candidate at the National Institute of Industrial Engineering (NITIE), Mumbai. He did his Master of Science in Environmental Chemistry from Regional Engineering College (presently, National Institute of Technology), Rourkela, India and MPhil in Environmental Studies from School of Energy, DAVV, Indore, India. He has around 12 years of industrial experience in environment management and sustainability. His research interests include cleaner technologies, environmental policy, climate change and sustainable development. Santanu Kumar Satapathy is the corresponding author and can be contacted at: santanu.satapathy1@gmail.com

Shirish Sangle is an Associate Professor of Sustainable Business at the National Institute of Industrial Engineering (NITIE), Mumbai, India. His research interests include corporate sustainability, stakeholder engagement and cleaner technologies.

Seema Unnikrishnan is a Professor and Dean Academics at the National Institute of Industrial Engineering (NITIE), Mumbai, India. She has done her Masters in Environmental Toxicology from PG Institute of Basic Medical Sciences, University of Madras and is the first rank holder. She has a Post graduate Diploma in Environmental Law and Fellowship (Doctorate) of NITIE. Her total number of years of experience is 24 years, 21 years as a Faculty at the NITIE and three years as a Trainee Scientist in the Central Pollution Control Board (CPCB). She has several research publications in the field of environmental management. Her areas of expertise are environmental management, environmental law, sustainability and cleaner production, air quality management, CDM and disaster management.