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DETERMINANTS OF VOLUNTARY ENVIRONMENTALLY SOUND TECHNOLOGY ADOPTION AND AN ASSESSMENT OF DYNAMIC INCONSISTENCY IN ADOPTION DECISION IN INDUSTRY IN ETHIOPIA

By

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List of Acronyms

BAT Best Available Technology

BOD Biological Oxygen Demand

COD Chemical Oxygen Demand

CPT Cleaner Production Technology

CS Corporate Sustainability

CSA Central Statistics Authority

CSR Corporate Social Responsibility

ECPC Ethiopian Cleaner Production Center

EPA Environmental Protection Agency

EPE Environmental Policy of Ethiopia

EMAS Environment Management and Auditing Scheme

EMT Environment Management Team

EMS Environment Management System

EST Environmentally Sound Technology

HACCP Hazard Analyses and Critical Control Point

ISO International Standardizing Authority

NGO Non Governmental Organization

PAT Pollution Abating Technology

PAR Principal Agent Relationship

RUM Random Utility Model

SOP Standard Operating Procedure,

SME Small and Medium-Sized Enterprises

UNIDO United Nations Industrial Development Organization

Abstract

The assessment of the determinants of the adoption of ESTs and the reasons for not adopting and continuity are explored in this paper. Towards the first question, four dimensions of possible determinants were identified. The variables that came out as most significant in the adoption decision are the ones pertaining to the plant characteristics of the firm. Specifically, the variables in this category are: the environmental commitment of the firm, the form of ownership of the firm as either foreigner owned or not and its arrangement as being either public or private, the technological capability of the firm, the number of years it has been in operation, and the number of employees. This underlines that the diversity of the firms plays a role in determining the EST option they adopt and thus imply the need for environmental policy to account for the heterogeneity of the firms in its design and implementation. This was done using the ordered probit model following the hierarchical nature of the response variables. Towards the second question, the heckman probit selection model is used and the results explained in the principal agent framework suggest that the form of management, among other things, does come into play in determining whether the firm continues with ESTs or not once they are adopted. This suggests that incentives or more generally the efficiency of mechanism design determines the effective implementation of a venture embarked upon despite the saving potential promised, and in cases savings earned, following the adoption of the ESTs. This implies the need for environmental policy to take into consideration internal management issues for effective realization of the environmental policy objectives drawn.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Industry continues to be a major cause of environmental problems, both globally and locally. It has a strong influence on both the local environmental situation and quality of life (ECPC, 2007). Over the 20th century, industrial production has increased by a factor of 40 and energy use increased by a factor of 16. Material flows in industrial countries amount today to about 60 tons of material per capita a year McNeill, 2000 cited in Nilsson et.al. (2007). The traditional list of environmental problems associated with industrial activities include: green house gas (GHG) emission, air pollution, chlorinated toxics, heavy metal emission, nutrient exhaust, nutrient discharge, noise pollution and as such (Moors 2005).

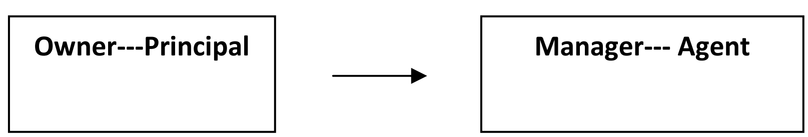
Some of these problems, for example air pollution, are not new phenomena. Nilsson et.al. (2007) note that the earliest reference to it date to the Middle Ages where in 1307 King Edward I banned the use of coal in London. Since then, the response of economies to growing pollution has come a long way. ECPC (2007) summarizes this evolution as: ignorance, dilution, treatment, recycling and cleaner production, or more conventionally: ignorance, reactive and proactive policies.

This study attempts to answer a few questions related to this topic. This is done in two sections that deal with:

1. What are the determinants for the voluntary adoption of Environmentally Sound Technologies (ESTs). The aim is to assess and document the relative importance of factors that play a role in a firm's decision to adopt a certain environmentally sound technology.

It is important to distinguish what constitute the ESTs. Luken et.al (2007) notes that there are two different options in the ESTs: pollution abating technology (PAT) and cleaner technology (CT). The difference between PATs and CTs is in the environmental and economic implications involved. Environmentally, PATS tend to only change the medium affected while CPs do not, as it focuses on reducing emission from the source. Economically, PATs are mostly cost increasing while CTs are generally productivity enhancing and cost lowering technological options (Nilsson et.al. 2007). A firms' decision to adopt ESTs would depend on a multitude of factors; some are contextual and some firm specific (Kemp et.al.2008). The understanding of the underlying drivers behind a firm's decision to voluntarily adopt ESTs is imperative. This, however, is not a direct forward endeavor.

2. Is it possible to define what determines a firm's commitment to its voluntarily adopted ESTs in a Principal-Agent-Relationship framework?



This requires one to look at it in such a way that the owner is the principal and the manager is an agent who is supposed to act on behalf of the principal and see to it that the firm is engaged in cost saving processes. In line with this, the agent, on his own term, will have the capacity to further contract certain responsibilities and see to it that they are being followed through adequately. To capture the whole picture, the whole relationship will have to be evaluated from the perspectives of: the agent type, the task, and the situation. The agent's character describes how the agent came into being and his capacity with regards the issue at hand; in this case the continued implementation of the ESTs the firm has adopted. The task describes the job the agent is supposed to do and what he has done in connection to it. The situation describes the circumstances the agent is brought in to. This is the organizational setup that existed irrespective of the agent and the particular task to be handled (Lietke et.al 2000).

1.2 Statement of the Problem

Over the past few decades, developing countries have registered a major improvement in the environmental performance of their industries. The increased availability of the PATs and CTs has been an important factor. The increasing availability makes the price of the technology lesser on average and hence contributing to increased adoption. However, there still remains a big gap between developing and developed countries in environmental performance. Energy use intensity, water use intensity, water pollution intensity are about three, eleven and six times higher respectively (Luken et.al. 2007). It is essential to understand what factors motivate improved industrial environmental behavior.

The government, the market, and the civil society constitute the institutional network within which the firm operates. The incentive mechanism created in this framework determines the actions taken by the firm, or lack thereof (Eggersson 1997). The effectiveness of the policies devised in the economy influences the decision of a firm in a multitude of ways. The economic policy, by ways of the industrial policy, the trade policy and resource pricing policy affects the decision of a firm regarding what technology to employ (Siaminwe et.al 2005). A change in any of these policies brings about change in the incentive structure and hence a different behavior.

The underlying concept behind pollution taxation is that the firm will adjust its behavior if it becomes economically reasonable enough to change it (Reijnders, 2003). Certain firms have, however, done so without taxes having been imposed (Hillary, et.al 1999). Yet even after tax imposition, the firm may keep its old practice if the cost of the new technology is much costlier than having to pay the punitive payments or alternatively if the enforcement of the law is not strong (Siaminwe et.al 2005, Hale, 1996). Still, some firms voluntarily follow through environmental standards and adopt technologies thus prescribed. This prompts the question ― what determines a firms decision regarding the adoption of ESTs.

Lopez et.al. (2006) note that the failure to implement high yielding environmental protection investment is a key source of environmental degradation. Furthermore, it argues that the failure to achieve environmental sustainability may become an obstacle to sustained economic growth. A growth pattern that does not take the environment in to consideration will face a greater challenge in meeting its needs, eventually. Sustained economic growth depends on a proper understanding and incorporation of environmental concerns (Johnston 1994). The first best solution is to find an environmental policy that furthers the joint goals of maintaining environmental integrity and increasing firm's profit. The corporate response to this is expected to be positive, fueled by the savings made from reduced input requirements, possibility of recycling and the associated reduction in resource purchase, reductions in waste and the related reduction in disposal costs (Freinmann, 2000). The theoretical foundation of this is that there exists what is called "slack inefficiency", or alternatively known as "x-inefficiency". If the firm is not already minimizing its costs, then some rearrangement can result in reduced costs and thus a profit margin (Eggersson 1997).

Why the firm is not initially taking measures that promise cost reductions is an interesting question. What is more interesting is, why after adopting such a scheme, a firm deviates from it. This may even be put as why some firms fail to adopt such a scheme after witnessing others benefiting from it. DeCannio (1993) discusses several reasons why a firm may fail to make energy saving investments. These include, bounded rationality, principal-agent relations, and moral hazard, where organizational and informational constraints make satisficing the overall objective as opposed to maximizing. This point was first pioneered by Herbert Simon (Lietke et.al 2000). The microeconomics discourse on maximization relies on the assumptions that the classical "economic man" knew all alternative courses of action and their consequences, had a stable preference function for all consequences, and made optimal decisions by maximization, while the "administrative man" "satisficed" under "bounded rationality." (Harris et.al. 2000).

In principal-agent relations, before-the-fact and after the-fact controls by the principal both ultimately rely on incentives and sanctions on the agent for their effectiveness (Donald 2006). Different financial markets, factor markets, and product market structures, different economic systems and policies, different social awareness levels, different degrees of donor involvements and the associated strings, and different corruption levels make the incentive structure differ from one plant to another and thus justify a plant level study be undertaken on the continuous implementation of the ESTs (Luken et.al. 2007).

Economic benefits have been ripped following ESTs, especially CTs, implying the presence of low hanging fruits. The contending literatures here are the "hidden cost hypothesis" and the "Porter hypothesis" with specific anecdotes for each hypothesis (Gabbel 2001). The firm, above all, will have the information on all the relevant parameters in its decision to voluntarily adopt or not and while adopting, how long it wants to go with it. The policy maker will have to inquire in to these parameters and their effects on the margin if an effective policy is to be designed and implemented (Siaminwe et.al 2005).

A major motivational factor in a firm's decision regarding what technology to adopt depends among other things on the potential to generate profits **(**Johnston et.al 2009). This has been documented in foreign countries and in Ethiopia as well. ECPC documents anecdotes where firms actually benefited from the implementation of the ESTs. The main reason being that the technology option implemented was a resource efficient and cost cutting technology (Nilsson et.al. 2007). This, however, requires the firms to have information about it. It also needs that the firms have a correct perception, which can be a major problem (ECPC, 2009).

1.3 Objective of the Study

The general objective of the study is to assess and identify the major determining factors that influence a firm's decision regarding the adoption of a pollution abating technology and a cleaner production process, and the organizational problems that come in to play in the continued implementation of the ESTs. Consistent with the findings, policy recommendations will be made.

The specific objectives are:

- Identify the determining factors that influence different level of adoption of ESTs ,
- Assess how well the principal-agent theory captures the dynamic inconsistency in adoption decision on the part of employed firm managers as distinct from the owners themselves managing these firms, and
- Make policy recommendations in view of the findings that would contribute to the creation of an enabling environment for the better adoption of the EST.

1.4 Significance of the Study

The increase in voluntary adoption of ESTs is an important step in achieving sustainable economic growth and environmental sustainability simultaneously (Lopez et.al. 2006). This requires the establishment and proper functioning of institutions. These institutions can be either formal or informal and the pressure could as well be either domestic or foreign in its origin (Eggersson 1997). Despite the source, a proper understanding of the factors that facilitate or delay a firm from voluntarily engaging in ESTs adoption is imperative in crafting environmental policies (Siaminwe et.al 2005).

This study will focus on identifying the determinants to adoption and continued implementation of EST adoption. The findings will help shade light on what would prompt a firm to meet environmental requirements.

1.5 Organization of the Thesis

There are seven chapters, appendices, and a bibliography in this thesis. The first chapter lays the ground for the rest in that it is the introductory part. In the second chapter, empirical and theoretical literature review is presented. Following that, the third chapter discusses the classification of ESTs and the Ethiopian experience. In the fourth chapter, the analytical method is presented while in the fifth and sixth chapter, the results of the econometric methods employed will be discussed. The seventh chapter is on the conclusion and recommendation in the light of the findings. The appendix section presents the questionnaire used in this study, the construction of index variables, and the kernel density estimates.

1.6 Scope of the Study

The areas selected for this study are what are identified as Ethiopia's industrial priority areas by the industrial development policy. These are: food and beverage, construction, agro processing, textile and garment and, leather and leather products (ECPC, 2009). As the focus of the assistance in spreading the implementation of ESTs is currently focused on these areas, so has the study. The selection of the firms for this study is consistent with the priority areas as identified by the government and the qualifications set forth by the ECPC, which is the facilitating process unit for ESTs adoption. The findings herein will shade light on ESTs adoption relevant to these sectors. This may not, however, be binding to the rest of the manufacturing sub-sector.

The area of concern in this paper is the industrial sector. And the focus is on voluntary adoption of ESTs as opposed to forced adoption. No attempt is made to address the voluntary adoption of ESTs in the agricultural and service sectors.

While discussing the determinants, some implications on the environmental performance of the firms may be noted but it is limited to an important but a preliminary investigation in to the financial benefits while no attempt is made to look in to the mechanics of the technology options.

In the incentives role as a continuity determinant, it is only financial incentives and a requirement to make a regular reporting on environmental performance that are considered i.e. non economic incentives are not included.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Literature Review

2.1.1 An Overview of Determinants of ESTs Adoption

With every production process, environment-threatening by-products are created (waste, waste water, emissions). This is dictated by the laws of thermodynamics. In the last few years, these threats have been reduced by the application of end-of-pipe environmental measures, for example, by using water treatment plants or waste air filters (Kemp et.al 2008). In contrast, resource efficiency i.e.the adoption of cleaner technologies focuses on the avoidance of environmental pollution and on resource conservation during the production process, through intelligent production structures such as the closure of the lubricants cycle and innovative technology that enables increased efficiency, fewer emissions and less waste result. (Nilsson et.al. 2007).

Decoupling economic growth from environmental impact and creating the ‘space’ for poor people to meet their basic needs will require producers to change design, production and marketing activities **(**Boks *2006)*. Consumers will also need to provide for environmental and social concerns – in addition to price, convenience and quality – in their consumption decisions **(**Kerry 2000). Given the breadth of the challenges and actions required, activities are focused on specific tools encompassing policies, market-based instruments and voluntary approaches, with emphasis given to some specific economic sectors **(**Siaminwe et.al 2005). This requires an investigation of the key drivers of resource efficiency **(**Joachim 1997). The more general drivers that force enterprises to integrate resource efficiency into the operational strategy for ensuring competitiveness include soaring oil prices, scarcer resources, and increasing demand side pressure on greener products and services (Luken et.al 2007, Eagan et.al 1997).

All this reqiures a concerted effort to find an optimal mix of policies (Siaminwe et.al 2005). Thus, a combination of different policies may be resorted to, as opposed to stand alone policies, which, despite some strong sides, suffer serious limitations. The sole application of voluntary policies thus may be difficult for reasons as the missing of many of the non regulatory factors reputed to motivate firms to improve environmental performance in developing countries (Reijnders, 2003). In addition to that, informal regulation may depend on strong formal regulation to be effective and these too are missing (Montalvo 2003).

Luken et. al. (2007) develops a heuristic model of plant-level EST adoption, which bears a certain resemblance to the World Bank "new model" of pollution control. This model reflects the view that a plant's decision to adopt EST is a function of many factors, both contextual and plant specific. The contextual factors comprise the incentives that plants are presented with to adopt ESTs. Broadly speaking, these include the environmental policy, the economic policy, and the technological policy. The institutions in place for the transmission of the incentives are: the regulatory agencies, technology support institutions, international donors, the media, local communities, NGO's, trade and business associations, factor availability, and product market: domestic or export (Nill 2008, Hale, 1996). The interactions of these will influence the firm by ways of its environmental commitment. Besides this, the firm specific factors that are noteworthy include: ownership, profit, size and technological capabilities (Koefoed et.al. *2008)*.

2.1.2 The Firm and Change: procedures, routines, and implications

Coase (1992), cited in Gabel et.al (2001), argues that the firm in mainstream economic theory has often been described as a 'black box.'…. This is very extraordinary given that most resources in a modern economic system are employed within firms, with how these resources are used being dependent on administrative decisions and not directly on the operation of a market (Zwetsloot et. al. 1996). Developing this line further, Stiglitz (1991), cited in Gabel et.al (2001), notes that if economists wish to understand how resources in modern economies are allocated, we must understand what goes on inside organizations.

Gabel et.al. (2001) contend that, since, by assumption, environmental problems had to originate in the market, it was natural to seek to solve them by fixing the market's flaws. Economists have for several generations written of the cause of public policy instruments that do so. Failure of organizations to coordinate behavior can result in environmental accidents entirely independent of failures of markets. Settings apparently free of market problems are not necessarily free of environmental risk (Eggersson 1997).

Gabel et.al (2001) cites Cyert and March (1992), in noting to propose that the way in which the organization searches for alternatives is substantially a function of the operating rule it has. The organization uses standard operating procedures and rules of thumb to make and implement choices (Zwetsloot et. al. 1996). In the short run, these procedures dominate the decisions made. They also identified several types of procedures: task performing, record keeping, information handling and planning.

Gabel et.al (2001) cited Hayek (1945) as noting that it is with respect to the knowledge of the particular circumstances of time and place that practically every individual has some advantage over all others because he possesses unique information of which beneficial use might be made, but of which use can be made only if the decisions depending on it are left to him or are made with his active co-operation and thus making the case for voluntary adoption policies.

2.1.3 Modeling a Determinant by way of Showing Efficiency Frontiers that Account for Agents Imperfect Information

An approach to model the time and rate of adoption may take a top-down approach or a bottom-up approach. A problem with the former is that it doesn't provide the degree of sector disaggregation that would be required for analyses at the level of the firm, while the latter does not consider strategic behavior that may delay the diffusion of innovation.

This far, many adoption inhibitors and drivers have been reviewed. Then, on a more mathematical note, Gabel et.al. (2001) model a particular motivator in voluntary adoption of ESTs: the increase in fines and damages for negligence of environmental problems. This is based on the notion of industrial organization. He documents that there has been little rigorous analysis of how a company's environmental strategy is operationalized in the management control systems, formal and informal, that would normally convert strategy into action. And he goes on to develop a model on this by contending that behind the corporate veil lie causes of systematic organizational failure that are analogous in many respects to problems of externalities in the context of market-mediated transactions. And there are management tools (for example, Pigouvian taxes, rules of civil and criminal liability, and marketable property rights) that might remedy market failings. The causes of organizational failure include perverse incentives, hidden actions, imperfect information, strategic behavior and moral hazard (DeCanio, 1993, Staniskis et. al. 2003). The management tools include monitoring technologies, contract design, task allocation decisions, centralization and decentralization of authority and accounting systems, inter alia (Boks *2006)*.

Gabel et.al. (2001) develops the model based on the following notes. Organizational failures in an environmental context will be of two types. The first is a choice made or an action taken with a negative risk-adjusted expected value. This could be a violation of the environmental laws or some action that entails an excessive risk of causing an environmental accident for which the firm will be liable (a type II error). This is not a calculated decision. The second is the failure to take a legitimate and profitable action (a type I error). Errors are inadvertent; they occur because information is imperfect, communication is costly and human rationality is limited (Harris et.al. 2000).

To model these errors, one must model a decision-making process within a firm. This is in the framework of a corporate principal developing an environmental policy for the corporate agents whose actions invariably entail risk of error. The objective of the policy is to reduce the probability of these errors. He uses two decision variables. One can be measured in terms of direct cost for training agents, for providing them with information, for staff to support them and for auditing and monitoring the agents (Lietke et.al 2000). Specific examples of such costs might include involvement with compliance with EMAS or ISO 14000 requirements and the cost of introducing green accounting systems. Presuming these efforts are effective, they should reduce organizational failures of both types (Konstadinos 2006).

The second decision variable is the constraint on agents' decision-making latitude. Two basic means are available to do this: standard operating procedure (SOPs) and centralization of authority. Either one denies agents the ability to make ad hoc decisions (Lietke et.al 2000).

Then faced with a stream of choices the decision tree and the payoffs will be.

P(N)	P(A/N)	P(S/A,N)	P(N)P(A/N)P(S/A,N)=P(N,A,S)	$-C_2$
		P(~~S~~/A,N)	P(N)P(A/N)P(~~S~~/A,N)= P(N,A,~~S~~)	π
	P(~~A~~/N)			

P(N)	P(A/~~N~~)	P(S/A,~~N~~)	P(~~N~~)P(A/~~N~~)P(S/A,~~N~~)=P(~~N~~,A,S)	$\pi - C_1$
		P(~~S~~/A,~~N~~)	P(~~N~~)P(A/~~N~~)P(~~S~~/A,~~N~~)= P(~~N~~,A,~~S~~)	π
	P(~~A~~/~~N~~)			

So the firm's principal must design an environmental policy to maximize an expected return,

E(R)= {P(N,A,~~S~~)} +P(~~N~~,A,~~S~~) π – P(N,A,S)C_2 + P(~~N~~,A,S)(π-C_1) – C_3 ....**A**

Where:

P(N,A,~~S~~)> 0 is the probability that a negligent action is taken but not detected.

P(~~N~~,A,~~S~~) > 0 is the probability that a legitimate action is taken.

P(N,A,S) > 0 is the probability that a negligent action is taken and detected

P(~~N~~,A,S) > 0 is the probability that a non-negligent action results in an environmental accident.

C_1 is compensation and damages from a non-negligent accident

C_2 is punitive fines, damages, compensation and other costs from a negligent accident (C_2> C_1)

C_3 is cost of training and monitoring agents

π is the profit earned from a legitimate action taken or a negligent action that is not detected.

He simplifies the expected return by converting the joint probabilities into conditional probabilities and expressing them as the type I and II errors discussed above.

$f = P(\not{A}/\not{N})$ is the probability that the company will make a type I error, that it will leave low-hanging fruit unpicked.

$g = P(A/N)$ is the probability that the company will make a type II error; that it will take a negligent action.

$M = P(S/A,\not{N})$ is the probability that a non-negligent action results in an environmental accident.

$n = P(\not{S}/A,N)$ is the probability that a negligent action causes no accident then,

$\alpha=(1-n)\ C_2-n\pi$ is the company/s expected cost a negligent action ($\alpha > 0$)

$\beta = \pi - m\ C_1$ is the company's expected benefit of a legitimate action ($\beta > 0$)

The requirement that α and β be positive implies, consistent with the text, that a rational actor would neither be purposefully negligent nor overlook a profitable action.

$$E(R) = -P(N)g\alpha + P(\not{N})(1-f)\beta - C_3 \text{ -------------------------------------} \mathbf{B}$$

Gabel et.al. (2001) identify that the decision variables for the principal are the expenditure on training, information and monitoring, C_3, and a continuous variable X that measures the extent of SOPs controlling the agents' behavior. A high value of X will denote extensive SOPs (or centralization). A low value, by contrast, means that the agent is empowered to make choices with few constraints. These two policy variables determine the type I and II error probabilities, f and g, with partial derivatives shown below.

$$f= f(C_3,X) \text{---} \mathbf{C}$$

$$g =g(C_3,X) \text{ --} \mathbf{D}$$

Partial derivatives	
$f_c < 0$	$g_{cx} > 0$
$f_x < 0$	$f_{cc} > 0$
$g_c < 0$	$f_{xx} > 0$
$g_x < 0$	$g_{cc} > 0$
$f_{cx} < 0$	$g_{xx} > 0$

The principal will maximize E(R) by varying C_3 and X. The first-order conditions can be solved for a maximum to give C_3* and X*, the optimal corporate environmental policy.

The manager's objective is to maximize E(R) in equation **B** by varying C_3 and X with error probabilities implied by equations **C** and **D.** First order conditions for a maximum are

$$\partial E(R)/\partial C_3 = P(N)g_c\alpha - P(\not{N})f_c\beta - 1 = 0 \text{------------------------------------} \mathbf{E}$$

$$\partial E(R)/\partial X_3 = P(N)g_x\alpha - P(\not{N})f_x\beta = 0 \quad \text{------------------------------------} \mathbf{F}$$

The two first-order conditions can be solved to give $\mathbf{C_3}^*$ and $\mathbf{X}^*$, the profit maximizing values of $\mathbf{C_3}$ and **X**.

Second-order conditions required for a maximum are

$$P(N)g_{cc}\alpha - P(\not{N})f_{cc}\beta > 0$$

$$P(N)g_{xx}\alpha - P(\not{N})f_{xx}\beta > 0$$

and

$$\{P(N)g_{cc}\alpha - P(\not{N})f_{cc}\beta\}\ \{P(N)g_{xx}\alpha + P(\not{N})f_{xx}\beta\} - \{P(N)g_{cx}\alpha + P(\not{N})f_{cx}\beta\}^2 > 0$$

It goes on to show that the first two inequalities hold from our earlier assumptions. The third cannot be guaranteed, however. It simply describes a condition that must exist if there is to be a profit-maximizing equilibrium.

Comparative static analysis gives the signs shown below

Signs of comparative static results for the corporation

Exogenous variable	Endogenous variable			
	C_3^*	X^*	f	g
C_1	(-)	(+)	(+)	(?)
C_2	(+)	(+)	(?)	(-)
m	(-)	(+)	(+)	(?)
n	(-)	(-)	(?)	(+)
π	(+)	(+)	(?)	(?)

In conclusion, Gabel et.al. (2001) holds that stricter environmental policy (interpreted here as a policy change that increases the penalties for negligence and reduces the frequency of accidents) may increase a firm's returns by reducing it absolute cost s, that is, it may fit the results Michael Porter hypothesized **(**Luken et.al. 2007). And the firm could not have raised its profit unilaterally without the change in public policy. Although it could unilaterally mimic the increase in fines and damages for negligence, it needed the public policy maker to reduce the liability for non-negligent accidents. In other words, the firm was on an efficiency frontier prior to the policy change, an efficiency frontier that took account of the agents' imperfect information. Alternative explanations are given by DeCanio (1993) and Lietke et.al (2000), and Staniskis et. al. (2003).

2.1.4 The Social and Political Rules and Change

The rights of individuals to the use of resources (i.e., property rights) in any society are to be construed as supported by the force of etiquette, social custom, ostracism, and formal legally enacted laws supported by the states' power of violence of punishment (Eggersson 1997). And the economic outcomes of production depend in an important way on the social and political rules that govern economic activity. Many economists have attempted to derive the optimal structure of rules or property rights in the context of externality problems (spillovers effects) such as pollution (Montalvo 2003). In this context, the rule of liabilities also matter (Segerson 1998).

The prevailing set of penalties and rewards affects the behavior of rational agents and hence the output of the firm. The external rules of the game delimit the internal rules of the game available for the firm to choose from given the state of knowledge. Such parameters as: partnership or corporate form of ownership, the degree of decentralization, whether to own or lease equipment, and the nature of compensation plans, by affecting the costs of using alternative contractual arrangements, determine the behavior of firms (Eggersson 1997).

Certain social arrangements are associated with a greater net output than other arrangements (Lietke et.al 2000). New legal instruments can affect productivity just as strongly as new techniques of production. And thus signify the need for concerted action to be taken where technological change alone is pursued but it is coupled with the corresponding legal instruments to complement it (Bonilla et. al. 2010).

The rational individual may react to uncertainty by adhering strictly to custom and conventional behavior that in the past had been associated with success. A trial and-error approach may also be sought. What really counts is the various actions actually tried, for it is from these that 'success' is selected, not from some set of perfect actions (Eggersson 1997).

2.1.5 An Overview of the Principal - Agent Model: Central Agency Concepts

The basic agency model and the resulting agency problem of determining the optimal contract for the agent's service are a function of a set of assumptions. These include: ***Human assumptions*** where agents are treated as self-interested, individual profit or utility maximizers and boundedly rational as there is environmental uncertainty in terms of outcomes and the agent is assumed to be more risk averse than is the principal. The other set of assumptions is ***organizational***. These are (at least partial) goal conflict exists between principal and agent, some information asymmetry exists between the principal and the agent (where the agent is typically the better informed actor), preeminence of efficiency as effectiveness criterion; the principal will always attempt to choose a contract which brings about the best possible outcome subject to the constraints given. The next set of assumptions is on ***information***. Information, here, is treated as a commodity, i.e., it is purchasable at a certain cost (Lietke et.al. 2000).

With the contract between principal and agent to delegate a certain task as the unit of analysis, the key idea of agency theory can be summarized as follows: The principal-agent-relationship should reflect the efficient organization of agency costs, which are the sum total of all information costs and risk-bearing costs. Hence, agency theory centers on the contracting problem between principal and agent (Lietke et.al 2000).

Such a contracting problem is observable when looking at the owner manager relationship (Arrow 1985). The manager, the agent, is supposed to be the overseer of the firm's operation and he cannot be expected to go down to the floor level and execute all duties-and so he delegates. The question then becomes about the effective manner of his contracting the duty. To be considered in line with the wishes of the owner, here the principal, the agent will have to contract forward the duty of continuous ESTs opportunity realizations. And so we look in to how behaved, effective in contracting duties forward, the agent is. This would then mean: has he employed an Environment Management Team (EMT) or a Cleaner Production Team (CPT), has he employed the EMT or CPT in such a way that the employment is efficient or effort inspiring, (measured as term of EMT or CPT employment based on temporary terms), is the pay scheme sensitive to environment management performance, has he requested the EMT or CPT to continuously report to himself (the manager) regularly on environmental performance, has the manager set in the contract that up on failure of meeting specified targets, the EMT or CPT suffers some punishment, or incentive otherwise.

Then of course, the question of why the management does not make the contract efficient comes in to question and thus make apparent the same round of questions to be made about the manner of the contracting the manager had upon employment by the owner (DeCanio 1993, Staniskis et. al. 2003).

This would require one to look in to: Is the manager an employee or is he the owner as well, is his employment sensitized to performance by way of his term of employment being temporary, is his pay sensitive to environmental management performance, does his term of employment require him to continuously report to the owner regarding the environmental performance, and will the manager suffer certain penalty upon failing to meet the specified environmental performance targets (Donald 2006).

Furthermore, this brings to mind why the owner does not make the contract to the manager and hence through him to the ESTs continuous implementation structured in an effort inspiring way? The owner's contract setting further depends on the environmental regulation present in the economy. This could be reflected in terms of the owner's license being subject to environmental performance through an internal and external environmental auditing result which should be made in a regular pattern. In the absence of such a demanding regulatory environment, the owner will be reluctant to design and implement an efficient contracting i.e. the regulation void thus works as an effort averting opportunity for the owner with regards to designing efficient contract (Donald 2006). The government failure here partly reflects its lack of commitment to the issue of the environment and through the cascading effect brings about an inefficient outcome.

The strength of environmental policy on corporate behavior can be judged from how well it influences the owner mechanism design effort. The cost to be inflicted on the business up on failing to comply with scientifically prescribed standard has to be considerable enough not to be overlooked. To compound this further, a regulation that is win-win in its nature will work to incentivize the owner into better design. Such design is now becoming more evident and is termed incentive regulation; a design to use the internal information and self interest of a manager towards a greater end (Donald 2006).

Apart from the regulatory environment, one market factor that may come into play in determining the effort devoted to efficient mechanism design is the nature of the product. One way this can be shown is through the availability of substitutes and hence the resultant pressure it creates on the firm to stay competitive. If there are only a limited number of competitors, then firm will not bother about its environmental image as there are limited substitutes in the market meaning that people will keep buying its product. This is especially in necessity items with of price, income, and cross price elasticity less than one (Ahouissoussi 1995). Thus the signaling benefit ecofriendliness conveys loses its luster (Kerry 2000). This is further compounded by limited awareness and activism in the country keeping the firm from getting premium on its environmental initiative (ECPC2007). Under such circumstances, it is only regulatory pressure that could push the firm in to pursuing alternative options to lighten the burden on the environment **(**Reijnders, 2003).

All these work to reduce, but not exhaust, the economics of voluntary adoption of ESTs as the firm still stands to benefit from the resource saving production practice. The more interesting question here perhaps is why is there a need for an external pressure for a firm to be on a cost minimizing path and why, once on this track, it tends to deviate from it despite the economic justifications for its continuity being strong? Different explanations are given by DeCanio (1993), Staniskis et. al. (2003), and Boyle (1999).

2.1.6 Modeling Principal-Agent Relation

Conventional theory assumed that, if a program increased net returns, producers would be satisfied with this program and support its adoption (Burrows, 1983). However, literature on technology adoption especially in a voluntary setting describes a host of variables coming in to play to determine the final outcome. These include such adoption constraints as riskiness, divisibility, substitutability, and availability of the technology option under discussion (Ahouissoussi'1995). In reality, even given producer cost savings in abatement costs for dealing with these constraints, there still appears reluctance for readily supporting ESTs on the part of a significant number of producers (ECPC 2007).

The principal, the owner, is interested in inducing a particular response from the agent, the manager. The principal's problem is designing an incentive payment for this inducement (Arrow 1985, Donald 2006). Let ***B*** represent the benefit in terms of reduced cost through effective utilization of every cleaner production opportunity associated with an agent of type ***i***. Effort and reluctance go in opposite direction. The more reluctant the agent, the less effort he exerts and thus reduce the savings in abatement cost that could have accrued to the principal. For convenience, suppose there are only two types of agents: a highly reluctant agent, thus representing a high opportunity cost associated with his reluctance to take advantage of cost reducing opportunities with a cost function denoted as **R*hCh*,** and a low-level reluctant agent, representing a loss of lower opportunity cost associated with his mild reluctance to take advantage of cost reducing opportunities i.e. cost agent denoted as **R*lCl***, where **R*hCh*** > **R*lCl***. These costs are opportunity costs as they represent lost opportunities in terms of reduced cost that could have accrued to the principal. The different effort averting levels of agents result in different amounts of lost opportunities. They represent a producer's loss in economic rent by switching from current production process to a cleaner production process. This loss is the total cost reduction realized less the cost of technology shift. In a well regulated market, the benefit would include potentially reduced charges on account of firm compliance to cleaning up of production process (Reijnders, 2003). The ESTs adoption thus works to mitigate externalities associated with the production and delivery of goods and services with the resulting potential enhancement of the producer's image and the third party's utility (Johnston 1994, Getzner 2002).

Generally, the principal has limited information on the type of opportunity cost function related to a degree of reluctance (effort avoidance), and so a probability of r_i, is associated with a type i cost function or degree of reluctance (Ahouissoussi 1995, Lietke et.al 2000). The principal must design an incentive scheme, ***S***, which does well on average whatever type of agent, is involved. The principal's optimization problem is:

$$\min_{R1,\,R2,\,S} \; r_1 R_h C_h + r_2 R_l C_l - S,$$

Such that

$$R_h C_h - S > 0,$$

$$R_l C_l - S > 0,$$

$$R_l\,(C_l) \leq R_l\,(C_h)$$

$$R_h\,(C_h) \leq R_h\,(C_l)$$

Where: S, is an incentive scheme,

$R_h C_h$ is the opportunity cost with a highly reluctant agent

R_lC_l is the opportunity cost with a lower level reluctant agent

r_1, is the probability that an agent is high reluctant agent

r_2, is the probability that an agent is low reluctant agent

The first two constraints are the participation constraints. If the opportunity cost lost that could have been realized is not potentially greater than the incentive payment S, the principal will not support the continued ESTs implementation. The last two constraints are the incentive compatibility constraints. The principal must choose an incentive scheme where there is no benefit for an agent in having an alternative level of reluctance (effort aversion) and hence lost opportunity than the one preferred by the principal. The optimal actions of the principal maybe determined by first considering the two incentive compatibility constraints along with the assumption $\boldsymbol{R_h(C_h)} > \boldsymbol{R_l(C_l)}$ for all R. This yield:

$$\boldsymbol{R_l\,(C_l) \leq R_l\,(C_h) < R_h\,(C_h)}$$

$$\boldsymbol{R_h\,(C_h) \leq R_h\,(C_l) > R_l\,(C_l)}$$

Which imply $\boldsymbol{R_l\,(C_l) \leq R_h\,(C_h)}$. Given both participation constraints, the principal wants $\boldsymbol{S}$ as small as possible. Any payment on the part of the principal to the agent that is lower in amount than $\boldsymbol{R_h\,(C_h)}$ yields a net return to the principal. At the most extreme, a payment due to a high reluctant-high cost agent will leave the agent just indifferent between seeing to the continuity of the EST adoption or not. This, without outside pressure, leaves the principal indifferent as well. However, if a regulatory charge on the principal is due on failing to continuously leave up to the EST implementation, then the principal will no more be just indifferent but will be willing to pay additional payment to the agent but the maximum will still be at the extreme equal to the one stipulated by the environment regulation enforcing authority. In all this, the less reluctant-less costly agent will potentially receive a surplus. As far as the agent's attendance to this duty saves the principal higher payment, the equilibrium is conceivable.

The finding that no environmental management team (EMT) employment in an effort inspiring design and so the failure to continuously realize the opportunities a cleaner production practice promises could make a case for the dynamically inconsistent decision in EST adoption as an issue of contracting efficiency and of management related failure than it is economic or technological (DeCanio 1993, Staniskis et. al. 2003). These questions are about the carrot and stick of motivation theories in management science and an efficient mechanism design in microeconomics (Donald 2006).

2.2 Empirical Literature

2.2. 1 Determinants of EST Adoption

Koefoed et.al. (*2008)*, in a study of the uptake of cleaner technology in the metal finishing sector in South Africa, notes that in the period 2000-2005 saw the launch of more than 12 full-scale demonstration plants with best available cleaner technology (BAT) with a payback time of 1.8 years; design and testing of a cleaner production apprentice education program; set-up of 3 industrial associations, which have merged into a commercial sustainable nationwide association. This serves to highlight the actual benefits that have been had following the adoption of the ESTs. Furthermore it notes the roles of the regulatory instruments, communication, training, cleaner technology assessments and subsidy in determining ESTs adoption.

Building on the benefits earned, Johnston et.al (2009) explore the motivation for the introduction of environmental management systems, and their certification. In the discourse, it distinguishes between their role in bringing about better compliance or improved performance, and as external indicators of good environmental practices to both other market participants and regulatory authorities i.e. are the adopters attempting to improve performance or signal performance? The findings are that both factors play a role in encouraging the adoption and certification of environment management systems (EMS's), but that the relative importance of different factors varies according to facility size. In addition to this, the implications on employment potential of ESTs was studied by Getzner (2002), who acknowledged the ecological benefits of ESTs, and in a survey of companies in five European countries, it finds that the quantitative impact on employment in companies adopting clean technologies is slightly positive, but the main effects of clean technologies lie in the qualitative sphere. Despite these benefits, however, the importance of the manner of government intervention or its misguidedness can have serious implications on the results expected. Towards this end Yhdego (1995), presents a survey of water, air and noise pollution for Tanzania. It noted that regulatory and corrective strategy implementation and trained manpower are lacking in the economy. Furthermore, it identified the following as having bearing on adoption of sophisticated pollution control technologies: lacks in conceptual framework, lacks in the public support and governmental motivation, legislation and regulatory infrastructure.

To further complement this study, the implementation of well devised policies' potential in furthering better adoption was demonstrated by Hilson **(**2000) which reviews that in the Americas, years of unregulated mining and mineral processing activities resulted in huge environmental costs, and that this was despite environmental movement. It notes that the advent of the first environmental legislation leads to selected mines in this region experiencing noticeable reductions in pollution. These mines are ones that have been able to integrate a number of cleaner technologies and cleaner production (CP) practices. It identifies barriers as legislative, technological, and economic in nature and to rectify these it recommends that regional governments play an expanded environmental role and make CP a national goal. Furthermore, Montalvo (2003) notes that the manner in which the policies are devised should account for the dynamic setting within which the firms operate. Montalvo also notes that over the last decade, literature on the "greening" of industry and environmental policy has provided numerous important insights into the determinants of the firm's innovative behavior in cleaner technologies and explores the conditions under which the firms' innovative behavior could be fostered. Regression and simulation outcomes indicate that stringent environmental regulation without consideration to the dynamics of technical change, environmental and economic risk perceptions on the part of firms would play against the promotion of innovation in cleaner production. Montalvo (2008) further complements the earlier study by presenting a selective survey of papers that at present represent the general wisdom concerning the factors affecting adoption and how this is a primary condition to diffusion and exploitation of cleaner technologies CT.

The contribution of civil society to the adoption of ESTs is presented by Thorpe (1994), which examines some of the contributions by the public and non-governmental organizations (NGOs) to the adoption of ESTs by firms. It examines the need for public participation within the 'precautionary approach', the benefits of actively disseminating company emission and toxic use data to local communities and the importance of international NGO networking and campaigning. It also raises the importance of labor and Third World NGO participation in achieving environmentally and socially sustainable communities. The same area of study was pursued by Verheul (1999), in which it was underscored that in their decisions to adopt cleaner technologies, small and medium-sized enterprises (SMEs) are strongly influenced by organizations like suppliers, customers and local authorities. This paper studies how these networks influence the dissemination of cleaner technologies to SMEs and thus integrate both macroeconomic factors and civil society influence on adoption decision.

With a bit of a difference in focus of study, Massoud et.al. (2010) assess the factors influencing the implementation of ISO 14001 Environmental Management System in developing countries taking the food industry in Lebanon as a case example. The analyses of the survey data revealed that the food industry is generally more concerned with safety and quality issues rather than environmental issues. Economical and organizational factors are the most significant incentives required to motivate the food industry to adopt ISO 14001. The industry is less likely to voluntarily consider adopting ISO 14001 before acquiring a quality management certification i.e. ISO 9001 or until ISO 14001 certification gain more recognition in the international food sector and thus highlight the effects of market factors by considering alternative scenarios. This area as determinant was studied a bit earlier by Luken et.al (1995), which considered the potential size of the export market for cleaner industrial technology from developed to developing countries. It notes that even though the practice of adopting ESTs is there, not much is known about the size of the market. It finds that if only 5% of the value of the export of end-of-pipe and cleaner process technologies alone had been embedded in cleaner technology, it would have been equal to the value of the export of end-of-pipe technology. And a year later Hale (1996), in a review of the effects of ecolabelling in the UK ,discussed how environmental management and cleaner production are rapidly becoming critical economic, trading, and business competitiveness issues and that countries have already gone through a process of implementing legislation for the protection and enhancement of the environment and that the role of business and industry in maintaining environmental quality and that this is now increasingly coming under scrutiny with a view to making them more environmentally friendly. This paper concludes with the note that if businesses outside the EU are to expand and compete in the international market, then they must understand and take into account environmental factors in their markets.

In a bid to incorporate both market factors and role of regulation at once Reijnders (2003) explores the roles of prices and regulations. It notes that traditionally, low prices of inputs, low costs associated with non-product outputs and poor regulatory forcing have often not been conducive to diffusion of cleaner production and that developments have been noted in the field of taxation, subsidies, liability and permits that tend to be more favorable to cleaner production leading to a conclusion that extension may favor cleaner production more in the future. It recommends that cleaner production stands to gain much by slashing subsidies and substantial ecotaxation of inputs and non-product outputs. Similarly, the regulatory enforcement of best available technologies and liability for waste and tradable permits are recognized to help the diffusion of cleaner production.

A further different argument in determinants was introduced by Kemp et.al.(2008) who, in the study of the diffusion of clean technologies, documents that the diffusion of clean technology (same as the diffusion of normal innovations) is governed by endogenous mechanisms (epidemic learning and learning economies) and by exogenous mechanisms and identified the following as important factors: Policy, the characteristics of the clean technology, absorptive capacities of potential adopters and the age structure of capital and thus bringing into light the influence of plant characteristics in determining adoption. Furthermore, it acknowledges that further research is needed on the influence of public policy on clean technology choice, expectations (about learning economies and prices), adjustment costs, network externalities and complementary innovations on clean technology adoption choices. And in 2010, the influence of management issues in adoption decision was introduced by Bonilla et. al. (2010), which noted that cleaner technologies and CP, are in general, diffusing comparatively slowly. It was identified that the adoption of environmentally sound technological solutions based upon scientific research and societal testing was another relevant emphasis that needed to be addressed. Further it notes that this is being increasingly done by some companies via implementation of environmentally-oriented, socially responsible economically sound, management programs; such approaches provide the benefit of helping them to simultaneously make environmental, social and economic progress. The role of regulatory legislation as a promoter of technological improvements, managerial strategies and environmentally oriented projects to ensure compliance is underscored in this paper. The inter-relationships among policy makers, environmentally and ethically conscious consumers, responsible producers, evolving corporate social responsibility (CSR) requirements in international trade and proper worker's rights as being complex due to diverse interests and timeframes was noted in this study. However, it concludes that there is an ever increasing evidence that transparent exchange of information and environmentally oriented education programs, at all age levels, is an essential component of a holistic approach to sustainable societal development. This argument was also made by Eagan et.al. (1997), which noted that companies were beginning to incorporate environmental considerations into their business activities by way of focusing on the environmental aspects of product or process, and that design activities hold a particular promise to generate business success.

By integrating all these factors at once, Siaminwe et.al. (2005) reviews findings of a study conducted to identify the appropriate policy strategies for cleaner production in Zambia and notes that the major constraints that hindered implementation of cleaner production in the industry were financial problems, poor/weak enforcement of environmental laws, lack of knowledge, lack of awareness and lack of technical competence. Similarly, potential motivators for cleaner production in industry were identified and included the macro-economic climate, economic reforms and policies, economic incentives, regulation and environmental leadership. And in conclusion, it documents that the low levels of cleaner production adoption were mainly due to the lack of environmental standards in some industries, low levels of cleaner production awareness, limited understanding of commercial and economic benefits of utilization of cleaner production approaches, inadequate institutional arrangements for the promotion and implementation of cleaner production and the uninspiring enforcement of existing environmental laws. Another feature that is worth the consideration is the dynamic nature of the determining factors. Nishitani (2009) in an empirical study of the initial adoption of ISO 14001 in Japanese manufacturing firms analyzed: 1) the determinants of initial ISO 14001 adoptions respective to 1996–2004; and 2) the determinants of initial ISO 14001 adoptions during the period 1996–2004 and it found that: 1) the determinants of the initial ISO 14001 adoption differed among the years of adoption but in the end it reached the same conclusion that introduced this literature review that there is a positive relationship between economic performance and initial ISO 14001 adoption.

2.2.2 Incentives and the Continuity Decision

In an approach to model the factors that come into play in why firms fail to capitalize on cost effective and technically feasible technologies in Lithuania, Zimbabwe and Vietnam, Staniskis et. al. (2003) notes that despite the financial benefits and environmental advantages, the profound economic, political and social problems, served to keep back firms from the benefits and highlighted the need for domestic and international efforts to strengthen environmental financing. A recommendation for these problems was further discussed by Taylor (2005). This study notes that in order to devise better adoption and results in ESTs, it is necessary to understand that there is always room for further improvement, as with the initial case for the cleaner productions themselves, in policy devising stage. Specifically, the study holds that firstly, regulatory compliance programs and timetables should leave room for cleaner production (versus end-of-pipe) approaches; secondly, cleaner production co-funding programs should target small and medium-sized enterprises (SME) and require them to use a multimedia approach (air, water, waste), this is especially more important in developing countries as SME's dominate the manufacturing sector; third, education programs should incorporate demonstration assessments, feasibility assessments, and follow-up communication to foster implementation and continuous improvement; and fourthly mandated cleaner production should include absolute (i.e. waste/ton production) rather than relative standards (i.e. X% reduction from status quo) in order to avoid penalizing historically proactive corporations.

This framework, however, on its own is not foolproof as is studied by Hillary, et.al (1999). In this study, which aims to assess which framework works better in voluntary initiatives from the EU environmental management and audit scheme (EMAS) and the international standard ISO 14001 and other frameworks, it is noted that neither have successfully challenged industry to seek cleaner production options. This goes to confirm that frameworks on their own do not do the trick unless coupled with other management initiatives to encourage continuous implementation. Following the same line of argument Nill (2008), discusses that the typical focus of diffusion analysis on one new technology and patterns of its evolution in time tends to neglect important features of technological evolution such as the dynamics of technological competition and the importance of the institutional framework. It further notes that this is particularly so for cleaner technologies which have to compete with well established technologies and of which diffusion dynamics are related to environmental policy too.

In an attempt to discuss issues other than policy and their implication on initial adoption and the decision to continue with a once adopted EST option, Boyle (1999) discusses how firms in New Zealand benefited from the implementation of ESTs (design for environment and life cycle assessment), but that this is not being implemented on a broad basis, particularly in small businesses. One main reason was that many key personnel in businesses had only little or no knowledge of environmental concerns or of the cost of pollution or waste production. Furthermore, the study notes that this far, the focus was on recycling, not on reduction. And in a study with a holistic approach, Lesley (2006), documents the limitations of cleaner production programs as organizational change agents. This paper notes that the framework necessary for appropriate investigation of the critical success factors include: a diagnostic phase, visioning, iterative use of the vision (to motivate, inspire and drive continuous improvement), distinctive tasks (to enhance involvement), participatory design of the program (to enhance commitment), and inclusion of top level managers at key stages in the process (to maximize leadership, commitment, progress and support). The fulfillment of these is reported to be a source of savings for the firms.

This is explored in detail in a study by Johnston (1994), where it is argued that reductions in pollution and improvements in profitability are not mutually exclusive. As a proof to this, it documents that in the first 18 months of a project established to demonstrate the benefits of waste minimization and cleaner technology in the UK, the 11 participating companies have made savings of over £2 million a year. Reductions in the use of inputs such as water, energy and raw materials exceeded savings in effluent production by a significant margin, thereby confirming the profitability of programs. Same result is reported by Freinmann (2000), which documents that managers reported, through questionnaires, that they made considerable savings with measures of corporate environmental protection: 30% between €5000 and €500,000 per year and another 30% claimed savings between €50, 000 to €250,000 per year. A total of 15% obtained more than €250, 000 and that related to cost of the environment management and auditing scheme (EMAS) the average repayment time was less than a year and a half and a later study in the US found a similar result. Skea 2000 quotes a study by Dorfman et. al. (1992) about how 29 chemical plants in the US introduced a mixture of cleaner production options and managed a reduction of hazardous waste streams by 71% with a payback period of 13 months.

Furthermore, in a Titanium oxide industry, a move to continuous processing led to a 99.6 percent reduction in sulfur dioxide emission, a 40% reduction in acid waste and a 25% reduction in energy use.

A recent study in the same area by Gabbel et.al. (2001) notes that energy efficiency contest or run for what are called the "low hanging fruits" began in 1981 by the Louisiana division of Dow Chemical. And that in just eight years following this contest, there were 95 projects that were picked, costing a total of $21.9m – and yielding an average return of 190 percent. Furthermore the study documents that the centre for the exploitation of science and technology of the UK ran an eighteen-month project which resulted in more than ₤11 million a year saving for the eleven participating companies, mostly from simple changes in processes that reduced inputs of water, energy and raw materials. In conclusion, it reports that the US Environmental Protection Agency (EPA) has estimated that, if the entire country were to switch to energy-efficient lighting, its electricity bill would fall by 10 percent. A similar result was found by Hilmi Yüksel 2008. This study investigated cleaner production practices in Turkey through a survey of questionnaire. It noted that ISO 14001 environment management system (EMS) motivated the firms to use resources for pollution prevention and to apply cleaner production practices. According to the results of the survey, it can be stated that ISO 14001 EMS enhances the environmental performance of the firms.

All this, however, hinges on the commitment of the management to the resource saving investments. Detailed discussion on this was made by Zwetsloot et. al. **(**1996), which noted that, in an interview at the first European roundtable on cleaner production programs (1994), (1) cooperation, training and communication, (2) assessing tangible benefits, (3) leadership and management commitment, (4) commitment and motivation of employees, and (5) factors ensuring good program management were the essential success factors in Cleaner Production (CP) programs, and documented the response in the scale of importance as is presented. In an attempt to answer why, despite the potential savings that could be generated, there may be lack of management commitment, Kerry (2000) notes that the role played by the consumer is quite significant. The lack of knowledge on the part of the consumer regarding the environmental impact of the product and its production process may work against attempts by government or environmental activists' effort to green up the firms under consideration. This is basically because green consumerism does little to alter production process since the consumer is not generally well informed about the precise nature of such processes, and in any case less able to affect the choice of processes in any direct way. But it notes that process changes will occur if industry too becomes environmentally conscious, and/or the cost signals to industry alter its production practices and thus highlighted the influence of consciousness or costs as the motivating force towards committing firms to cleaner production practices. The role of incentives was discussed earlier in greater length in Kilmann (1995). In the study to identify critical success factors that were learned in a variety of organizations in both the US and Europe, it noted the importance of the incentive mechanism in place as a determining factor in successful continuity of cleaner production practices. The paper adopts a holistic approach and presents a sequence of eight interrelated tracks, which consists of five system tracks (culture, skills, team, strategy-structure, reward system) and three process tracks (gradual process, radical process, learning process). A recent study with the same assessment was made by Joachim (1997). In a study of the barriers to energy efficiency in German commercial and services sectors, it shows at the level of entire sectors, that the lack of information about energy consumption patterns and about energy efficiency measures, lack of staff time, priority setting within organizations, and – in particular – the investor/user dilemma are all relevant barriers. Furthermore, it notes that allowing for sector-specific differences in the relevance of these individual barriers yields a more heterogeneous picture i.e. the numbers and types of relevant barriers vary across sub-sectors and the majority of sub-sectors are subject to relatively few barriers. The statistically most significant barriers were found for the sub-sector of public administrations which traditionally are open to goal incongruence and the implication of investments or their lack is not necessarily reflected on the decision maker. This goes back to the previous points of the role of policy and management commitment.

In an attempt to consider all these points together, Goll et.al. (2004) examine the relationships between a company's emphasis on discretionary social responsibility, environment, and firm performance. It tests the proposition that environmental munificence and dynamism moderate the relationship between discretionary social responsibility and financial performance and finds that discretionary social responsibility contributes to firm performance in environments that are dynamic and munificent. A similar study done a bit earlier was that of Waddock et.al. (2002), discusses how firms are coming more and more under pressure to manage responsibly as well as profitably. The pressure for expanding the emphasis on profits to managing responsibly derive from three general sources: primary stakeholders such as owners, employees, customers, and suppliers; secondary stakeholders such as non-governmental organization activists, communities, and governments; and general societal trends and institutional forces. This paper notes that to respond to these pressures, many multinational corporations in particular are developing what are called total responsibility management systems approaches for managing their responsibilities to stakeholders and the natural environment. The need for the consideration of the heterogeneity of firms was further discussed by Marcel (2002), who reviews the debate on the concepts and definitions of Corporate Social Responsibility (CSR) and Corporate Sustainability (CS). It notes that the impact of changing contexts and situations and practical considerations, show that "one solution fits all" definition for CS(R) should be abandoned, and the way forward should be based on accepting various and more specific definitions matching the development, awareness and ambition levels of organizations. In a study of the base metal production and management, Moors (2005) recommends that one solution to the barriers for radical innovations is firm-internal, inter-firm and firm-external strategies.

Same objective but a different approach to answering why there is such a slower rate of adoption and significant commitment problems were evident was given by DeCanio (1993). This study notes that in most companies, cost saving investments is subject to demanding payback criteria and that many investments in energy efficiency fail to be made despite their apparent profitability. It identifies the culprits to include: bounded rationality, principal agent problems, and moral hazard. This has the implication that government can simultaneously improve overall energy efficiency and increase private sector productivity by providing informational and organizational services that go beyond the traditional regulatory framework. Following the focus on management issues and their implication on adoption and continuity decision, Argandoña (2004) discuss the web of incentives regarding companies' ethical, social and environmental responsibilities that played a role in continuity decision. The web includes the regulation by an authority or agency; those designed to create market incentives; and those that rely on self-regulation by companies themselves. It notes the challenge in a sole consideration of regulation given the costs and drawbacks and the need for the creation on the part of the firms their own ethical, social and environmental management systems or programs.

This is expected to help develop and sustain ethical behavior in organizations. Furthermore, it discusses the need for a coupling instrument for an ethical management program to be effective if it is self regulated. This is especially important in developing countries with potential for growth that can benefit from a managed efficient form of development. Following on this, Yanti (2009) documents that in Malaysia, electric motors account for more than 70% of the total growth from 1991 to 2004 in electricity consumption in this sector. And that this implies the appearance of resource saving potentials in the sector. This study notes that the first step in this direction is the creation of a procedure for testing and rating equipment.

In a bid to complete the components of what actually constitute incentives, Boks **(***2006)*, acknowledges the roles played by the traditional intervention mechanisms as internal value chain issues such as formal organization, tool development, customization and formal management commitment. And in the end, it identifies less noticed but equally important factors relating to incentive packages that focus more on the social aspects, psychological and sometimes intangible processes that can 'make or break' ecodesign implementation. Furthermore, organizational considerations as unwillingness to cooperate, gaps between ecodesign proponents and executors, and other organizational complexities are noted as playing an important role.

A further variant to what may be considered as incentive, Konstadinos (2006) summarizes the experience of Greek firms that have been awarded the environmental management and auditing scheme (EMAS) certificate. It notes that an important dimension of the EMAS is that it entails closer monitoring of the production process by way of disclosure and thus provides for the success of the program.

2.2.3 SUMMARY

The pool of evidence shows the multitude of factors that determine adoption of ESTs. These may be conveniently categorized as contextual (a function of the interplay of macroeconomic policies through the network of incentives webs it creates like in environmental policy, the economic policy, and the technological policy) and industry and firm specific factors (the amount of cleaner production options that can be created for the industry, the manner of how the firm conducts itself with regards to the environment in its product life cycle, the absorptive capacity of the firms in how well an established engineering unit it has, the quality management it operates, the practice of green marketing and how the price of resources especially energy comes in to play) alongside the civil society's influence on firm behavior. Most of the studies reviewed have addressed the issue of adoption determinants by considering only one of the dimensions of factors presented here or by combining two or at most three elements. Insightful as this may be, it obviously misses what may be an important determinant in adoption decision. This paper intends to fill this gap by attempting to incorporate relevant variables from all the dimensions mentioned, namely: plant characteristics, market factors, governmental factors, and civil society factors.

The attractive attribute of EST, most notably, the cleaner production technologies, is its capability to generate benefits while contributing to the protection of the environment. The benefits and the amount have been reviewed. Interestingly enough though, the adoption rate is low and firms are reported to have slided down from their initial level of adoption or altogether skipped a year or more in its practice. This has been the case not only in developing countries but developed countries likewise. The review has provided insight why this may be the case by considering issues of macroeconomic policies, lack of awareness in adoption and optimal use, lack in management commitment and investigating into the impact of incentives in continuity decision. This thesis takes up on the last factor identified by these studies and adopts a principal agent framework approach to the study of problems in dynamic inconsistency in adoption decision of managers of firms. Most of the studies are qualitative in nature and do not seem to adopt a particular framework for their discussion. This thesis intends to fill this gap by way of adopting an econometric tool towards meeting the objectives of identifying the determining factors that influence different level of adoption of ESTs, and assessing how well the principal-agent theory captures the dynamic inconsistency in adoption decision on the part of employed firm managers as distinct from the owners themselves managing these firms, and based on the results, make policy.

CHAPTER THREE: ESTs: CLASSIFICATIONS AND THE ETHIOPIAN EXPERIENCE

3.1 Introduction

ESTs are technologies that protect the environment. These are: less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they are substitutes (Nilsson et.al. 2007). One can identify two different options in the ESTs: pollution abating technology (PAT) and cleaner technology (CT) (Kemp et.al. 2008). In this chapter, each will be reviewed.

3.2 Classifications of ESTs

1. **PATs**

The traditional methods are the technical waste stream treatment approaches, the so-called end-of-pipe technology. One possibility to handle the pollution problem in an industrial plant is to take care of the waste in specially designed waste treatment facilities. An example is wastewater or sewerage treatment plants (WWTPs). The strategy of separating pollutants from a water flow with a designed cleaning facility constitutes a so-called filter strategy or "end-of-pipe" technology (Nilsson et.al. 2007).

Remediation is and was practiced when polluters were legally forced by those who had suffered from the emission. In rehabilitation of an abandoned lagoon, ECPC documents a decrease in PH from 12.18 to 5.49, BOD decrease from 2139Mg/L to 1210 Mg/L, and decrease in COD from7310 Mg/L to 3280 Mg/L (ECPC 2007). The problem, however, is that as long as the discharges are going on, the remediation measure has to continue. Step one is to stop the pollution. Remediation is often the only way to give the polluted sites back their former function (Moors 2005).

2. CTs

Cleaner Production is a preventative approach to environmental protection that focuses on increasing resource efficiency and reducing the generation of pollution and waste at source, rather than addressing and mitigating the effects of pollution and waste (Nilsson et. al. 2007). Cleaner production may be achieved in practice through the use of the following operational tools. The First is Good housekeeping. This involves making changes in operational procedures and management in order to eliminate waste and the generation of emissions. Examples include the prevention of leaks, spills and other forms of wastage. The second option is input substitution. Here, industries can substitute raw materials with less toxic or renewable materials, or with auxiliary materials that have a longer service lifetime in production. Third is better process control. Here industries can effect better process control through process automation, process optimisation, equipment redesign and process substitution in order to run their processes more efficiently and at lower waste and emission generation rates. The fourth is on-site recovery/reuse. This involves the recovery and the useful application of waste materials or pollutants at the site where they have been generated. Fifth is production of useful by-products. Sixth is equipment modification. This requires the modification of existing production equipment and utilities in order to run the processes more efficiently, and at lower waste and emission generation rates. Seventh is product modification. This requires the modification of the product characteristics in order to avoid or minimise the environmental impacts of the product during or after its use. Eighth is technology change. This involves the replacement of existing technology with other technologies in order to minimise pollution and waste generation in the production process. (Nilsson et. al. 2007).

3.3 National Cleaner Production Centres

Some developed countries, such as Norway, have placed emphasis on the legislative framework, whilst highlighting the promotion and use of voluntary instruments (Montalvo 2003). In Africa, National Cleaner Production Centres have been established in Ethiopia, Kenya, Morocco, Mozambique, Nigeria, South Africa, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe (ECPC 2007). These centres work with firms in assisting with the implementation of ESTs on a voluntary basis.

Cleaner Production activities have been taking place in Ethiopia for about a decade now. Despite the demonstrated economic, social and environmental benefits of the adoption of CP practices, as has been documented by ECPC and presented in the section on discussion of results, the adoption of CP by the various role-players in Ethiopia has been slow. The 2007 review of Cleaner Production in Ethiopia identified a number of potential barriers and drivers for the implementation of CP. The barriers include: awareness constraints, capacity constraints, technology constraints, financial constraints, regulatory constraints.

Towards alleviating this, different policy regimes have been adopted including the latest Provisional Standards for Industrial Pollution Control in Ethiopia with the sectoral standard effluent levels issued in Jan. 12, 2008. Notable articles in Environmental Policy of Ethiopia (EPE) related to the management of the environment in general and the adoption cleaner production practice in particular include the adherence to the precautionary principle of minimizing and where possible, preventing discharge of substances and to disallow the discharge when they are likely to be hazardous and to promote waste minimization processes including the efficient recycling of materials wherever possible.

The adoption of the ESTs is based on a voluntary basis. The adoption of these technologies could have been facilitated if there was an incentive regime provided by the government following the adoption of ESTs by firms. One of the challenges in this area is the misconception that CP Production has largely been viewed as an operational matter as opposed to a strategic issue that needs to be directed through national policy. However, things seem to be looking up in this area. One area where incentives besides what is delivered by the EST adopted that is in the pipe line is a possible reduction in insurance payment the firms make on account of better working environment they have created following the requirements of crafting and implementing environmental management system, which after assessment by external auditors results in the firm earning the ISO 14001 certificate.

The general understanding is that a strategy policy should be devised with these dimensions to make maximize its chance of success: information and awareness, capacity building, technology development and cooperation, financial support, and policy and regulation to ensure adoption of cleaner production practices over traditional reactive policies.

CHAPTER FOUR: ANALYTICAL METHODS

4.1 Methodology

4.1.1 Source of Data

The sources of the data for this study are composed of both primary and secondary data. Reference books, relevant literature and surveys undertaken by individual, organizations, and journals have been reviewed. Data collected from the Central Statistics Authority (CSA), the World Bank, UNIDO, and ECPC have been reviewed whenever appropriate.

Regarding primary data, questionnaires were used in in-person and telephone interviews when other alternatives were not feasible. This was done because the firms under study are distributed in different parts of the country, making in-person interview of all difficult due to time and financial constraints. Some of the data have been cross referenced with those maintained by the ECPC before entering analyses.

4.1.2 Methods of Analyses

The ordered probit model is employed to investigate what determines the adoption of the EST options which have a hierarchical order. This covers the first issue to be investigated. The application of the principal-agent relation is implemented using a Heckman Probit model. The details of these models are presented in the analytical methods section.

The unit of analyses is firms. Their number and the product lines they are involved in are discussed in the results discussion part. The selection of these firms is based on the list obtained from the ECPC that it worked with and it is the population of these firms that is considered and thus no sampling is involved and thus no discussion on it will be made.

4.2 Analysis of the Determinants of Voluntary Adoption of ESTs

4.2.1 Choice of a Choice Model

Choice models in an applied work can be viewed from the stages of model building processes beginning with theory generation, and then parameterization, and finally estimation. These models address the issues of the nature of preferences, the nature of choice alternatives, the choice rule, and the nature of the resulting choice. And traditionally, we have the following typologies: the neoclassical economic theory choice model as extended by Lancaster, Risk-Preference Theory of choices under uncertainty (e.g., von Neumann-Morgenstern, 1947), Strict Utility Model, and Random Utility Model (Corstjens et.al. 1983). In terms of the nature of preference, while the first three theories postulate deterministic preference structures, i.e. the individual is assumed always to assign the same utility to the same choice alternative while the random utility model is based on stochastic preferences where the individual draws at random a member of a set of utility functions for each choice occasion. In terms of choice alternatives, in the case of deterministic choice alternatives, the decision maker is certain about the values of the characteristics for each of the choice alternatives and no adjustments need to be made to the preference function. In terms of choice rules, the most common decision rule is the maximization of utility over all choice alternatives; variants to this include decision rules implied by disjunctive, conjunctive and lexicographic models.

When one comes to the nature of the resulting choice, two distinguishing features under these theories are (1) the distinction between continuous and discrete choice, and (2) the distinction between probabilistic and deterministic choice. The issue of continuity and discreteness rests on the kind of substitution allowed among alternatives in the choice set. Continuous choice models are used to predict the quantity allocation decision and intensive margins are calculated to describe how intensively an individual consumes an alternative, given a set of available alternatives in measurable quantities. On the other hand, discrete choice models are used to predict choice probabilities and extensive margins are calculated to describe the margin along which adjustments by the consumer would be made with respect to the selection or nonselection of an alternative. And, the individual's choice is modeled as though it was the result of a sequence of some discrete events and that the individual is understood to select one and only one of the elements at each choice occasion. In the standard indifference curve analysis terms, for discrete choice (substitution at the extensive margin) the constrained utility maximizing solution will always be a corner solution (Corstjens et. al. 1983).

The parameterization approaches adopted include utility trees, the integration of utility and demand functions, and revealed preference. These differ in terms of what they hold needs to be parameterized. The random utility model requires that *ui* (the utility function of individual *i*) and *ei* (the deviation of the fitted from the observed) be parameterized.

Given the objective of the thesis, an accounting for idiosyncratic attribute is naturally called for i.e. the firms attributes that distinguish it in terms of the EST it has adopted. This is strengthened when one considers the number of stakeholders involved in decision making regarding the adoption of this technology option at an individual firm level which leaves room for the presence of multiple utility functions for multiple EST options.

Furthermore, without experience with the technology at least for some time, it is difficult to assume that the adopting agent is certain about the values of the characteristics of the EST option to be embarked upon, and even this requires controlling for other disturbances. When one comes to the resulting choice, the question under consideration is not about the amount of quantity allocated in the presence of alternatives rather the selection of one of the elements of the EST option. It is based on this that the predicted discrete changes of the dependent variable with respect to the regressors are discussed. Other reasons cited for adopting the RUM include that it allows the assumption of individuals behaving randomly so that faced repeatedly with the same alternative set, the same individual makes different choices; a stochastic choice is induced by unobserved data, including situational constraints in each observation for each individual and varying tastes, and measurement and sampling error being present (Corstjens et.al. 1983). This paper does not claim to have exhausted all variables that can possibly come in to play in the final decision process and thus its adoption of the RUM is justified.

4.2.2 Analytical Framework

The decision on whether or not to adopt a new technology can be considered under the general framework of utility or profit maximization. It is assumed that economic agents adopt a certain option only when the perceived utility or net benefit from using such a method is greater than is an alternative or the case without it. Although utility is not directly observed, the actions of economic agents are observed through the choices they make. A key note here is that '*utility*' in this case is adopted to refer to the general objective function the firm uses when it evaluates alternatives, like profits, and it shouldn't be confused for inconsistent framework, which is that such discussion should be based in production economics than in consumer theory discourse.

Suppose that y_j and y_k represent a firm's utility for two choices which are denoted by $U_{j \text{ and }} U_k$ respectively. The random utility model could then be specified as:

$$U_j = \beta_j X_i + \varepsilon_j \quad \text{and } U_k = \beta_k X_i + \varepsilon_k \text{ --- } (1)$$

Where U_j and U_k are perceived utilities of adoption options j and k, respectively. X is the vector of explanatory variables that influence the perceived desirability of the technology option under discussion, and B_j and B_k are parameters to be estimated. And ε_j and ε_k are error terms assumed to be independently and identically distributed (Greene 2003). In the case, where firm i decides to use option j, it follows that the perceived utility or benefit from option j is greater than the utility from the other option, namely k, and it is shown as:

$$U_j (\beta_j X_i + \varepsilon_j) >(U_k \beta X_i + \varepsilon_k), k \neq j \text{ ----------------------------- } (2)$$

The probability that a firm will use method j among the set of technology options could then be defined as:

$$P(Y = 1| X) = P (U_j > U_k) \text{ --- } (3)$$

$$P (\beta_j X_j + \varepsilon_j - \beta_k X - \varepsilon_k > 0 |X) \text{ -- } (4)$$

$$P (\beta_j X_j - \beta_k X + \varepsilon^* > 0|X) \text{ -- } (5)$$

$$P(X^*X + \varepsilon > 0|X) = F(\beta^* X_i) \text{ --- } (6)$$

Where Y is the limited dependent variables indicating the choice the firm has made from the options given, P is a probability function, $U_{j,}$ and U_k are the utilities for options j and k respectively and X is the explanatory variables of the utility function, and $\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term, and F (B^*X_j) is a cumulative distribution function of ε^* evaluated at B^*X_i. The exact distribution of F depends on the distribution of the random disturbance term, ε^*. Depending on the distribution that the random disturbance term follows, several qualitative choice models can be estimated (Greene 2003).

4.2.3 Empirical Model

4.2.3.1 Model Choice

The ordered probit model will be employed in this section. The use of this model is justified in that the technology option, the dependent variable, has an order in terms of technological complexity. An alternative model with the same capability to capture the ordered nature of the dependent variable is the ordered logit model. The choice of the ordered probit model over the ordered logit model is on account of the difference in their treatment of the result which is held constant and which is allowed to vary. A working assumption in the ordinal logit model is what is called the parallel slopes assumption (proportional odds assumption), which requires that the separate equations for each category differ only in their intercepts. This means that the slopes are assumed to be the same when going from each category to the next. This means, furthermore, that the effect is proportionate change in the odds or for all response categories y_i=j, while in the ordered probit model we estimate the coefficient for each category of the independent variable to be the same and the cut points are free to vary, but in both cases the marginal effects of the regressors on the probabilities are not equal to the coefficients (Wooldridge 2002). In the listed EST options, the difference between these alternative orders are not necessarily the same or identical, neither need they be assumed so. For these reasons, the ordered probit model is chosen.

This method has been shown to be able to be used to analyze ESTs adoption (Luken et.al. 2007). The advantage of the ordered probit model is that it permits the analysis of decision across options that are hierarchical in nature thus allowing the determination of choice probabilities for different categories, and the marginal effect of each regressor.

The probability of observing $\boldsymbol{y_j}$ **=m** equals the probability that the estimated function is within the cut points estimated for the outcome.

$$\mathbf{P_{jm} = Pr\ (Y_i = m) = Pr\ (\alpha m\text{-}1 < (\beta 1X_{1j} + \beta_2X_{2j} + \ldots\ \varepsilon_{m)} \leq \alpha_m)}$$

In the ordered probit, ε_i is assumed to be normally distributed across observations. The mean and variance are normalized to 0 and 1 respectively. Since we have three categories, the three probabilities are

$$Prob(Y = 0|x) = \Phi(-x'\beta)$$

$$Prob(Y = 1|x) = \Phi(\alpha - x'\beta) - \Phi(-x'\beta)$$

$$Prob(Y = 2|x) = 1 - \Phi(\alpha - x'\beta)$$

For the three probabilities, the marginal effects are:

- $\frac{\partial Prob(Y = 0|x)}{\partial x} = -\text{Ø}(x'\beta)\ \beta$
- $\frac{\partial Prob(Y = 1|x)}{\partial x} = (\text{Ø}(-x'\beta) - \text{Ø}(\alpha - x'\beta))\ \beta$
- $\frac{\partial Prob(Y = 2|x)}{\partial x} = \text{Ø}(\alpha - x'\beta)\ \beta$

Where Φ is standard normal cumulative distribution function (cdf) and Ø is the standard normal density. To describe the ordered probit mode, let y denote the order of the ESTs under consideration and x contains characteristics firms, the market influence, civil society influence, and the influence of the government by a way of establishing a coordinating center run with government fund alongside an international donor. The question is how, ceteris paribus, changes in the elements of x affect the response probabilities p $(y = m|x)$ m=1, 2…..j. Wooldridge (2002) notes that, except in cases where the magnitudes of the estimated parameter have some meaning, omitted heterogeneity in probit models is not a problem when it is independent of x. That is, ignoring it consistently estimates the average partial effect. Of course, this argument hinges on the normality of the missed variable and the probit structural equation. Furthermore it notes that under such conditions, several alternatives can be considered regarding the estimation of discrete response models that relax parametric assumptions on $P(y = 1|x)$. These include certain restrictions on the cumulative distribution function and the distribution of x, and then the semi parametric estimators can be consistent and asymptotically normal. However, if the interest lies in knowing the magnitude of the change in $P(y = 1|x)$ for a given change in xj, unless, heteroskedasticity is accounted for, the estimated parameter and the resultant partial effects calculus may have opposite signs thus signaling the need for careful assessment of the standard error.

4.2.3.2 Model Variables

EST adoption, expressed as an ordinal variable, can take the following values: 0=PATs only; 1=PATs plus lower order of complexity CTs [(a) input material change and (b) better process control]; 2=PATs plus medium order of complexity CTs [(c) equipment modification; (d) on-site reuse and (e) useful by-products]; 3=PATs plus higher order of complexity CTs [(f) major technology change and (g) product modification]. Cleaner production programs are conveniently categorized into one of eight categories, all discussed in the previous chapter, with the most basic lower order of technological complexity of CT being good housekeeping. This particular option is not considered for the analyses since it is too difficult to define and verify its application across different sectors as each has unique cases.

For this study a variety of dimensions are considered. This is based on consideration of what constitute the institutional framework in the operation of the firm (Eggersson T. 1997). These include in plant characteristics, government influence, market factors, and civil society influence. In the in plant characteristics category, the variables include environmental commitment, ownership structure, technological capability of the firm, the number of years in operation, and the size of the firm measured in terms of the number of people working for it. The environmental commitment of the firm looks into the manner with which the firm conducts itself with regards to the environment. Naturally, a firm with an environmental policy and one that has institutionalized the system of environment management alongside the other management systems is assumed to have higher odds of adopting a higher order EST **(**Zwetsloot et.al. 1996). The structure of the firm given in binomial options of Corporate and Sole Proprietor enters the investigation mainly to see if the risk associated with the structure of the business had a bearing on higher order option adoption decision. This is because a new course of practice entails a certain degree of risk and the manner of response to this risk varies based on the structure of the firm. A sole proprietor has higher risk aversiveness on average as compared to corporate form of organization (Montalvo 2003) given the outcome of the application of the new course of practice being fully borne by the decision maker where as in corporate form of administration, the resultant effect reflecting on the decision maker is not is limited, thus reducing the risk faced. With regard to ownership, other forms of interest include foreign ownership and whether the firm as a private firm or public property determines which level of ESTs is adopted. It is hypothesized that firms owned by foreigners tend to be cleaner. This is particularly the case with developing countries because it is assumed that foreign involvement facilitates the adoption of cleaner technologies (Luken et. al.2007). Private firms are mostly expected to have a cleaner production practice. Public enterprises are mostly assumed to be pollution intensive possibly because they are protected from formal and informal regulatory pressure. These firms are also hypothesized to be wasteful in resource management as the direct results are not borne by the decision makers in comparison to a private form of ownership. Given all these factors against public firms, it is natural to assume a positive and significant correlation between private ownership and higher order EST adoption (Joachim 1997). The technological capability of the firm, whose construction alongside others is presented in Appendix II, is supposed to be a measure of the firm's capability to identify, assess and implement changes in production practice. This further includes the firm's capability to absorb and utilize information effectively (Koefoed et.al. *2008)*. The size of the firm measured in terms of the number of its workers is assumed to be associated with economies of scale in technology use. It is also assumed to augment access to information and greater technological skill.

The number of firms in the sector the firm operates in is included if there is a practice of green marketing and to assess its statistical significance i.e. greener production practice promises more marketing opportunity, which is the apparent reality and this is a competitive edge for the firm. Alternatively, it can be seen as a product differentiating move by the firm. The microeconomic view of this in terms of market concentration is that a market structure between a perfectly competitive and a monopoly form stands to benefit from advertising or creating a competitive advantage by augmenting one of its product or production dimensions. The test is then to see if this pattern holds across the different sectors that are not necessarily substitutes to one another. This figure is a 14 year average of the number of firms as reported by the Central Statistics Authority (CSA 2009). The details are of the classification of the operation of the firms and thus the categorization for the collection of the data is presented in the next section along with the number of firms that have adopted the ESTs. It is hypothesized that if the variable is to be considered, it should be a longer term, but not very long, average as the adoption decision would look at competition in the market (Eagan et.al 1997). Another variable that is featured in this study from the CSA is the ratio of energy cost to total cost. This is taken as, out of a thousand birr spent, how much of it goes to the purchase of energy. The ratio of energy cost to total cost is included because these technology options do play a cost cutting role and it is assumed that firms with large expenditure on energy are assumed as adopting higher EST option (Johnston 1994). In the civil society influence, the role of NGO's and the complaints filed on the firm by the people around it are expected to influence adoption decision (Thorpe 1994). The details of these explanatory variables are discussed in the next chapter.

4.3 Principal Agent Relations Analyses of Dynamic Inconsistency in the Adoption of ESTs

4.3.1 Analytical Framework

The premise for adoption and continued implementation of a technology option relies on the rationality of adoption and continuity (Bonilla et al 2010). Multiple alternative scenarios can be looked into. If UA_t represents the utility of adoption at time ***t***, UN_t represent the utility of non adoption at time ***t*** or the utility from maintaining the current course of production, and if EC_t represents the shadow environmental tax that has to be borne by the firm on account of the damage inflicted upon the environment because of the current production practice then adoption makes sense for the firm if:

$$\mathbf{UA_t - UN_t > EC_t.}$$

If $UA_t - UN_t = EC_t$, the firm is indifferent between adopting that technology that promises to clean the production process and thus make the firm compliant with the relevant environmental act. If $UA_t - UN_t < EC_t$, then no adoption would be the right thing to do for the firm, at least financially. This is a static setting. In a dynamic setting, continuity of adoption assumes that the absolute size of these figures may change but the requirement that the firm makes a saving either directly from the adoption or through the reduced taxes due on the firm, is still maintained. In this sense, the dynamics becomes a series of discrete decision with the same requirement. If at time ***t*** the firm had adopted the EST and if at ***t+1*** it discontinued the project, it could mean, with the rationality requirement stated earlier, that the firm failed to make savings or the **ECt** was reduced by fiscal policy change and thus reduced the savings in the form of opportunity cost saved. The particular interest of this section is not, however, the investigation of whether the decision to discontinue was justified in the light of **EC**s and dynamics of savings, though they will be controlled for. The question is with regard to the influence of the form of management in the continuity of the EST namely; does the distinction in owner management (the principal) versus employee (agent) management of the firm have a bearing on the continuity after controlling for the relevant considerations namely savings associated with the ESTs over costs i.e. the Principal Agent Relation (P-A-R).

4.3.2 Empirical Model

4.3.2.1 Model Choice

The issues of selectivity may arise due to self-selection with the outcome of interest determined in part by individual choice of whether or not to participate in the activity of interest or from oversampling of those who have chosen to participate. In either case, similar issues arise and thus justify the employment of a model that captures this. The selection models are usually called sample selection models. With this problem present, running an OLS would yield consistent, but inefficient estimates of coefficients and standard errors, and thus resulting interpretations will be compromised (Greene 2003).

In the course of the heckman probit selection model, the correlation between error terms can be estimated by $\hat{\rho} = \sigma 1 / \sigma 2$. This allows one to check whether or not the errors are correlated and the sample selection correction is required or not. It is important to use the heteroskedasticity-robust standard errors for the second stage regression. This will take account of two problems: first, even if β_1 were known, the error in stage 2 regression is heteroskedastic. Secondly, since β_1 is being replaced by $\hat{\beta}_1$, there will be room for complications. The estimator of β_2 is consistent. The estimator requires distributional assumptions weaker than joint normality of ε_1 and ε_2 and it can be relaxed further to permit semiparametric estimations (Greene 2003).

The bivariate sample selection model with normal errors is theoretically identified without any restrictions on the regressors. However, if there are exactly the same regressors, the model is close to being unidentified which leads to multicollinearity problems. Towards this, Wooldridge (2002) indicates that it is highly desirable to have at least one element in the first stage of the heckman process that is not important in the second stage. Then, we can estimate binary response models with sample selection if we assume that the latent errors are bivariate normal and independent of the explanatory variables. In the model variables presented below, these issues are accounted for.

The continuation with a once adopted green technological option depends among other things on the savings it generates. If there are direct benefits to be made out of it, then it would be rational to expect that the agent will continue to implement it. If, on the other hand, it does not have any direct benefits, it will have to be justified by an opportunity cost of noncompliance that is too high to be ignored. In anyway, it is customary to expect the project to make a savings for it to be continued (Zwetsloot et.al. 1996), and thus continuation becomes a two-stage process: first, benefiting from the green technology adoption and second deciding to continue or not. This implies the need for the use of Heckman's sample selectivity probit model (Greene 2003).

If there is an individual firm with fully observed outcome, called a participant in the activity being studied, then we can define a binary indicator variable d = 1for participants and d=0. Furthermore, if Y > 0 is for observed participants and if Y = 0 for non participants, then the two models for Y can be given by

$$\mathbf{F\ (y|x) = \begin{cases} Pr\ (d = 0|x)\ if\ Y = 0 \\ Pr\ ((d = 1|x)\ f\ (y|d = 1, x)\ if\ y > 0 \end{cases}}$$

One can generate a latent variable extension of this model by d = 1 if **$I = x'\beta + \varepsilon > 0$**

The probit model for sample selection assumes that an underlying relationship exists; the latent equation is given by

$$Y_i^* = X_j\beta + \varepsilon_j$$

Such that we observe only the binary outcome given by the probit model as

$$Y_i^{probit} = (y_i^* > 0)$$

The dependent variable is observed only if j is observed if the selection equation

$$Y_i^{selection} = (Z_i\delta + \varepsilon_{2i} > 0)$$

$$\varepsilon_1 \sim N\ (0, 1)$$

$$\varepsilon_2 \sim N\ (0, 1)$$

$$Corr\ (\varepsilon_1, \varepsilon_2) = \rho$$

Where X is a K-vector of regressors, Z is an M vector of regressors; ε_1 and ε_2 are error terms, where $\rho \neq 0$, standard probit technique applied to equation $\mathbf{Y_i^* = X_j\beta + U_j}$ yields a biased result. Thus the heckman probit provides consistent, asymptotically efficient estimate for all parameters in such models. Thus the heckman probit model is applied to this question.

4.3.2.2 Model Variables

For this study, the first stage of the Heckman probit model considers whether the firm made savings following the adoption of the EST; this is the selection model. The second stage model looks at whether the firm continued with its adoption decision; this is conditional up on the first stage. This second stage is the outcome model.

Explanatory Variables for the Selection Equation

For the selection model, it is hypothesized that, higher option adoption, technological capability, export orientation, the ratio of energy cost to total cost, and the size of the firm by count of the number of people on its payroll are believed to influence the savings generated from the adopted option (Zwetsloot et. al. 1996). A firm with higher ratio of energy cost to total cost is assumed to benefit from the cost saving dimension of the benefits of ESTs (Johnston 1994). It is also hypothesized that there is a positive link between higher order option and the benefits thus generated, without any claim to linearity or otherwise (Bonilla et. al. 2010). Export orientation is introduced because there is a growing demand on the international market for firms to be environmentally friendly and thus a friendlier firm can be hypothesized as having a better market access and thus better economies of scale (Luken et. al. 2007, Hale 1996).

Explanatory Variables for the Outcome Model

The variables hypothesized as influencing the continuity of decision include: the manner of how the firm is run i.e. if it is the owner that is running the firm as opposed to an employed agent. This captures the interest of the principal agent relation (Lietke et.al 2000). Aside from this, whether the firm had in place an environmental management team or a cleaner production team or not is also worth consideration. This would represent that the firm has instituted environmental management in to its other operational systems with the necessary incentive package namely the remuneration for the duty and the requirement to make a periodical reporting on environmental performance (Yüksel 2008). Same variables on part of management are also included. The number of years the firm has been in business, the export orientation (Bonilla et al 2010, Hale, 1996) is also explored.

CHAPTER FIVE: ANALYSIS OF THE DETERMINANTS OF VOLUNTARY ADOPTION OF ESTs

5.1 Description

From the listed EST options, there is not a firm that has adopted the highest of them all namely PAT + Higher CT. In terms of distribution, it is PAT + Middle CT's that has the highest number of firms followed by PAT +Lower CT. This may be attributed to the high cost associated with changing the entirety of the technology. In the table below, the variables, their mean values, standard deviations and their descriptions are given. The four dimensions of the determinants are presented alongside what constitute these categories. Some of the variables are composed of a number of questions. Their construction is presented in Appendix II. Notable among these are: environmental commitment and technological capabilities. Environmental commitment includes questions on the firm having an environmental management policy, an environmental management system, and the firm participating in any waste minimization pollution prevention program. And the technological capability contains questions on the existence of an engineering unit, the existence of a quality management system, the relative level of process technology, the level of technological activity over the period and the relative level of product and the extent of its technology linkage with other enterprises, like suppliers, buyers, competitors, and technology support institutions.

Table 1 Descriptive statistics of Variables

Dependent Variable: EST Index	PAT Only	PAT + Lower CT	PAT + Medium CT	PAT + Higher CT
Percent	19.4%	36.1%	44.5%	0%

Explanatory Variables	Mean	Std. Dev	Description
In-plant characteristics			
Environmental Commitment(EnvCom)	0.34	0.479	Dummy takes on value 1 if all question components are fulfilled.
Ownership Structure (OWN: Pro/Cor)	0.78	0.421	Dummy takes the value 1 if the firm is structured under a corporate form and zero if under sole proprietor
Foreign Investment	0.084	0.28	Dummy takes the value 1 if the firm is owned by a foreigner and zero otherwise
Ownership (OWN:Pr/Pb)	0.25	0.44	Dummy takes the value 1 if the firm is owned by the Public and zero if by a private agent
Size of Employee (Numsta)	786.056	770.98	Continuous
Technological capabilities (TECHCAP)	0.44	0.51	Dummy takes the value 1 if the firm has strong technological capability
Year In Business (Year Old)	24.78	15.49	Continuous
Government			
International donor assistance (DONOR)	1	0	Dummy takes the value 1 if the firm had assistance in EST adoption process
Markets			
Export orientation (EXPORT)	0.67	0.48	Dummy takes the value 1 if the firm exports its product to foreign market
Number of firms in the sector(NumSec)	27.03	23.08	Continuous
Ratio of Energy Cost to Total cost(RatEnerTC)	106.20	143.19	Continuous
Civil society			
Business association influence (ASSOC)	0	0	Dummy takes the value 1 if the firm had Business association influence on EST adoption
Community pressure in complaint (COMPLAIN)	0.39	0.495	Dummy takes the value 1 if the firm had been complained upon on its environmental performance by the civic society
NGO Influence	0	0	Dummy takes the value 1 if the firm had NGO assistance in EST adoption

5.2 Estimation Results

The ordered probit model was used to assess the impact of the independent variables on a plant's choice for adoption of ESTs. The use of this model is justified in that the technology option, the dependent variable, has an order in terms of technological complexity. In addition to this the difference between these alternative order options are not necessarily the same or identical. The reported standard error is robust in order to control for heteroskedasticity. This was following the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity, where the *p* value for homoskedasticity was only 0.5412.

The questionnaire prepared for this paper contained 14 variables spread along 4 dimensions proposed as having influence on adoption decision. Sector dummies were proposed to capture the abatement costs and process technologies but were dropped because with the limited the number of firms under this study, the addition of variables, unless strictly justified, will compromise the degree of freedom of the estimation and in addition, it would require one to control for size of firm which is only approximated and not fully captured by size of employees. This may call for controlling for installed capacity and ratio of it that is in use, and level of produce and others. Furthermore, the difference in cleaner production options generated varies across sectors and thus will have a bearing even after controlling for these and other variables.

From the 14 variables, three variables, namely Business Association Influence (ASSOC), International Donor Assistance (InDoA), and NGO Influence were dropped as there was no variation in them. Not a single firm mentioned influence of Business Association (ASSOC) as having played a role. Apparently, these associations don't play any mentionable role in technology transfer. The same was the case for NGO Influence as none of the firms had obtained any assistance from NGOs in implementing the cleaner production practice. This goes to suggest that NGOs working in the area of environmental protection haven't played a notable role as one would expect in assisting firms with cleaning up their production practices and in the process reducing the externality associated with their untidy practice. With regards the International Donor Assistance (InDoA), the whole project i.e. the Ethiopian Cleaner Production Center (ECPC) with the Ministry of Science and Technology, the major agent responsible for the implementation of the EST in Ethiopia, works with international donors as the UNIDO, COOPERAZIONE ITALIANA, and Austrian Aid as its major partners. This implies that each firm has benefited from international donors as in that the very essence of the establishment of the Ethiopian Cleaner Production Center (ECPC) and subsequently a part of the cost incurred by the firms was covered by these international agents. This variable, which is a dummy variable, is uniform for each firm irrespective of the EST option the firm has adopted.

Table 2 Sectoral Classification of Firms in the Study

Sectoral Distribution		**Number**
Food and Beverage 11	Macaroni and Spaghetti	1
	Sugar Confectionary	1
	Malt Liquor	5
	Mineral Water and Soft Drink	1
	Edible Oil	2
	Preserving and Processing Meat & Vegetables	1
Textile and Garment 6	Textile	3
	Apparel	3
Tannery		10
Paper and Pulp		1
Chemical and Chem. Products		2
Pharmaceuticals		2
Rubber Products		1
Glass and Glass Products		1
Basic Iron		1
Structural Clay		1
Total		**36**

In the full model, there are several insignificant parameters resulting from comparatively weaker influence of these variables and multicollinearity among the variables. The smallness of the number of firms is also a possible reason. In the course of the study, correlation test among variables was made with result that there was correlation with the highest at 0.7. This was evident in that if the firm has an ISO 14001, there is a tendency that some variables would change altogether.

Table 3 Summary Result for the Full Model

Variable	Coefficient	Std.Err(Robust)
Environmental Commitment(EnvCom)	11. 86932***	1.76584
Ownership Structure (OWN: Pro/Cor)	.8531429	1.345385
Foreign Investment	2.856219*	1.638916
Ownership (OWN:Pr/Pb)	-4.682455***	1.276582
Size of Employee (Numsta)	.0050345***	.0015961
Technological capabilities (TECHCAP)	2.661214***	.9889913
Year In Business (Year Old)	-.1659678***	.0546913
Export orientation (EXPORT)	-.6955213	1.144498
Number of firms in the sector(NumSec)	.4218426	.2992459
Ratio of Energy Cost to Total cost(RatEnerTC)	.005107*	.0029973
Community pressure in complaint (COMPLAIN)	14.50426	10.23465
Number of firms in the sector ($NumSec^2$)	-.009921	.0070972
Number of obs = 36		
Wald chi2(11) = 832.58		
Prob > chi2 = 0.0000		
Pseudo R2 = 0.7803		
* , *** significant at 10% and 1% probability level respectively		

In order to remove multicollinearity and assess a statistically significant model, several rounds of top-down and bottom-up estimations were run until the results from these approaches were all the same. This model is identified as the final model (Table 4). It is based on this model that further discussion is made. The variables in the final model are: Environmental Commitment (EnvCom), Foreign Investment (ForeInv), Ownership (OWN: Pr/Pb), Size of Employee (Numsta), Technological capabilities (TECHCAP), and Year In Business (YearOld).

Table 4 Summary Results for the Final Model

Variable	Coefficient	Std.Err(Robust)
Environmental Commitment(EnvCom)	10.18801***	.8891995
Foreign Investment	2.610515***	.8005587
Ownership (OWN:Pr/Pb)	-3.378932***	.967402
Size of Employee (Numsta)	.0034498***	.0008685
Technological capabilities (TECHCAP)	1.472771***	.5381761
Year In Business (Year Old)	-.1248391 ***	.0296024
Number of obs = 36		
Wald chi2(6) = 465.57		
Prob > chi2 = 0.0000		
Pseudo R2 = 0.7114		
*** significant at 1% probability level		

The interpretation of the coefficients from this final model cannot be made directly as the estimation is non-linear. Instead, the parameters are transformed in to predicted probabilities. This allows one to interpret the result in terms of discrete changes in the probabilities as a result of variations in the independent variables (Greene 2003). The likelihood of a firm appearing in a particular EST category is indicated by a predicted probability that is based on the estimated parameters. When the level of a particular variable changes, there is a corresponding change in these probabilities. For some EST categories, the change will be positive and for some negative as the sum must come to zero. This is done by changing one variable at a time while keeping others constant. These magnitudes of change can take the form of 0→1, Δ1, and Δδ. These are based on the nature of the variable. For binomial variables the only possible change is 0→1 while for continuous variables the Δ1 is presented and for TECHCAP, which is a multinomial variable, Δ1 and Δδ is presented with Δδ the standard deviation around the mean. This last one is meant to capture the natural volatility of the variables in the sample and may be used as an equal change measure if other multinomial variables were present. The **Average** Δ indicates what is called the average absolute discrete change i.e. the overall effect of the increase in variables, regardless of the EST level adopted. It is an average of absolute value of the changes across the EST levels. The details are presented in the table below.

An exogeneity test, originally proposed by Smith and Blundell (1986), was performed for all explanatory variables in the final model. The endogeneity hypothesis was rejected for all variables. Furthermore, Kernel density was used to test for normality of the error and the results suggest the error is normal. The graphed result is presented in Appendix III

Table 5 Changes in the Predicted Probabilities of the Three Levels of EST Adoption

Variable	Change	Average Δ	PAT Only	PAT + Lower CT	PAT + Medium CT
Environmental Commitment(EnvCom)	0→1	0.6133	-.001921	-.9179347	.9198557
Foreign Investment	0→1	0.0254	-6.42e-10	-.0379961	.0379961
Ownership (OWN:Pr/Pb)	0→1	0.4693	.0000875	.7038258	-.7039133
Size of Employee (Numsta)	Δ1	0.000127	-3.60e-12	-.0001893	.0001893
Year In Business (Year Old)	Δ1	0.00457	1.30e-10	.00685	-.00685
Technological capabilities (TECHCAP)	Δ1	0.054	-1.54e-09	- .080812	.080812
	Δδ	0.0378	.00000	.05666	.05666

For EnvCom, and ForeInv a status change from 0 to 1 increases the probability of a plant appearing in the higher categories while for OWNPr/Pb has just the opposite effect. For the variable TECHCAP and Numsta a status change of Δ1 increases the probability of a plant appearing in the higher categories while the opposite is true for the number of years the firm has been in operation.

Specifically, a change from 0 to 1 for environmental commitment increases the probability of appearing in the higher category by 92 percent. This is the largest among all variables. This mainly has to do with that the construction of the variable EnvCom, discussed in Appendix II, which tends to be high for firms that have the ISO14001. This would mean the firm has environmental policy and has an environmental management team in operation, thus increasing the chances of the firm generating a higher order EST option coupled with the environment management team and a representative officer with the sole duty of the generation and implementation of the ESTs (further details are presented in the next section). Out of the 36 firms that constitute the totality of firms in Ethiopia engaging in the National Cleaner Production Center ECPC, 12 have gotten the ISO14001. 6 have been recertified (which takes place after the third year of the first issuance of the certificate), while the rest are in the process of performing internal and external environmental auditing, which is an integral part of the certification and recertification process.

For TECHCAP, a change from 0 to 1 increases the probability that the firm appears in the higher categories by 8.08 percent. The detail of the construction of this index (TECHCAP) is presented in Appendix II and again higher TECHCAP basically means the firm has the technical, managerial, and the organizational skills necessary to adopt information and equipment efficiently. Evidently, this makes a significant change in the firms EST standings.

For ForeInv, a change from 0 to 1 increases the probability of a firm appearing in the PAT + Middle cleaner production category by 3.7 percent. All of these changes are consistent with expectations. One interesting difference from our expectation is the effect of form of ownership as being either private or public. It was initially assumed that private firms were cleaner as compared to publicly owned firms. Contrary to this expectation, a change in ownership from public to private increases the probability of a firm appearing in the lowest category by 0.008% percent. A possible explanation to this is that most of the public firms were under pressure to clean up their production practice as they are about to be privatized (ECPC 2007).

Coming to size of employee (NumSta), and Year in Business (Year Old), it can be seen that a unit change in Numsta has a small yet positive effect in probability of a firm appearing in the higher category, 0.01percent. As is initially hypothesized, larger firms have advantage in economies of scale in use if technologies in addition to better access to capital, information, and technological skills. On the other hand, younger firms tend to be cleaner. A unit increase in the number of years the firm has been in business decreases the firm's probability of falling in the higher category by 0.685 percent.

CHAPTER SIX PRINCIPAL AGENT RELATIONS ANALYSES OF DYNAMIC INCONSISTENCY IN THE ADOPTION OF ESTs:

6.1 Introduction

The variables in this study are divided into two separate equations: selection and outcome equations. This was done by hypothesizing the possible relation between the variables and the dependent variables and the pair wise correlations with their significance was tested for before identifying in which model the variable goes to. Export orientation of the firm enters both equations while Size of Employee, HigherOptio, Technological cap, and Ratio of Energy Cost to Total cost enter the selection equation. Owner Managed Firm and Year in Businesses enter outcome equation. The means and standard deviations of each variable are presented in the table below. Other variables and the manner of how they are handled are discussed in latter sections.

Table 6 Descriptive Statistics for Model Variables for the Heckman Probit Selection Model

Outcome Equation			**Selection Equation**		
Dependent Variable			Dependent Variable		
Description	% of firms that continued	% of firms that didn't continue	**Description**	% of firms that saved	% of firms that didn't save
	45.16	54.84		67.74	32.26
Continuation with EST			Savings Made		
Independent Variable			Independent Variable		
Description	Mean	Standard Deviation	**Description**	Mean	Standard Deviation
Owner Managed Firm (OwMana)	0.0967742	0.3005372			
			Higher Option Adopter(HigherAdo)	0.483871	0.5080005
			Technological capabilities (TECHCAP)	0.483871	0.5080005
Year In Business (Year Old)	26.51613	15.88473			
Export orientation (EXPORT)	0.7096774	0.4614144	Export orientation (EXPORT)	0.7096774	0.4614144
			Ratio of Energy Cost to Total cost(RatEnerTC)	104.8732	149.6135
			Size of Employee (Numsta)	837.2903	815.2055

6.2 Benefits Generated

6.2.1 Savings from ESTs

The analyses of savings indicate that 67.74 percent of the firms that have adopted the EST have reported to have benefited in the area of their social, economics, and the environmental bottom lines. Included among these are: reduction in waste through reuse a considerable proportion of it while others have been sold as useful by products, and some have reported reduced insurance claims as a result of the environmental damage preparedness unit they instituted by employees and as a result of reductions in volatile gas emission reduction, reductions in fuel and water consumption. Other benefits include reduction and resale of used oil, plastics, furnace oils, and electricity, reduction in bad smell due to rotting especially in the tanning sector. Furthermore, the effluent of some of the firms was being used for irrigation down stream causing health hazards and the reduction in discharge of chemicals with the water has thus reduced the health hazard for the people downstream. In addition to this, firms that have been awarded the ISO14001 have reported increases in market penetration as a result of their environmentally friendlier production practices (Bonilla et. al. 2010, Luken et. al. 2007). In the environmental front, savings have been reported in the areas of reductions in green house gases, reductions in COD, BOD, and PH loads, reductions in defective products entering the nearby rivers and soil, better waste segregation. The social benefits include reduced complaints, reduced risk for workers from exposure to chemicals, increased aesthetic value, and improved company images.

6.3 Savings and Decisions to Continue Through With the ESTs

As has been discussed earlier, 67.74 % of the firms have gotten benefits over cost following the adoption of the ESTs in the three fronts of social, economic, and the environment. Interestingly enough though, it is only 45.16% of the firms that have this far not failed to maintain the EST they once adopted. This question was framed in such a way to see if the firm had skipped a year in its practice of cleaner production practices or if they had slided backwards in the order of EST initially adopted. Here, it is argued that firms that have made savings but failed to maintain the steam have common characteristics and it will be assessed from a principal-agent relation point of view. It is, furthermore, argued that firms managed by employed managers (agents) as opposed to the owner himself, are open to goal incongruence which opens room for ignoring opportunities that could benefit the firm unless the agent is given the incentive necessary to minimize the gap.

In this analysis, the number of firms is smaller by 5 compared with the analysis for determinants of adoption of ESTs presented above. This is because it is required that the firm has at least a year with the EST and it is less than a year for 5 of the firms since they started the adoption. These firms have just started the adoption and it hasn't been a year yet. These are from the sectors of chemicals, basic metal, rubber, pharmaceuticals, and malt liquor processing sector.

Table 7 Sectoral Classification of Firms in the Study

Sectoral Distribution		Number
Food and Beverage 11	Macaroni and Spaghetti	1
	Sugar Confectionary	1
	Malt Liquor	4
	Mineral Water and Soft Drink	1
	Edible Oil	2
	Preserving and Processing Meat & Vegetables	1
Textile and Garment 6	Textile	3
	Apparel	3
Tannery		10
Paper and Pulp		1
Chemical and Chem. Products		1
Pharmaceuticals		1
Glass and Glass Products		1
Structural Clay		1
TOTAL		**31**

6.4 Regression Results

The use of the heckman probit model over the standard probit model is justified when there is a sample selection problem i.e. when there is dependence of the error terms from the outcome and selection models. The same is also justified her as *rho* was significantly different from zero (Wald chi^2 = 10.94 with P = 0.0009). Moreover, the likelihood function of the Heckman probit model was significant (Wald chi^2 = 328.23 with P < 0.0000), thus showing the strong explanatory power of the model. Following the discussion from the section on analytical method, the reported standard errors are robust.

In the selection model, the variables that are significant are: technological capability (TECHCAP), higher order ESTs option adoption (HigherOptio), export orientation of the firm

(EXPO), and the ratio of energy cost to total cost (RatEnerTC). In the outcome model, the result that is significant is the variable of interest in this study i.e. the management of the firm and EXPO. Other variables that entered the regression for controlling purposes include: the establishment of an environment management team, the reporting requirement on the teams and the presence of the incentive package for the environmental management team, the reporting requirement on the part of the management with regards environmental performance, along with the variables on plant characteristics. However, the high degree of correlation between some of the variables, most notably, variables relating to the establishment of an environmental management teams with its operative systems, presented in the correlation matrix, made the variables insignificant and had to be iteratively dropped. This was until the variable of interest was saved with other variables significant to control for the impact of the variable of interest and thus the data was salvaged for by the correlation matrix presented in the next section.

Both the adoption of a higher order ESTs option (HigherOptio) and Owner Managed Firm enter the study as a dummy variable and when the firm is managed by the owner himself as opposed to an employed manager, the probability of the firm continuing with the EST increases by 34 percent, holding others constant. The Hausman exogeneity test was performed for the explanatory variables in the model below. The exogeneity hypothesis was not rejected for any of the variables. This suggests the initial assumption that the variables under consideration are all exogenous. Furthermore, the errors were tested for normality with the kernel density test and they appear normal. The results are presented in Appendix III.

Table 8 Summary Result for Heckman Probit Selection Model

	OUTCOME MODEL				SELECTION MODEL			
	Regression		Marginal Impact		Regression		Marginal Value	
Explanatory Variable	Coefficient	P value	Coefficient	P value	Coefficient	P value	Coefficient	P value
Owner Managed Firm	3.62***	0.0001	0.34***	0.0001				
Export orientation	0.79**	0.017	-0.026	0.753	-1.30**	0.047	-0.026	0.753
Size of Employee					-0.00021	0.706	-0.000057	0.716
Year In Busin.	-0.0053	0.113	-0.0016	0.137				
HigherOptio.					1.69*	0.052	0.45*	0.072
Technological cap					0.83**	0.018	0.24***	0.003
Ratio of Energy Cost to Total cost(RatEnerTC)					-0.0024**	0.04	-0.00067*	0.093
Total Obs. 31								
Censored 10								
Uncensored 21								
Wald chi^2 zero slope 10.94***								
Wald chi^2 328.23***								
***, **,*= significant at 1% , 5%, and 10% probability level.								

In the following matrix, the correlation between the variables continuity, savings, the degree of adoption, export orientation, the firm being managed by an employed agent as opposed to the owner himself, the manager having the incentive to get payment and make a regular reporting on environmental performance of the firm, the establishment of an environment management team or a cleaner production team, and the requirement on the part of the environmental management team to make a regular reporting on environmental performance is presented and it portrays the degree to which, among others, the continuity of EST adoption is highly correlated with the presence of the incentive mechanism, and the lack thereof. The figures in the parentheses are the p values.

Table 9. Correlation Matrix with the Respective Degrees of Significance.

	Contin.	Saving	Manem	manrep+pay	EMTCPT	EMTCPTrep	ManaRe.
Contin.	1						
Saving	.35 (0.0544)	1					
Manem	-.36 (0.0462)	.24 (0.1917)	1				
manrep+pay	.82 (0.0000)	.52 (0.0068)	.25 (0.2218)	1			
EMTCPT	.57 (0.0010)	.77 (0.0000)	.15 (0.4478)	.67 (0.000)	1		
EMTCPTrep.	.88 (0.0000)	.55 (0.0014)	.04 (0.8470)	.94 (0.000)	.73 (0.000)	1	
ManaRe.	.82 (0.0000)	.52 (0.0033)	.25 (0.1882)	1 (0.000)	.68 (0.000)	.94 (0.000)	1

Where Contin. Stands for continuation, saving stands for whether the firm had made savings following the adoption of the ESTs or not, Manem stands for the manager being an employee, manrep+pay stands for joint presence of a reporting requirements on environmental performance of the firm by the manager and the presence of the incentives in terms of extra payments, EMTCPT stands for the presence of an environmental management team, or alternatively a cleaner production team, EMTCPTrep represents the requirement on this team on environmental performance.

As is vividly shown, the correlation between a manager that is expected to make a report on environmental performance and has an additional incentive of payment associated with good environmental performance and continuation or not skipping a year is 0.82. Furthermore, with these incentives present, there is a high correlation with higher order technology option adoption at 0.77, in contrast to when it doesn't have the system. In addition, if the manager has these incentives, the correlation with establishing an environmental management system or the cleaner production team is 0.67. And this is important because continuity and the establishment of this system are highly correlated at 0.57.

Furthermore, there is a high correlation (0.76) between a firm with this system and savings suggesting that the team is essentially there to maximize from the potentials the practice promises. The establishment of this system is not, however, a full guarantee that the adoption will continue.

In order to guarantee this, while the duty of looking after the firms' environmental performance is contracted down to employees it should be done with the recognition that a goal incongruence is being created and thus the logic of the principal agent relation comes in to play once more, this time the manager being the principal as he is contracting the job further down to employees, now the agents. In order for the continuation to be guaranteed, the incentives should as well be present by way of the employees being paid extra for the time they spend with this new task or a new office being opened up just for this. In addition, it should be required of the new officer or the employees who are handling the duty on the extra time basis be expected to make a regular report on the environmental performance. When this is in place, one can see that the correlation between the system being there and continuity grows from 0.673 to 0.88, and when the manager has the incentive, the correlation with establishing a system with its own incentives is quite high at 0.94, making it almost automatic that a full incentive for the manger makes possible the creation of a system with the necessary incentive to see to it that the continuation is assured. This is in comparison to when the manager doesn't have the incentive, in which case the correlation between an employee managed firm and the establishment of a system with its incentives is so low at 0.04.This goes to confirm that the presence of the incentives comes in to play in the continuity, or lack thereof. This is further pronounced when one looks at the correlation between a firm managed by an employee is highly correlated with non continuity at -0.36. This shows that an employee managed firm tends to be more reluctant to search for, adopt, and continue with environmentally sound technologies as possibly with other resource use reducing opportunities. The role of incentives is signified by the fact that when the manager has the incentive, then the correlation with continuity changes into positive with correlation coefficient at 0.24 rising from -0.36. Combined with the potential goal conflict between the manager and the owner, the pre-contractual problem very easily leads to ESTs implementation reluctance and the post-contractual problem leads to moral hazard (Arrow 1985). The need for crafting and implementing an effort inspiring contract then becomes a natural conclusion.

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7. 1 Conclusions

The apparent insignificance of the variables Ownership Structure (OWN: Pro/Cor), Export orientation (EXPORT), Number of firms in the sector (NumSec) and ($NumSec^2$), Community pressure in complaint (COMPLAIN), Ratio of Energy Cost to Total cost(RatEnerTC) implies that market factors and Civil Society Influence are not as important as was initially hypothesized in influencing EST adoption.

A possible reason why OWN Pro/Cor isn't significant may be traced to the fact that the partial cost involved was covered by the international donors and that in the process absorbed the risk associated with this investment. This variable's influence may as well have been absorbed by others. This is especially important in that for the more risky firms, i.e. the proprietors, 37.5% of them are foreign owned and 50% of them have the higher adoption in practice. The amount of finances involved is also important for a firm to react in a risk averting manner (Gabel et.al.2001). Future research can identify alternative variables to capture other aspects of the firm associated with risk and assess its role.

NUMSEC's apparent insignificance may be traced to the firms' focus on other dimensions of their products and production process for signaling purposes. The less costly and more regulated dimensions are apparently not exhausted enough for firms to green their production practice to earn themselves a competitive edge. Another requirement aside from the firm's perception of competition is the consumers'. As noted in the literature review, this is the case because green consumerism does little to alter production process since the consumer is not generally well informed about the precise nature of such processes, and in any case less able to affect the choice of processes in any direct way (Kerry 2000). The economic impetus for the firms comes when cost signals to industry alter its production practice (Eggersson 1997).

Export's insignificance may as well rely on the challenge in monitoring firm specific performance of all firms in the international market. Despite international certification practices, the detailed step by step practice of the firm is hard to account for. This issue was pioneered by Akerlof 1970 and in an application to Malaysia; Yanti (2009) makes the same note. Alternative explanations are given by Lietke et.al (2000) and Donald (2006). This is especially interesting given that 66% of the firms under investigation did export their products to the international market. A sector specific investigation could fill this gap. This is because the requirements for a firm engaged in food and beverage cannot be the same as those in the tanning sector. 37.5% of the firms are from the food and beverage sector and the main requirement on them entering the international market is what is called the Hazard Analyses and Critical Control Point (HACCP) Massoud et.al 2010. Furthermore, export's influence is related more to product specification than production process (Luken et.al. 2007). Future research can identify if there is a critical level of adoption below which adoption isn't important but become important afterwards.

Community pressure in complaints at the firm (COMPLAIN) may have had influence if property right is well defined and enforced. Meaning that despite the firm's practice encroaching on the utility function of the third party, the ill-definition of property rights may fail to influence the firms' practice and render the complaints of the civil society lacking in legal basis. This begs the question of the setting of property rights and its enforcement alongside the enactment and enforcement of environmental laws. This has been cited as a limiting factor to cleaner production practices in the literature (Siaminwe 2005, Yhdego 1995, Hale 1996). In all these, it should also be known that the definition of variables is also important in determining what composes the variables and thus its significance. This could lead to differences in significances of variables across different studies. Montalvo (2003), for example, finds an impact, though limited, of community pressure on the willingness of a firm to undertake technology change in assessing the determinants of the willingness of the firm to adopt/develop cleaner technologies in Mexico.

Following the difference in the form of the structuring of these variables, it is difficult to assess which of the variables has the largest overall impact. However, the relative impact of variables can be assessed for same categories. For the binomial variables, EnvCom has the largest impact with the lowest being foreign investments influence, and in the continuous category; Year Old has the largest impact with Numsta as the apparent lower impact variable. In terms of the different categories of the determinants, the in plant characteristics are the ones that come out as the most significant.

In the principal agent assessment of dynamic inconsistency in adoption decision by firm managers', the variable in "Year in Business" wasn't significant unlike in the determinants of adoption section. This is possibly because continuation is more of an issue of creating the system that guarantees continuity (Killman 1995), which includes, but not limited to, the establishment of the environment management system which should be coupled with the incentive package to ensure its continuity (Hillary et.al. 1999, Lesley 2006). Furthermore, size of employee is not significant in the savings generated following the adoption of the EST. An important conclusion that emerges from this study is that the variables that were significant in the adoption stage aren't necessarily important in the continuity decision (Nishitani 2009). This is with the exception of technological capability variable. An interesting example here is, how being a public firm was better from the point of view of adoption over being a private firm, but when it comes to continuity, the opposite is true. There is a negative correlation between the firm being public and its continuity at -0.11644. This is consistent with how the manager of these firms are not the owners themselves, further highlighting the issue of goal incongruence and it implication in dynamically inconsistent decision to keep up with what has been adopted (Lietke et.al. 2000). Another conclusion of relevance is the need for the consideration of internal management issues in addition to solely environmental considerations in environmental policies if these policies are to be effective (Boks *2006,* Hillary et.al. 1999).

Notably, the size of the firm measured in terms of the number of employees, the number of years it has been in operation, the environmental commitment of the firm and other components of plant specific characteristics that were significant in the adoption decision are not important determinants in continuity decisions. This was with the exception of technological capability. That is basically because it is required to operationalize the EST. Another interesting significant variable is the export orientation of the firm (Luken et. al. 2007). This variable was not significant in the adoption determination phase but it is significant here. This confirms the need for future study to assess if there is a critical adoption rate beyond which adoption isn't important but that level of ESTs adoption or more generally greener production practice is important for market entrance, legal compliance or other consideration.

It should be noted, however, that in the incentive package, it is only financial incentives in terms of payment and requirement to make reports on the environmental performance of the firm that are considered and entered the analyses. Other forms of incentives include more social aspects or psychological incentives which aren't necessarily financial in nature but do play significant roles in influencing behavior (Boks *2006*).

7. 2 Recommendations

As presented in the conclusion, firm specific factors are the dominant determinants of adoption and any policy endeavor aiming to improve the speed of uptake of these technologies should consider the heterogeneity of these firms (Siaminwe et.al. 2005). To devise a policy that doesn't account for this will be, at best, ineffective, if not counterproductive **(**Luken et.al. 2007).

The apparent high impact of environmental commitment of the firm suggests that policy measures aimed at building environmental commitment can be very effective (Zwetsloot et. al. 1996). Creating opportunities for firms to engage in pollution prevention programs and assisting with the carving and implementation of environmental management systems with the corresponding environmental policies will ensure faster adoption **(**Luken et.al. 2007). Furthermore, there is a need for raising awareness among firms on the possibility of a joint achievement of profits and environmental protection. Raising awareness among private firms is also important in that they will not be reluctant to adopt ESTs especially given it generates savings while enhancing environmental regulation compliance (Johnston 1994, Siaminwe et.al. 2005).

The same can be said for technological capability. Enhancing firms' technology linkage with other enterprises, like technology support institutions, and in the process, reducing its search for technology, while increasing the awareness and the spreading of availability of quality management system facilitating establishments will serve to increase rate of adoption. This is especially with firms that have been in the business for long time (Koefoed et.al. *1995)*.

Openness to foreign investors can also be considered a good move on account of the protection of the environment beside the job creation opportunities, and potential foreign exchange generation among others (Luken et.al. 2007). Furthermore, the importance of public disclosure or information provision as a policy instrument needs to be underlined to influence the behavior of firms' and consumers' likewise. One way to approach this is labeling or certification following the practice of firms in line with a specified guideline. The benefits of these have been shown to be manifold. This applies to both studies of determinants of adoption and the decision of continuation with a once adopted EST.

Facilitation on the part of the government in assisting firms' entry into international market will ensure continuity as the growing environmental concern and green consumerism in the international stage serves as a controlling mechanism for greening the firms' production practice (Hale 1996, Bonilla et. al. 2010, Thorpe 1994). Despite the challenges, international certification does influence purchase decision and thus double benefit in better environmental management and improved export earnings can be earned at once.

The recommendations on enhancing higher order adoption will serve to complement in assuring continuity following its association with savings, financial incentives the firms show great interest in (Kilmann 1995). This confirms the need for environmental policies taking in to consideration the need to recognize the heterogeneity of firms in their characteristics and its bearing on adoption and continuation (Kemp et.al.2008).

The importance of incentives has been established and it should be incorporated in environmental policies. These policies should consider internal management issues in addition to environmental implication of the product and production process (Zwetsloot et. al. 1996, Hale. 1996). Whatever intervention approach is adopted, one most important consideration here is that the focus should be redirected from the firm *per se* to the management.

The inconsistency in adoption decision is helped by the fact that the adoption and continuation is a self regulated engagement, highlighting among other things, despite its benefits, an endeavor may not necessarily be followed through, thus justifying the need for environment policy involvement on the part of the regulator (Gabel 2001, Hilson 2000). An alternative here is a co-regulation. This could specifically mean either negotiated agreements which requires the implementation of CP measures and making a report on its performance with firms agreeing to certain standards that must be met by industry in return for specified post-compliance incentives or an environmental management systems such as ISO 14001 and other relevant standards which may be linked to permit requirements or public voluntary programmes, where firms agree to achieve CP goals and to publicly report on their environmental performance, in return for improved public recognition, and possible access to governmental technical assistance. The unfortunate reality is that these incentives are missing or at best their attempted implementation has been fragmented.

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8. APPENDICES

Appendix I Questionnaire

1. How long has the firm been in business? ___________________years.
2. What is the form of ownership?

   1. Sole Proprietor ☐ 2. Partnership ☐ 3. Public ☐ 4. Corporate ☐
3. Is there a foreign involvement in the firm ownership? 1. No ☐ 2. yes ☐

   - If yes, what is the share of foreign involvement in ownership from total?_____________%

4. What is the number of workers currently ______________________________?
5. Does the firm have an environmental policy? 1. No ☐ 2. yes ☐
   - If yes, how long since its ratification? ____________________Years.
6. Does the firm have an environmental management system? 1. No ☐ 2. yes ☐
   - If yes, how long has it been in operation? __________________years.
7. Did the firm participate in any waste minimization or pollution prevention programs?

   1. No ☐ 2. yes ☐
   2. If yes how many? ___________________

. 8. What is the relative extent of the firm's search for technology in terms of time?

   1. -3 months 2. 3-6 months 3. 6-9 months 4. 9-12 months

9. Does there exist an engineering department or unit?

   1. None ☐ 2. basic ☐ 3. well established ☐

   2. What is the total number of staff in this department or unit_____________?

10. Does there exist a quality management system?

   1. None ☐ 2. Yes ☐

   2. If yes, please complete the following table.

The year the certificate was awarded	Which certificate was awarded

11. How would the level of the process technology be rated?

1. Traditional ☐ 2. Standard-modern ☐ 3. best available technology ☐

12. What is the level of technological activity measured in terms of the percentage of technology change over the year 2001?_______________.

13. What is the relative level of product quality?

    1. Not Export quality 2. Export quality

14. What is the extent of its technology linkage with other enterprises, that is, suppliers, buyers, competitors, technology support institutions, that is technology centers and universities measured in terms of number of institutions the firm works with regards to section and operation of technology at hand?

    1. 1-2 ☐ 2. 3-4 ☐ 3. 5-6 ☐

15. How long has the present production process been operational Without major changes?___________________years.

16. Share of profit from sales in % a year before adoption_______ & in year 2001 _____?

17. Does the firm export its product to a foreign market? 1. No ☐ 2. yes ☐

    - If yes, what is the share of the firm's produce that reach international market_______%
    - Have buyers had any pressure on the plants ESTs adoption 1.No ☐ 2. Yes ☐

18. What is the share of source of the technology in use that is foreign, as an average of the total machinery? _________________%.

19. Did forms of cooperation exist between the manager and the regulator, for example, consultation on regulations, negotiated standards and emissions, and was opportunity given for voluntary compliance by companies? 1. No ☐ 2. yes ☐

20. Did the regulator instead of just penalizing, offer an advice on the environmentally sound technology adoption?

    1. No ☐ 2. yes ☐

21. Did the plant management make information on pollutant release freely available to the public? 1. No ☐ 2. yes ☐

22. Has the firm gotten any inspection by a government environmental office?

    1. No ☐ 2. Yes ☐

23. Has the firm had regulatory sanctions? 1. No ☐ 2. Yes ☐

    - If your answer to the above question is yes, please complete the following table.

Year of inspection	Years when sanctions were imposed

24. What is the type of a cleaner production technique that your firm has adopted to reduce the impact of pollution that may be produced.

1. [(a) input material change and (b) better process control
2. [(c) equipment modification; (d) on-site reuse and (e) useful by-products
3. [(f) major technology change and (g) product modification

25. Did the firm had any external technical assistance in identifying, assessing, selecting, negotiating, transferring and/or implementing the reported environmentally sound technology adoption? 1. No ☐ 2.yes ☐

26. Has the adoption strengthened the plant's competitiveness?

1. No ☐ 2. yes ☐

27. Has the firm participated in environmental trainings by government initiatives together with international donor agent through a Cleaner Production Center?

1. No ☐ 2. Yes ☐

- If your answer to the above question was yes, Pleas complete the following table on the years your firm attended these trainings and the number of workers who participated in these trainings and the total number of workers at those times.

Year	Type of training (basic, advanced, in-plant)	Number of participants from your firm.	The number of workers at these times.

Is the firm in any business association? 1. No ☐ 2. yes ☐

- If yes, for how many years? ________________________ years.

- Has the business association had any influence on your decision to adopt the environmentally sound technology? 1.No ☐ 2.yes ☐

28. What is the number of complaints filed by local community on the firm this far? ____________________?

29. Does the firm work with environmental NGO's? 1. No ☐ 2. yes ☐

- If yes, how many __________________NGO's.

30. Was there a year skipped in CP implementation since the first year it was practiced or was there a year the CP option that was adopted changed in to a lower form or done away with at once?

    1. No ☐ 2. Yes ☐

31. Is the owner also the manager?

    1. No ☐ 2. Yes ☐

33. Is there a paid Environmental Management Representative or Cleaner Production Team?

    1. No ☐ 2. Yes ☐

34. Is management compensation is a function of long term activities?

    1. No ☐ 2. Yes ☐

35. Is the compensation system for people under him constant or a function of performance?

    1. No ☐ 2. Yes ☐

36. Is the EMRs or the personnel responsible for the implementation of the ESTs wage is sensitive to environmental auditing.

    1. No ☐ 2. Yes ☐

37. Is there corporate sanction of the management for non performance on the part of the EMR or personnel responsible for the implementation of the ESTs?

    1. No ☐ 2. Yes ☐

38. Is there a regular reporting on the performance by the environmental management?

    1. No ☐ 2. Yes ☐

    - If yes, what is the number of times the EM performance is reported in a year?

39. How many times a year does the firm get an external agent to make environmental auditing? ____.

    - If yes, what is the number of times the EM performance is reported in a year?

Appendix II Construction of Variables

A. Civil society influence:

1. Business Association Influence **(**BuAsI**)**: this looks in to whether the firms principal business association had influenced its decision to adopt EST (No = 0, yes = 1).

2. Community Pressure (ComP)**:** (No = 0, Yes = 1).

3. NGO has there been an NGO assistance in EST implementation?(No =0, Yes = 1)

B. **Government role**

1. International Donor Assistance (InDoA**):** this indicates whether a plant had participated in a donor funded, government- approved demonstration project through a Cleaner Production center (No = 0, yes = 1).

C. Market factor:

1. Export orientation (ExpO**)**: this is a proxy measure of the influence of buyers pressure on a plants ESTs adoption (No = 0, Yes = 1).
2. The number of firms in the sector NUMSEC
3. The ratio of energy cost to total cost RatEnerTc

D. **Plant character**

1. Environmental Commitment (EnvCom): This index is constructed by a composition of the following elements: (0 if at least one is 0 and 1 if all are yes).

- Does the firm have an environmental management policy? (no = 0, yes = 1),
- Does the firm have an environmental management system? (no = 0, yes = 1),
- Did the firm participate in any waste minimization pollution prevention program? (No = 0, yes =1).

2. Ownership (OwProCor): The form of ownership, ranging from proprietorship and partners to closed corporate and open corporate*, (proprietor and partners = 0, corporate and open corporate = 1).

3. Ownership (OwPriPub): The form of ownership, ranging from private to public, (public = 0, private = 1).

4. Size: this is measured in terms of the number of employees.

5. Technological Capability (TechCap): This index is constructed by the following elements:

- The relative extent of its search for technology (1. -3 months 2. 3-6 months 3. 6-9 months 4. 9-12 months),
- The existence of an engineering department (none = 0, basic = 1/ well established = 2),
- The existence of a quality management system(none = 0, yes = 1, ISO compatible =2),
- The relative level of process technology(traditional = 0, standard-modern = 1, best available technology = 2),
- The level of technological activity over the period(non = 0, some = 1, a lot = 2), and
- The relative level of product quality (1. Not Export quality 2. Export quality).

The extent of its technology linkage with other enterprises, that is, suppliers, buyers, competitors, technology support institutions, that is technology centers and universities.

APPENDIX III

KERNEL DENSITY ESTIMATES

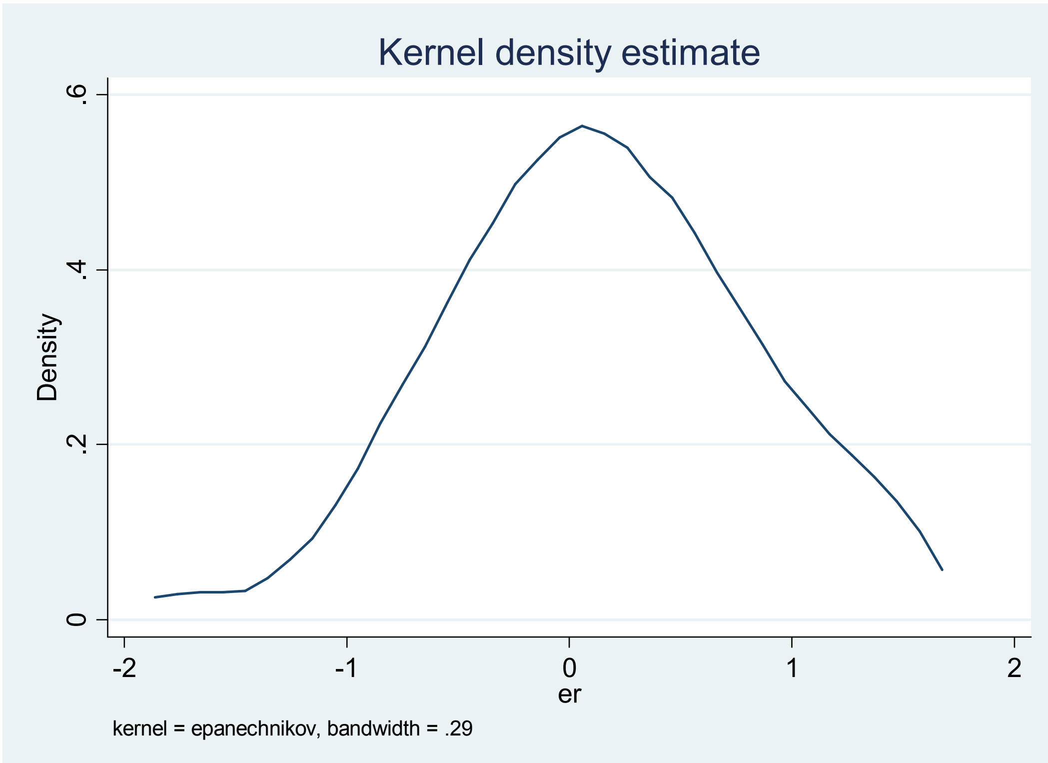

FIG 1. The kernel density test of error normality for the results of the ordered probit model.

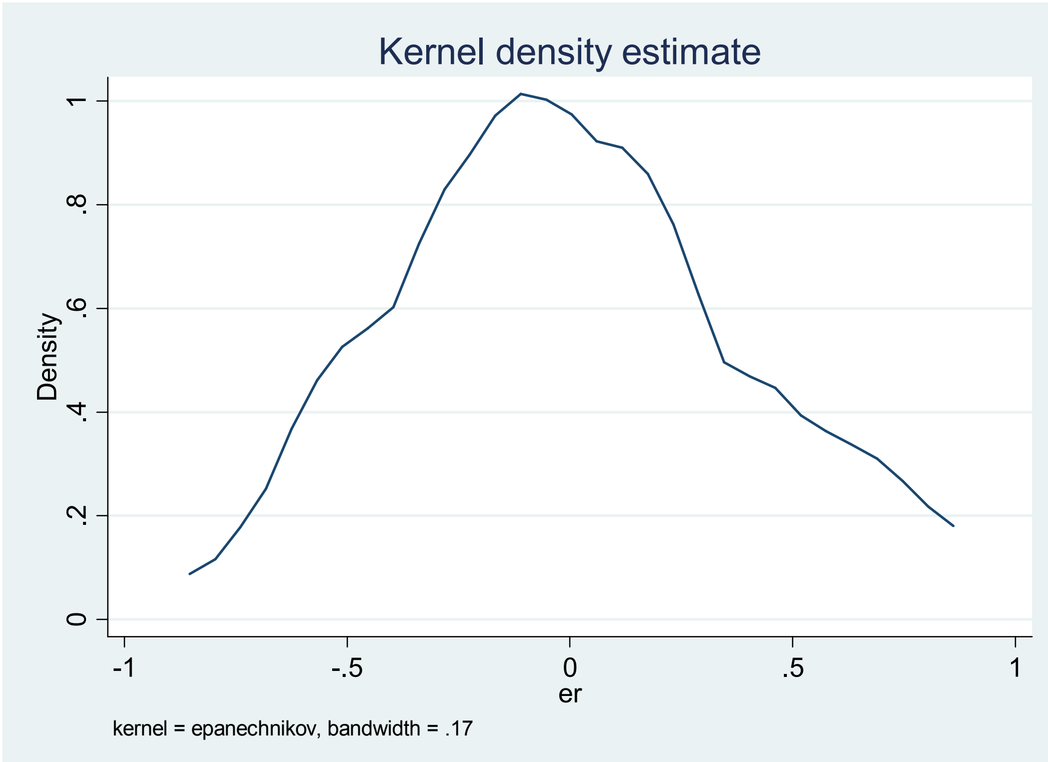

FIG 2. The kernel density test of error normality for the selection equation.

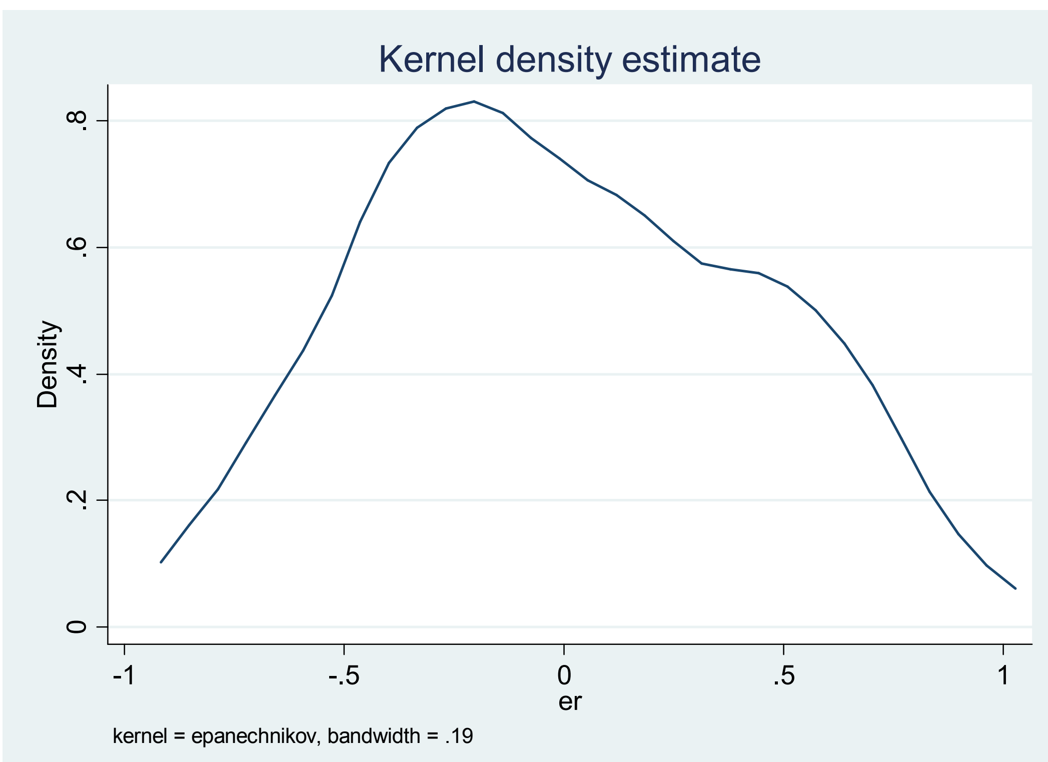

FIG 3. The kernel density test of error normality for the outcome equation.