Green Growth: An Environmental Technology Approach

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Abstract

This research is focused on achieving green growth through an environmental technology approach. Developing environmental technology we examined four elements considering the enforcement of intellectual property rights (IPRs), research and development (R&D) expenditures, the size of the market capture by GDP and most importantly the environmental taxations. This study includes the 11 developed countries which are Austria, Australia, Canada, France, Japan, Finland, Germany, Sweden, U.K and U.S. Technology change can be better handled by panel data than by pure cross-section or pure time series. It can minimize the bias if we used the aggregate individuals or firms. Estimation techniques depend on short panel or long panel. This study used the Pooled Least Square estimation techniques like Fixed Effect Model (FEM) and random effect model (REM) for both balance period of 2000-2005 and unbalanced period from 1995-2005. The study concluded the policy formulation in making developed's climate resilient economies.

Key words: Intellectual Property Rights, Foreign Direct Investment, Technology Licensing

JEL Classification: O34, F19, L24

1 Introduction

Green growth policies provide strategies to overcome the economic policies, which have devastating impact on the sustainability of the country growth pattern. The growth that sustains development and increases the opportunities of jobs and income with low environmental degradations. Sustainable economic growth is achieved through the green environmental technologies to maintain and restore environmental quality and ecological integrity, while meeting the needs of all people with the lowest possible environmental impacts. It is a strategy that seeks to maximize economic output (GDP) while minimizing the ecological burden[1]. United Nations Economic Social Commission for Asia and Pacific (UNESCAP) in his theme paper on green growth based green growth on five tracks namely, a) green tax and budget reform b) development of sustainable infrastructure c) promotion of sustainable consumption and production d) greening the market and green business e) economic-efficiency indicators. One of the basic purpose of the green growth is to facilitate green accounting, economist are of the view that there is need for GDP measuring to include green accounting as the existing national income accounts excludes environment. The growth, which considered the inter-temporal welfare considered the social discount rate, aggregate supply and demand analysis in the context of environmental degradation and considering the structure change of the economy is defined as green growth.

In recognition of the global challenges the rapidly rising green house gases emission is one of the important challenges the ecology/ecosystem has to face. The International Energy Agency (IEA) technology perspective assess the strategies to reduce the carbon dioxide (CO^2) emissions to 14 Gt for 2050 keeping the 2005 as a baseline emission 62 Gt. The cost effective combination of technologies to reduce the CO^2 emissions from the baseline of 62Gt to 14Gt are: Carbon dioxide Capture and Storage (CCS) industry and

[1] United Nation and Economic Commissions of Asia Pacific (UNESCAP)

transformation (9%), CCS power generation (10%), nuclear (6%), renewables (21%), power generation efficiency and fuel switching (7%), end use fuel switching (11%), end use electricity efficiency (12%), and end use fuel efficiency (24%).

The reduction in GHGs requires technological change; technologies at general and cleaner technologies specifically are useful for development of most the low carbon economies. Technology includes all tools, machines, instruments, housing, clothing, communication and skills etc, which we used to produce new things and are very meaningful in growth and development. Green technology is defined as: “The development and application of products equipment’s and system used to conserve natural resources and environment which minimize and reduces the negative impacts of human activities”[2]. There are four pillars of green technology policy namely energy, environment, economy and social. In energy technology promote the efficient uses of resources. Technologies conserve and protect the environment and minimize the adverse impacts in environment, improve the economic development through the technology and innovation. Moreover, the International Technology Center (ITC) defined the green technology as: “Goods and services to measure, prevent and limit pollution, to improve environmental conditions of the air, water, soil, waste and noise related problems which are affordable, adaptable and available at the market of distributed use and export” This study is considering technological opportunities as the development of green technology, transfer of green technology and diffusion of green technologies.

1.2 Accelerating the Climate Change Technology:

Eco-innovation strategies are needed to accelerate climate technologies vis a vis to overcome the market barriers that exist all along the technology development chain for mitigation and adaptation technology. The markets for climate technology are imperfect and extensive with barriers to full and fast market diffusion. Therefore more innovative, internationally coordinated and integrated innovation strategies are needed to scale

[2] http://www.gpnm.org/e/articles/Definition-of-Green-Technology-by-KETTHA-Ministry-of-Energy-Green-Technology-and-Water-a5.html 6 Oct 2010.

climate technology at the speed needed to counter climate change impacts. Public private strategies are needed to complement pricing mechanism and enabling polices.

Limiting the concentration of green house gases in the atmosphere is largely a problem of technological innovation. Climate innovation polices will be necessary to accelerate rates and performance improvements and cost reduction of technologies[3].

1.3 Access to Climate Technologies:

Climate change presents significant challenges for developing countries. Therefore developing countries urgently need the climate change technologies. Developing countries need to employ climate change technologies in order to prevent climate disaster. Climate change technology development will benefit developing countries directly by providing useful technologies due to the support for endogenous climate change, research and development, management of developing countries intellectual assets, climate change technology, commercialization, awareness programs and periodic assessment. International climate change discussion leading to Copenhagen and beyond present and provide opportunities to link climate change technology transfer with development of national innovation systems in order to achieve concrete results for developing countries. Intellectual property rights will have to become a tool of developing countries in their struggle to gain access to climate change technology.

To assess these technologies faces some barriers like economic, human capacity related barriers and institutional barriers. Smaller developing countries are confronted with many such barriers to development and transfer of technology. A range of economic and trade related instruments provide opportunities for multilateral action to promote climate-relevant innovation and technological transformation provide, an "enabling environment". Governments of the developed and developing countries start a number of programs focusing on green innovation and emphasize the renewable energy resources in 2008-2009. Development and transfer of technology has emerged as a basic building block in the crafting of a post 2012 global regime on climate change. New government involvements in R&D programs may prove to be beneficial in this regard and climate

[3] WIPO conference on Innovation and Climate Change

negotiators representing governments should be better able to influence the direction of industry. The private sector may be encouraged to extend the benefits of new technology by entering into mutually beneficial arrangements with foreign joint venture partners.

1.4 Environmental Innovations:

Eco-innovation strategies are needs to accelerate climate technologies vis a vis to overcome the market barriers that exist all along the technology development chain for mitigation and adaptation technology. Therefore more innovative, internationally coordinated and integrated innovation strategies are needed to scale climate technology at the speed needed to counter climate change impacts. Climate innovation polices will be necessary to accelerate rates and performance improvements and cost reduction of technologies. The green environmental technologies focus on innovations. In the global debate the environmental innovations are taking place as of inventions and innovations in general. Innovation in environmental technologies can reduce the cost of materials, cost of productions and increase the rates of production and attractiveness of products in marketplace.

To support the development of environmental technology the four areas like intellectual property rights, research and development, market size (GDP) and environmental taxation are very important.

1.4.1 Environmental Innovation and Intellectual Property Rights (IPRs):

Recent years have witnessed a growing trend towards the appropriation of climate change technologies by intellectual property rights (IPRs). If this trend is to continue, IPRs are likely to play a key role in determining access to these technologies. If highly priced, access to protected interaction between Intellectual Property and the transfer of climate related technology could provide the basis for more efficient and evidence-based discussion. More opportunities for employment enlarge in the long run due to the green innovation (Feldstein, 2003). In developing countries the strengthening of Intellectual Property Rights regime speed up the global competition for capital and green technology (Maskus, 2005).

International Center for Trade and Sustainable Development [(ICTSD) 2008] presented that the IPRs promote innovation and knowledge. Relationship of IPRs and transfer of climate related technology would be helpful to increase the awareness and understanding. IPRs have deep implications for the future of global warming, reduction of emission and energy saving technology. A clean technology industry depends on stronger protection of IPRs eventually the stronger IPRs regime speed up the process of innovation and development. Relationship between the IPRs and entrance in environmentally sound technologies leave the impact on technological progress, development, and economic growth (Maskaus, 2010).

The above discussion concludes that through proper enforcement of intellectual property rights can achieve the development in environmental technology. Intellectual property plays a crucial role in trade and technology transfer. The enforcement of IPRs encourages economic growth and provides incentives for technology innovation. Similarly, the enforcement of IPRs encourages transfer of climate related technologies. The World Bank's Global Economic Prospects Report in (2002) confirms, "Across the range of income level, IPRs are associated with greater trade and FDIs flows, which in turn translate into foster rate of economic growth and development". Eventually, this flow of FDIs leads to the development of environmental technologies. The required and acceptable IPRs regimes bring efficiency, new innovations and the progress in research and development, which contribute into the development of environment technologies in the economy.

1.4.2 Environmental Innovation and Research & Development (R&D):

Research and development (R&D) expenditures is an essential part of climate policy, might lead to substantial efficiency gains and help containing climate policy costs. R&D induced by a climate policy might a need for additional R&D expenditure policy in ordered to foster technology diffusion and to overcome the various innovation market failures such as the underinvestment in R&D in the private sector. Active research and development created the new production of knowledge and technological change. New research and development produced the high quality of goods. Research and development increased because the higher degrees of technology transfer (Walz, 1995). Research and development increases the innovation in environmental technology (William et al, 1995). Developing countries successfully reduced the GHGs emissions through the research and development expenditures and achieved the energy efficient technologies (David and Roger Bate, 2004). In contrary Langinier (2009) extended the arguments that the innovations factor leads to the research and development.

The above discussion briefly concludes that research and development (R&D) introduces the environmentally friendly technology to reduce the environmental damages. New production of knowledge and technological change can be increase through the active research and development. New innovations and inventions can achieve due to the research and development.

1.4.3 The Environmental Innovations and Market Size (GDP):

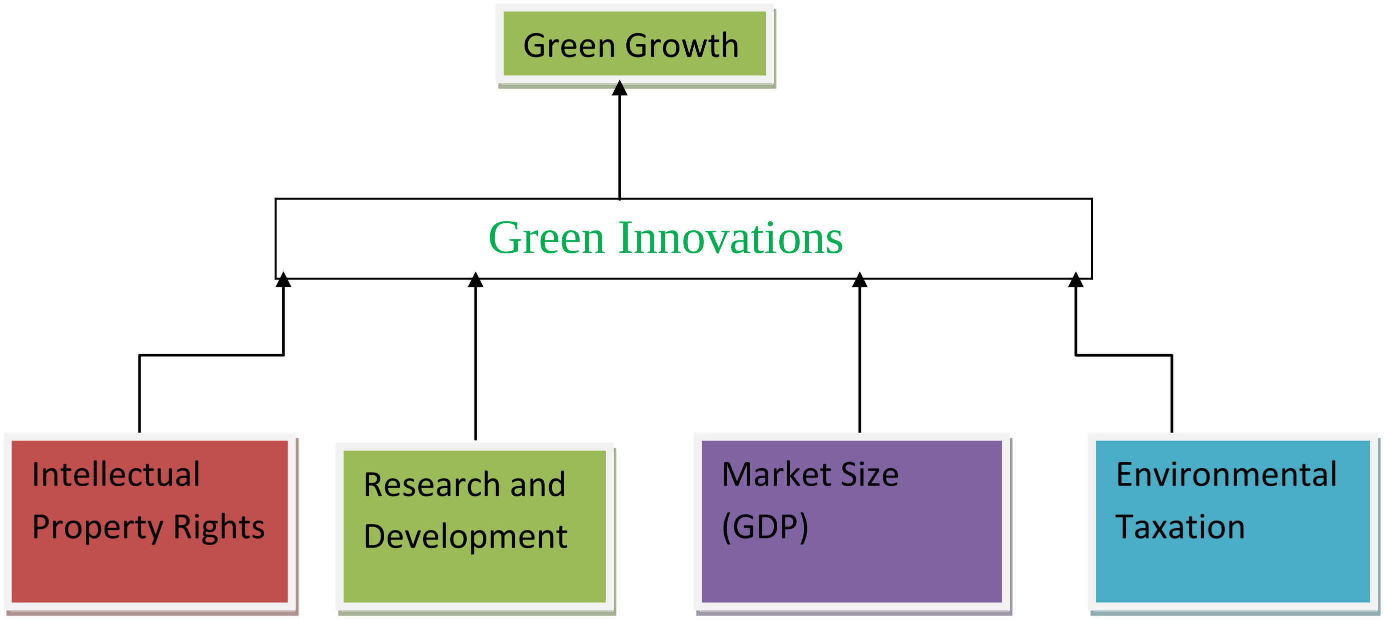
The positive dynamics in expansion in market size (GDP) is believed to expand the innovative activities in the economies. One possible reason for this expansion is industrial growth, which leads to invention and innovations mostly by achieving economies of scale. But still direct role of market size in innovations are not clear from the theory, whether it help in increase in R&D, reduction in taxes, provision of other incentives etc. Contrary, to the conventional economic growth phenomenon, we are replicating it into green growth phenomenon. The demand for the green products in the green markets size may contribute in green R&D, imposition of green taxes, structure change at the level of industries. This eventually may leads to green innovations. We are assuming that the environmental technologies are developed by the market size (GDP). New technologies support high volumes of goods and it brings more companions in the economy and thus innovations are growing fast. Large markets adopt more technological changes and market size is also affected with new technologies. When the market size increases then the environmental technologies enhance because when the GDP of one economy rise then they are able to invest more in green technologies.

1.4.4 Environmental Innovations and Environmental Taxes:

Taxes may have led the positive impact on environmental innovation and economy. Environmental tax credits encourage innovative behavior and the cleaner production techniques are more helpful in this sense (Organization for Economic Corporation and Development, 2008). Korea is badly affected by the urban air pollution. Government introduces the emissions trading schemes and reduced the emissions by larger and smaller emitters through the environmental taxation (OECD, 2009e). Switzerland's federal government imposes the tax on volatile organic compound (VOCs). Adaptation of technology and innovation is much more in larger firms and less in smaller firms due to the financial and information constraints (OECD, 2009e).

Sweden imposes the taxes on the emissions of nitrous oxide. New technology of nitrous oxide emissions abatement required the new innovations and innovation contribute ongoing emissions reductions and continuing declines in abatement cost (OECD, 2010). Air pollution from motor vehicles produced the emissions and for sake of the emissions reduction government imposed the taxes. Government gives their attention to enhance the innovative and environment friendly technologies. In nutshell, taxes have the positive effect on the environmental innovation (OECD, 2010).

The environmental taxation has a positive impact on green innovations because the government imposes the taxes on the polluters to reduce the level of emissions and provide the clean environment to the people. Specific environmental taxes e.g. CO_2 taxes will support the innovation in environmental/green technologies and also reduces the activities of high pollution. When the pollutants paid the taxes then increase the creation of new innovation, because the adaptation of incentives in order to minimize the tax payments. In this result potential innovation, production innovation, process innovation and organizational innovation are also goes up. Transfer of innovations among countries is due to the taxes in addition to the creation of innovations. Taxation brings about a full range of innovations, including new products and enhanced production techniques. The above theoretical framework is depicted as:



The graph clearly depicts the four important areas like IPRs, R&D expenditures, market size measured by country GDP and environmental taxations which ultimately has impact on green innovations and these green innovations eventually leads to green growth.

1.5 Objectives of the study:

The implications of Intellectual Property Rights (IPRs) for inventions and innovations are debatable in the literature. Although, the literature [(Keith E Maskus., 2005), (Archibugi.D. 2010)] focuses more on the positive role of the IPRs for innovations, while the maturity level of the Industry/Firm structure are important considering the implications of IPRs. One of our objectives of this study is chalk out the role of IPRs in innovations in general and green innovations particularly. To understand the process of eco-innovations this study identifies three other direct determinants like research and development (R&D), market size and environmental taxations. However we are mainly focusing on environmental taxations whether the environmental regimes works in green innovations. We don't have the data for green R&D, therefore we are considering overall R&D expenditures but its significance becomes less while linking it with green innovations. But one of our objectives is to find the role of R&D in green innovations.

Given the brief introduction of the problem stated earlier, this study addresses the problem of IPRs, environmental taxation, and R&D in green innovations in developed countries and would derive lessons for Pakistan. The specific objectives are following:

1. To find the impact of enforcement of Intellectual Property Rights (IPRs) in environmental innovation.
2. To assess the role of Research and Development (R&D) in environmental innovation.
3. To ascertain the role of environmental taxation in environmental innovation.
4. To derive the Policy implication from empirical results of the study.

1.6 Organization of the work:

Section 1 of this study includes definition of key terms, problem and purpose statements. Section 2 describes data description and methodology. Section 3 covers empirical estimations and results. Section 4 concludes the study with recommendations

2 Data and Methodology

2.1 Variables Specifications

2.1.1 Environmental Technology (Green Patents)

To know the action patterns and trends between technology the World Intellectual Property Organization (WIPO) present the data by field of technology. Patent statics by technology field are based on the “fractional counting” method. WIPO in June 2010 convert the International Patent Classifications (IPC) symbol into 35 corresponding fields of technology. In 2007 most applications are in computer field technology, electrical machinery and telecommunication and due to these technologies the highest annual growth rate was observed by 2003-2007.

On the other hand the OECD static database focus on the environment-related technology because climate change is hot issue and the environment related technologies plays an integral role in tackling climate change. A total of 65 different IPC classes were identified that dealt with purification of gases and emissions control. Three major technologies were categories, which are improvement in engine, treating pollutants produced before they are released into the atmosphere and reduce evaporation emissions.

2.1.2 Intellectual Property Rights (IPRs)

A number of studies have attempted to measure IPRs protection cross-nationally. Measurement of IPRs has become a critical issue for international business, scholars and practitioners. In this regards Rapp and Rozek’s (1990’s) attempted to quantify IPRs, they used patent laws as a proxy for IPRs of 159 countries. Patent laws are marked on a zero to five scale, where zero present a country with no patent laws and five represent a country having laws consistent with the standards established by the US chamber of commerce intellectual property task force. Furthermore, Seyoum (1996) also used the US chamber of commerce’s minimum standard for his criteria. However, his 0-3 scales of IPRs protection components where constructed from survey sent to IPRs practititioners. Seyoum constructed four variables such as patents, copyrights, trademarks and trade secrets for his analysis. Shrewood (1997) proposed a third measure of IPRs protection that combined the personal interviews. The protection scores range from 0-103 and where developed for eighteen countries[4].

To properly tackle the issues of measurement Ginarate and Park constructed IPRs index for 110 countries in the sample having data range from 1960-2005. It ranges in values from zero to five. Higher values of the index indicate stronger level of protection. In Rapp & Rozek and Syoum did not include a component for enforcement in their study, methods of differentiations is missing for example between "inadequate laws" are "seriously flawed" laws or between "generally good laws" and laws that are "fully consistent" with the minimum standards. In Seyoum's study it is unclear, on which criteria the raw data were reduced to a 0-103 scale. Sharewood's procedure is based on his experience. There exist no set rules while judging how many points to subtract for judicial independence, etc.

2.1.3 Research and Development (R&D)

Research and Development is one of the important components of invention and innovations. In this context environment technologies are largely depending on the R&D generally and green R&D expenditure specifically. Research and development expenditures improve the new innovative products and introduce the environment technology. R&D expenditures would help in commercialization of new technologies, create new business and reduces the risk through the research and development. This study hypothesized that the environment technology will efficiently increase with the help of the overall research and development expenditures. But limitation of green R&D expenditures data, we did not use it.

2.1.4 Market Size (GDP)

Market size (GDP) is an important explanatory variable of the development of environment technology. Market size is a measurement of the total volume of a given market. When determining market size it is very important to define the measurement as preciously as possible. There are three ways to measure the market size such as bottom-

[4] Ghulam Samad "Intellectual Property Rights and Economic Growth" 2007 pp. 711-722

up approach, top-down approach and end-user purchases. It is assumed that market size led the positive impact on development of environment technology.

2.1.5 Environmental Taxation

Environmental taxation is considered the most important explanatory variable of the development of environment technology. Environment related taxes encourage innovations and then environment technologies are developed. Benefits of the environment related taxes are when higher pollution costs make it economically inviting to invest in the development of new greener technologies. Taxes on pollution provide cleaner incentives to polluters to reduce emissions and seek out the cleaner alternatives. Environment related taxes can provide significant incentives for innovation and these incentives make it attractive to invest in research and development activities to develop environment technology. Environmental taxation plays a key role in introducing and developing the environment technology. Environment related taxes will always lead to innovative and the adaptation of new technology and processes. Taxes are the base of the new technology and innovations that should make monitoring easier and most cost effective. Environment related taxes introduce the full range of innovation as well as new products and improved production techniques.

2.2 Data Description:

This study included 11 developed countries namely Australia, Austria, Canada, Finland, France, Germany, Japan, Korea, Sweden, United Kingdom and United State based on the balanced data design for the 2000-2005. We faced many problems in the unbalanced data design for the 1995-2007. Therefore we used the balanced data in this study. Although, the unbalanced data estimations are given at the annexure. The green patents quantify the dependent variable of environmental technology. The data on Environmental technology is taken from the OECD, Patent Database (June 2008). The data on research and development (R&D) is taken from OECD statistics catalogues. Market size (GDP) is an important explanatory variable of the development of environment technology taken from the World Development Indicators (2008). The data of environmental taxation is also taken from OECD statistics catalogues.

2.3 Specification of the model:

The dependent variable is Environmental Technology and explanatory variables are Intellectual Property Rights (IPRs), Research and Development (R&D), Market size (GDP) and Environmental Taxation through the Tax rate of Patrol and Tax rate of Diesel. The general equation of this study is

Env.Tech = f [IPRs, R&D, Market size (GDP), Environmental Taxes (TRP, TRD)]

$(\text{Env.Tech})_{it} = \alpha_i + \beta_1 (\text{IPRs})_{it} + \beta_2 (\text{R\&D})_{it} + \beta_3 (\text{M.S})_{it} + \beta_4 (\text{TRP})_{it} + \beta_5 (\text{TRP})_{it} + V_{it}$

(i= 1, 2…N; t= 1, 2 …T)

$\mathbf{V_{it} = \mu_i + \sum W_{it}}$

Where:

ET = Environmental Technology, IPRs = Intellectual Property Rights, R&D = Research and Development, M.S = Market size (GDP), TRP = Tax rate of Patrol, TRD = Tax rate of Diesel and μ_i is unobservable individual country specific effects and $\sum w_{it}$ is other disturbances.

2.3.1 Pooled Least Square Estimation Techniques:

Fixed Effect Model (FEM) or Random Effect Model (REM) is used on the base of the balanced data design for 2000-2005. Hausman test is used to approve the validity of FEM or REM. The reason for this time period is that it contains a sizeable amount of data available for a large cross section of countries. In pooled least square estimation two techniques are used

- Fixed Effect Model (FEM)
- Random Effect Model (REM)

2.3.2 Fixed Effect Model (FEM):

Fixed Effect Model (FEM) using dummy variables is known as the least square dummy variable models. FEM is appropriate in situation where the specific intercept of countries may be correlated with one or more regresses. Even if it is assumed that the under lying model is pooled or random, the fixed effect estimators are always consistent. In fixed effect the constant is treated as specific group. This means that the model allows for different constants for each group. So the model is

$$\mathbf{Y_{it} = \alpha_i + \beta x_{it} + \mu_{it}}$$

To understand this lets consider the following model (D.Asteriou, 2005)

$$\mathbf{Y_{it} = \alpha_i+\beta_1 x_{1it}+ \beta_2 x_{2it+} \beta_3 x_{3it+} \ldots\ldots_{+} \beta_4 x_{4it} +\mu_i}$$

This can be rewritten in a matrix notation as:

$$\mathbf{Y = D\alpha + X\beta' + \mu}$$

$$Y = \begin{bmatrix} y1 \\ y2 \\ . \\ . \\ yn \end{bmatrix} \qquad D = \begin{bmatrix} iT & 0 & 0 \\ 0 & iT & 0 \\ 0 & 0 & iT \end{bmatrix}$$

$$\begin{bmatrix} x11 & x12 & x1k \\ x21 & x22 & x2k \\ xn1 & xNk & xNk \end{bmatrix} \qquad \text{a} = \begin{bmatrix} \boldsymbol{a1} \\ \boldsymbol{a2} \\ . \\ . \\ \boldsymbol{aN} \end{bmatrix}, \beta = \begin{bmatrix} \boldsymbol{b1} \\ \boldsymbol{b2} \\ . \\ . \\ \boldsymbol{bN} \end{bmatrix}$$

Before assessing the validity of the fixed effects methods, to do this the standard F-statics is used to check fixed effects against the simple common constant OLS method.

H_0: $a_1=a_2=\ldots\ldots\ldots\ldots.a_N$

F-statistics:

$$\mathbf{F= [(R^2_{FE}-R^2_{CC})/ (N-1)]/ (1-R^2_{FE})/ (NT-N-K) \tilde{} F\ (N-1, NT-N-K)}$$

Where R^2_{FE} is the coefficient of determination of the fixed effect model and R^2_{CC} is the coefficient of determination of the common constant model. If F-statistics is greater than the F-critical, then null hypothesis is rejected.

The Fixed Effects models may frequently have too many cross-sectional units of observations requiring too many dummy variables for their specification. Too, many dummy variables may sap the model of sufficient number of degrees of freedom for adequately powerful statistical tests. Moreover model with many such variables may be plagued with multi-co linearity which increase the standard errors and their by drains the model of statistical power to test parameters. If these models contain variables that do not vary within the groups, the parameters estimations may be precluded. Although the model residuals are assumed to be normally distributed and zero mean at constant variance, so there could easily be country specific heteroskedasticity or autocorrelation overtime that would further plague estimations.

It ignores all explanatory variables that don't vary over time. It means that it does not allow using other dummies in the model. This is not useful, when it is required to consider such dummies. It considered large number of degrees of freedom, which is a major cost. It makes it very hard for any slowly changing explanatory variables to be included in the model, because they will be highly collinear with the effects. The fixed effects model controls for all time invariant differences between countries, so the estimated coefficients of the fixed effect models cannot be biased because of omitted time-invariant characteristics like as culture, religion, gender, race, etc. one side effect is that they cannot be used to investigate time-invariant causes of the dependent variables.

Technically, time-invariant characteristics of the countries are perfectly collinear with the cross-sections dummies. Substantively, fixed effect models are design to study the causes of changes within a cross-sectional. Time-invariant characteristics cannot cause such a change, because it is constant for each person.

2.3.3 Random Effect Approach:

The crucial distinction between Fixed and Random Effect is whether the unobserved countries effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not (Green, 2008, p.183). Random effect model (REM) is consistent even if the true model is the pooled estimator. If the dummy variables do in fact represented a lack of knowledge about the model, why not express this ignorance through the disturbance term. This is preciously the approach suggested by the proponents so it is called Random Effect Model (REM).

The Random Effects Model

Original equation

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \beta_2 x_{2it} + \ldots + \beta_k x_{kit} + \varepsilon_{it}$$

$$y_{it} = \alpha_i + \beta_1 x_{1it} + \beta_2 x_{2it} + \ldots + \beta_k x_{kit} + \lambda_i + u_{it}$$

Remember $€_{it} = \lambda_i + \mu_{it}$ λ_i is now a part of error term

This approach is appropriate if observation is representative of a sample rather than the whole population. The Fixed Effect or LSDV modeling can be expensive in terms of degrees of freedom, if we have several cross-sectional units. Dummy variables in fact represent a lack of knowledge about the true model. The proponents of random effects model suggests to use the disturbance term U_{it} in ordered to capture the true effect.

Instead of treating α_i as fixed, now assume that it is a random variable with a mean value of α_1 (no subscript here) and the intercept value for an individual country can be expressed as:

$\boldsymbol{\alpha_{1i} = \alpha_1 + \lambda_i}$ **i= 1, 2, 3, 4 . . . N**

Composite error term $€_{it}$ consists of two components, $\boldsymbol{\lambda_i}$ which is the cross sectional or countries specific error component and U_{it}, which is the combined time series and cross-sectional error components.

$\boldsymbol{€_{it} = \lambda_i + U_{it}}$

The random effects model therefore takes the following form:

$\boldsymbol{Y_{it} = (\alpha + \lambda_i) + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots\ldots + \beta_k X_{kit} + U_{it}}$

$\boldsymbol{Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots\ldots + \beta_k X_{kit} + (\lambda_i + U_{it})}$

Obvious disadvantage of the random effect approach is that one should make specific assumption (i.e. country specific effects are uncorrelated with the exogenous variables included in the model) about the distribution of the random component. If the unobserved group-specific effects are correlated with the explanatory variables, then the estimates will be biased and inconsistent. An advantage of the Random Effects is that you can include the time-invariant variable. In the Fixed Effects model these variables are observed by the intercept. Random Effects assumed that the entity's error term is not correlated with the predictors, which allows for time-invariant variables to play a role as explanatory variable.

In Random Effect you need to specify those countries characteristics that may or may not influence the predictor variables. The problem with this is that some variables may not be available therefore leading to omitted variable bias in the model.

Disadvantages of the Random Effects are that one has to specify the conditional density of μ_i given:

$\mathbf{X_i = (X_i1 \ldots X_it), f} (\mu_{i \backslash} x_i)$,

While μ_i is unobservable. A common assumption is that f $(\mu_{i \backslash} x_i)$ is identical to the marginal density f (μ_i). However, if the effects are correlated with X_{it} or if there is a fundamental difference among individuals units, i.e. conditional on X_{it}, Y_{it} cannot be viewed as a random draw from a common distribution, common Random Effect model is misspecified and the resulting estimator is biased.

The Fixed Effects model assumes that each country differs in its intercept term (In FEM intercept vary across α_i of cross-sectional units while in REF, intercept is constant), whereas the Random Effects model assumes that each country differs in its error term. When the panel data is balanced one might expect that the Fixed Effects model will work better. In other cases, where the sample contains limited observations of the existing cross-sectional units, the random effect model might be more appropriate. The usefulness of fixed effects model and random effects model depends upon the assumptions one makes about the possible correlation between cross-sectional specific error components $\boldsymbol{\lambda_i}$ are constant and X's regressors. If assumption is $\boldsymbol{\lambda_i}$ and X's are uncorrelated, REM may be appropriate. Whereas if $\boldsymbol{\lambda_i}$ and X's are correlated to the FEM may be appropriate. These are the two fundamental differences in the two approaches.

In order to further investigate about whether fixed effects model or random effects model is more useful, so called Hausman test is used. Given a panel data model where Fixed effects would be appropriate the Hausman tests investigates whether random effects estimation could be almost as good. Hausman statistics may be viewed as a distance measure between the Fixed Effects and the Random Effects estimators.

Hausman test uses the following test statistics:

$$\mathbf{H = (\beta^{\wedge FE} - \beta^{\wedge RE})' [var (\beta^{\wedge FE}) - var (\beta^{\wedge RE})]^{-1} (\beta^{\wedge FE} - \beta^{\wedge RE}) \sim x^2 (k)}$$ [5]

For this test null hypothesis is;

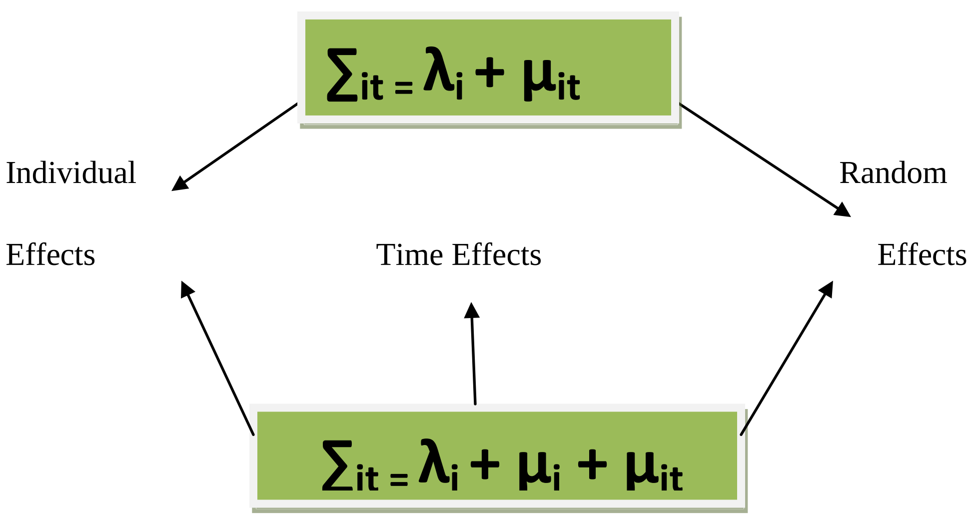
H_O: Random Effects model coefficients are consistent and efficient.

H_1: Random effects are inconsistent.

If the value of the Housman statistics is high, then the difference between the estimates is significant, it rejects the null hypothesis and the random effect model is inconsistent.

In contrast low value of the statistics implies that the random effects estimator is more appropriate.

2.3.4 One Way or Two Way Error Component:



One way error components means, it includes Individual Effect and Random Effect.

$\sum_{it} = \boldsymbol{\lambda_i} + \boldsymbol{\mu_{it}}$, Where the $\boldsymbol{\lambda_i}$ is the individual and $\boldsymbol{\mu_{it}}$ is Random Error.

Two Way error component means, it includes the individual effect, random effect and time effects.

$\sum_{it} = \boldsymbol{\lambda_i} + \boldsymbol{\mu_i} + \boldsymbol{\mu_{it}}$

Where $\boldsymbol{\lambda_i}$ is individual effect and $\boldsymbol{\mu_i}$ is random error and $\boldsymbol{\mu_{it}}$ is the time effects.

Two way error components cannot be applied to unbalanced data, and the one way error components is applicable to the balanced or unbalanced data. This study used the One Way Error Components. The One Way error component is applied to the balanced data design for the 2000-2005.

3 Empirical Estimation and Results

3.1 Empirical Findings

In order to estimate the pooled least square estimation techniques of fixed and random effect, we are going to check the stationarity of panel data by employing panel unit root test introduced by Phillips-Perron Fisher (Fisher-PP) Unit Root Test (Choi 2001). It considers the Kernel (Bartlett) method to correct for autocorrelation. We also check for the individual intercept to include individual fixed effects, individual trend and intercept to include both the fixed effects and trend, finally none to include no regressors. These results are exhibited in Table 1.

The table 1, clearly depicting that each specification of the panel unit root test (individual intercept, individual trend and intercept and none) rejects the null of unit root hypothesis for all the series that is combined tax on petrol & diesel (CTRit), the tax rate on petrol (TRPit), the green technology (GreenTit), are stationary at i.e. I (0), except the GDP I (1). The remaining two pool series i.e. tax rate on diesel (TRDit) and intellectual property right index (IPRit) are non-stationary. On the whole when we are using the combined tax rate we can say that the series are stationary, therefore, we proceeds for the pooled least square estimation techniques of fixed and random effects method

Table 1: Panel Unit Root Tests

Null: Unit root (assuming individual unit root process)			
Pool Series	Phillips-Perron Fisher Unit Root Test (Chi-Square)		
	Individual Intercept	Individual Trend and Intercept	None
CTRit	53.270 (0.0002)	50.290 (0.0005)	264.777 (0.0000)
TRPit	120.000 (0.0000)	279.730 (0.0000)	578.887 (0.0000)
TRDit	2.772 (1.000)	2.772 (1.000)	2.772 (1.000)
GreenTit	41.06 (0.0081)	29.11 (0.1415)	68.89 (0.0000)
R&D it	180.36 (0.0000)	165.95 (0.0000)	1200.54 (0.0000)
GDPit (Ist Difference)	30.031 (0.1177)	24.4000 (0.3266)	47.711 (0.0012)
IPR it	12.476 (0.9467)	12.476 (0.9467)	12.476 (0.9467)

Figures in parentheses are representing the P-values.

The Pooled Least Square (Balanced or Unbalanced) Fixed Effect and Random Effect Models are used to estimate equation and the results are presented in table 2 and table 3 at the end of the chapter. We are not considering the unbalanced estimation the reason is that the data is not frequently available for all years. Therefore, we used the balanced data and the results are highly significant in the balanced data. Since, there are no significant differences in the results of the above mentioned results. Their magnitudes are different but their signs are same, therefore the results have been interpreted in a combined manner. But here focus on the Fixed Effect because the results are highly significant in the Fixed Effect.

The individual results of the tax rate on patrol and tax rate on diesel are put in the Annex 1 and Annex 2. Whereas, the results of the combine tax rate are highly significant and positive as compared to individual results of the tax rate on patrol and diesel. The preliminary results show that the coefficients of the most of the standard explanatory variables carry the expected signs and are statistically significant.

Fixed Effect is shown clearly in table 2. It further depict that combine tax rate (CTRit) which is defined as the tax rate on patrol and tax rate on diesel, carries the expected sign and is highly significant. The finding shows that the combined tax rates have the positive relationship with the green technology and 86.76% green technology is increased due to the combine tax rate. One reason for this significant relationship is that if there is tax imposed on polluters then there would be the level of emissions and activities of high pollution. Taxes on pollution provide clear incentives to polluters to reduce emissions and seek out cleaner alternatives. By placing a direct cost on environmental damage, profit maximizing firms have increased incentives to economize on its use, compared to other environmental instruments, such as regulations concerning emission intensities or technology loss environment related taxation, as it encourages both the lowest cost abatement across polluters and provide incentives for abatement at each unit of pollution. When the pollutants pay taxes then the creation of the innovation is came because of the adaptation of incentives in order to minimize the tax payments and in this result potential innovation, production innovation, process innovation and organizational innovation are came. These incentives make it commercially attractive to invest in R&D activities to develop technologies. Taxes equate the marginal damages from pollution with the marginal cost of pollution abatement. Taxations bring about a full range of innovation, including new products and enhanced production techniques. Taxes on pollution provide cleaner incentives to polluters to reduce emissions and seek out the cleaner alternatives.

Another reason is that taxes on motor vehicles are major source of revenue for 11 developed countries government and taxes are the base of new technology and innovation that should make monitoring easier and most cost effective. Taxes lower the prices of permits but recover some of the wind fuel gains that firms receive by not having to buy their permits at auction. The scope of the expanded use of the environmentally related taxes in 11 countries is great, especially in addressing climate change. This result is corresponding with the (Organization for Economic Cooperation and Development, 2008. OECD, 2009. OECD, 2009e and OECD, 2010).

This study finds that for developed countries with the strengthening of IPR regime, the green technology is declining. The coefficient associated with IPR indicates that with a one unit increase (more strengthening) in the IPR index, the green technology declines by 11.34%. It means that the empirical results do not support positive relation between IPR and green technology in developed countries. The possible reason for this negative relationship might be the structure of the industries in the developed countries. Furthermore, enforcement of IPRs would not affect the green innovations in these industries. The structure of these industries has reached at the mature level and changing structure would cost those more instead of converting in to green innovations. Moreover, the IPRs enforcement index in these countries almost reached at the maximum of 5 (means full enforcement). Therefore, further IPRs enforcement wouldn't work. The Clean Development Mechanism (CDM) also verifies these study findings that the developed countries instead of changing their structure towards green technologies they are purchasing carbon credits from the developing countries.

Research and Development is defined as creating the new production of knowledge and technological change, it is significant and carry the expected signs. The findings show that there is a positive relation in R&D and green technology: green technologies are increase 1.31% due to the R&D. The coefficient of R&D indicates that as a result of 1% increase in the R&D, the green technologies increase by the 1.31%. The reason of this significant relationship is that new innovations and inventions are overcome due to the R&D. New R&D produces the higher quality of goods; create the new production of knowledge, technological change and higher degrees of technology transfer. R&D expenditure helps in commercialization of new technologies, create new business and reduce the risk through the R&D. Active R&D reduces the green house gas emissions and energy efficient technologies. . This result is subsequent with the (William, 1995. David and Roger Bate, 2004).

Market Size (GDP) has a significant impact on the green technologies of the Developed countries. In this regard the results are highly significant. The coefficient of the GDP indicates that as a result of 1% increase in GDP the green technologies increases by the 0.0209%. The empirical analysis favors the positive role of GDP in green technologies. When GDP increase then the Purchasing Power Parities increase and over the time Government realize about the environmental degradation and then there is progressive increase the green taxes. When taxes are levied from the polluters then polluters favor the green technologies rather than the taxes. This result is corresponding with the [Ward Van Den Berg (2011), David and Roger Bate (2004), Maskaus (2005), Thomas (2006) Steiner (2009)].

Table 2: Fixed Effect

Dependent Variable: Green Technology Method: Pooled EGLS (Cross-section weights) Total pool (balanced) observations: 726 White cross-section standard errors & covariance (d.f. corrected)				
Variables	Coefficient	St. Error	t-Statistic	Prob.
C	3.7545	0.0959	39.1118	0.0000
CTR	86.7693	8.6120	10.0753	0.0000
IPR	-11.3401	0.8387	-13.5195	0.0000
R&D	1.3198	0.6414	2.0576	0.0400
GDP	0.0209	0.0006	32.4154	0.0000
R-Squared	0.69			
Adjusted R-Squared	0.69			
F-Statistic	117.6160			
F-Statistic (Prob.)	0.0000			
Durbin-Watson stat	0.3867			

Table 3: Random Effect

Dependent Variable: Green Technology Method: Pooled EGLS (Cross-section weights) Total pool (balanced) observations: 726 White cross-section standard errors & covariance (d.f. corrected)				
Variables	Coefficient	St. Error	t-Statistic	Prob.
C	0.0473	0.3177	0.1489	0.8816
CTR	253.5789	4.8319	52.4799	0.0000
IPR	-40.9286	4.6384	-8.8238	0.0000
R&D	15.9355	6.9019	2.3088	0.0212
GDP	0.0326	0.0011	28.5715	0.0000
R-Squared 0.59 Adjusted R-Squared 0.58 F-Statistic 259.7878 F-Statistic (Prob.) 0.0000 Durbin-Watson stat 0.2498				

3.2 Econometric Tests

We applied the Hausman test to further investigate about whether fixed effects model or random effects model is more useful. The Hausman test favored the null of Fixed Effect Technique instead of alternative of Random Effect Technique. Also, apply Durbin-Watson d test to check for autocorrelation in time series and cross sectional data to identify the autocorrelation problem if any. This test assumes inclusion of intercept in regression model and there are no missing observations. In this case, the validity of this test is not useful to interpret for balance panel data. The value of D.W test is irrelevant in case of small time series which in this case is only five years, with eleven cross sections. However, we are considering this test to fulfill the basic requirements. Similarly, the first assumption violates the applicability of Constant Coefficient Method. However, D.W d statistic value can be usefully interpreted for balanced panel data (Fixed and Random effects). The value of the Durbin-Watson Statics is closed to 2 if the errors are uncorrelated. The values of D.W Stat for balanced data (2000-2005) are 0.034. We already explained when the time period is short and there is no need to take the lags because the minimum values are not matter in this case.

White General Hetroscedasticity, White Heteroscedasticity Variance and Standard Error methods were applied respectively to check and correct the problem of Heteroscedasticity, The usefulness of the White Heteroscedasticity Variance and Standard Error on Weighted Least Square (WLS) is that it does not assume, rather determines variance ($б_i^2$). The problem of Hetroscedasticity is more common in cross sectional data than in time series data, because it deals with members of cross country population at a given point of time, such as individual consumers, or their families, firms, industries, or geographical subdivisions like state, country, city etc (Janjua and Samad, 2007). Therefore, we explained the results of Fixed Effect estimations

4. Conclusions and Policy Implication

It is an open secret that the Environmental technology is perceived as an important source of reducing the emissions and to improve the efficiency in market(s). Such technologies play a vital role in tackling with the issues like climate change. Moreover, Green environment technologies focus on the innovation that resultants in minimizing the degradation of environment; reduce the green house gas emissions, improve the health, conserve the use of natural resources and also promotes the use of both renewable and non-renewable resources. Such innovations, also reduces the cost of materials, cost of production, increase the rates of production and attractiveness of products in the market place.

Our research has also proved that the promotion of environment technology and eco-innovation provides many benefits for business; fostering innovation, cutting production cost, creating jobs, reducing pressures on the environment and encourage competitiveness. Limiting the concentration of green house gases in the atmosphere is largely a major concern of the technology innovation.

The empirical results do not support the positive relation between the IPRs and green technologies in developed countries. Because the enforcement of IPRs does not affect the green innovations, as the organization of these industries reached at mature level and changing structure would cost those more instead of converting into green innovations.[6] Moreover, the IPRs enforcement index in these countries almost reached at the maximum of 5 [7] (means full enforcement). Hence, the developed countries, instead of changing their structure towards green technology, are purchasing carbon credits from the developing countries[8]. Nevertheless, our literature review of IPRs has a positive impact on eco-innovation, but this very study shows a negative relation. The possible reason for this negative relationship might be the structure of the industries in the developed countries. Furthermore, the enforcement of IPRs would not affect the green innovations in these industries. Because, the structure of these industries reached at the mature level and changing structure would cost those more instead of converting into green innovations. The Clean Development Mechanism (CDM) also verifies the said study.

Research and Development (R&D) plays positive and increasingly significant role in innovation and environmental technologies. Emphasizing R&D introduces the environment friendly technologies to reduce the environmental damages. Environment technologies are largely depending on R&D generally and green R&D. R&D expenditure improves the new innovative products and initiates the environment technologies. R&D expenditure would help in commercialization of new technologies, create new business and reduce the environment degradation. R&D resultants in the production of environment friendly and higher quality of goods, that ensures sustainable development. Such products would also be helpful in minimizing pollution and minimizing its other externalities.

Environmental taxation also plays a key role in introducing and developing the environmental technologies because environment related tax leads to innovation and adaptation of new technologies and processes, both at micro and macro level. Taxes

[6] This view is discussed by the Dr Zahiruddin Khan, IESE NUST in International conference on Green Technology organized by COMSTECH.
[7] Ghulam Samad, "Intellectual Property Rights and Economic Growth" 2007.
[8] CDM Mechanism

generate and huge income for the government which would be used to invest in the eco-technology. Environment related taxes introduce the full range of innovation, new products and new production techniques. Such taxes also provide significant incentives, both for consumers and producers that would trigger the revolution and innovative and environment friendly ideas in the field of science and technology.

The Important Policy Implications Are:

- Management of Intellectual Property Rights (IPR) based on eco-innovation.
- National intellectual property legislation should be updated and refined and IMPOSED.
- The role of ministries (environment), organizations/institutions, and Word Intellectual Property Organization (WIPO) should emphasize on the role of IPR and Green technology development.
- R&D base should be strengthened, which will encourage innovative efforts to invent environment friendly products.
- An effective environmental taxation needs to be introducing keeping in mind the willingness to pay of the individuals of the proposed community.

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Annex-I

Fixed Effect

Dependent Variable: Green Technology Method: Pooled EGLS (Cross-section weights) Total pool (balanced) observations: 726 White cross-section standard errors & covariance (d.f. corrected)				
Variables	Coefficient	St. Error	t-Statistic	Prob.
C	3.6618	0.1029	35.5731	0.0000
IPR	-12.8528	0.7805	-16.4668	0.0000
R&D	4.7400	0.7232	6.5537	0.0000
GDP	0.0207	0.0007	28.4744	0.0000
TRP	85.4756	22.4118	3.8138	0.0001
TRD	86.5914	13.3584	6.4821	0.0000
R-Squared 0.73 Adjusted R-Squared 0.72 F-Statistic 131.1818 F-Statistic (Prob.) 0.0000 Durbin-Watson stat 0.3957				

Annex-II

Random Effect

Dependent Variable: Green Technology Method: Pooled EGLS (Cross-section weights) Total pool (balanced) observations: 726 White cross-section standard errors & covariance (d.f. corrected)				
Variables	Coefficient	St. Error	t-Statistic	Prob.
C	0.0446	0.5349	0.0835	0.9335
IPR	-34.0442	2.0208	-16.8464	0.0000
R&D	-2.3497	1.2967	-1.8120	0.0704
GDP	0.0346	0.0013	25.5437	0.0000
TRP	468.6140	55.5425	8.4370	0.0000
TRD	-15.6808	62.1877	-0.2521	0.8010
R-Squared	0.60			
Adjusted R-Squared	0.59			
F-Statistic	216.0555			
F-Statistic (Prob.)	0.0000			
Durbin-Watson stat	0.2655			