Identification of Green Technologies in Pakistan

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CERTIFICATE

This is to certify that this thesis entitled: ***"Identification of Green Technologies in Pakistan"*** submitted by **Ms. Faiza Ashraf** accepted in its present form by the School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Environmental Economics.

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Contents

Abbreviations

COP	Conference of properties
EFW	Economic Freedom of the World
FDI	Foreign Direct Investment
GHGs	Greenhouse Gases
GCISC	Global Change Impact of study center
GDP	Gross Domestic Product
GDPgr	Gross domestic Product growth rate
IPRs	Intellectual Property Rights
IPO	Intellectual property Organization
ITC	International Technology Center
ICTSD	International Center for Trade and Sustainable Development
ICESCR	International Covenant on Economic, Social and cultural rights
IPCC	Intergovernmental panel on climate change
OLS	Ordinary Least Square
R&D	Research and Development expenditure
RLFP	Royalty License Fee Payment
TRIPS	Trade Related Intellectual Property Right
UNCTAD	United Nation Conference on Trade and Development
UNFCCC	United Nation Framework center for Climate Change
WTO	World Trade Organization
WIPO	World Intellectual Property Organization
ARDL	Autoregressive distributed lag
OLS	Ordinary least square
CLRM	Classical linear regression model

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Abstract

The research is focused on the identification of green technologies in Pakistan by using the Patent data of IPO-Pakistan and also find out the green technologies determinants in Pakistan by using the time series analysis from 2005-2017. After a very hectic and lengthy process of identification of green technologies by taking the key informant interviews from some respected teachers across the universities in Pakistan, and practitioner, who are expert in understanding functions of green technologies, 55% of the technologies are green from the 3281 technologies which are registered under the IPO-Pakistan. Similarly, this study also traced out inventor address who registered their innovations in Pakistan. 95% of the patents are invented in developed nations and rest of the 5% are invented in Pakistan that's mean we are not developing or creating the technologies but transfer these technologies from developed nations. Furthermore, sectoral analysis was also carried out to see which industry dominates green innovation in Pakistan. Pharmaceutical industry dominates the green patent because of its large registered innovations. The identified green technologies, used as a dependent variable in the study is count variable in nature that why we used negative binomial model as there is over dispersion in our data. Furthermore the estimation of time series, the ADF test for checking the stationarity found that the data is mixture of the I(0) and I(1), so solution of this problem found in literature is ARDL-Bound test. The ARDL-Bound test shows the no co-integration among the variables of the study due to limitation of the data as we need minimum 30 values for the estimation of time series but this study has only 13 years data that why it's a limitation of our study. There is a no long run relationship exist between the determinants of green technologies and registration of green technologies.so we take the growth rate of all the variables, to become the variables stationary at level. After applying the OLS for level data, we found a positively and negatively statistically insignificant results due to data limitation. For future research large data set may be helpful for getting the significant result. The result of both negative binomial model and OLS seems to be same as both are concluded as there is a need of more protected and strengthened an protected IPR's legislation system in Pakistan and also there is a need to increase in economic development and economic integration in Pakistan for the registration of green technologies.

Key words: climate change, Green technologies, Intellectual Property Rights

Chapter I

1.1 Introduction

Worldwide increase in temperature and erratic shift in precipitation is one of the fundamentals concern of both the developed and developing countries. Adaptation and mitigation measures are required to cater climate change issue. Green technologies, the improvement and use of products tools as well as method utilized to protect natural assets and environment which diminish as well as decreases the harmful effects of anthropological actions, are one of the fundamentals mitigation measures. Climate change mitigation technologies that also called a green technology, indicates technology that is considered environmentally friendly dependent on its production network.

Energy, economy, environment and the community are the four pillars of the green technology policy. It boosts the active use of resources in energy, which are environmental friendly to reduce the harmful impacts on human health as well as environment, and increase the economic growth. Furthermore, International Trade Center **(**ITC)[1] 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".

At present, there seems to be some debate on what the term “green technology” covers. The United Nations Framework Convention on Climate Change (UNFCCC)[2] refers to green technologies which are proposed to incorporate the following technologies such as technologies protecting the environment, less polluting technologies, technologies using resources in a more sustainable methods, technologies aiming at recycling of waste and products, and technologies handling residual wastes, e-g. By purification processes. While there is no commonly accepted definition of the term “green technology”, one may also

[1] International trade center (ITC) is the joint agency of world trade organization (WTO) and United Nation (UN) established in 1964.

[2] The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty negotiated at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro from 3 to 14 June 1992.

consider the term “green inventions” which is understood to refer to environmentally friendly inventions that often involve energy efficiency, alternatives to fossil fuel and carbon generation, pollution and toxic remediation, water purification, recycling, safety and health concerns, renewable resources, etc.

The question arises why green technologies are becoming so important and why the inventors should think green, the answer to this question is that the world has a fixed amount of natural resources, some of which are already depleted or ruined. For example, household batteries and electronics often contain dangerous chemicals that can pollute the groundwater after disposal, contaminating our soil and water with chemicals that cannot be removed from the drinking water supply and the food crops grown on contaminated soil. The risks to human health are great. Inventors should know that green inventions and clean technologies are good business. These are fast-growing markets with growing profits. Consumers should know that buying green inventions can reduce energy bills and that green inventions are often safer and healthier products. The active use of green technology can help to decrease the pollution and the main purpose green technology is to slow down the global warming and reduce the greenhouse effect for example we have to create green technologies, which do not damage the natural resources, species and human health. That’s why the developed and some of the developing countries have to protect their environment from destructive impacts by using green technologies

Intellectual property (IP) assume vital job as it indicates to the formation of psyche: creations, scholarly and imaginative mechanism, as well as images, name, and pictures utilized in trade. Current years have perceived an increasing development to the adoption of green technologies through IPRs. In developing countries, the establishment of Intellectual Property Rights (IPR’s) system hustle the universal war for assets and green technologies (Maskus, 2004). **(**ICTSD[3] 2008) presents IPRs encourages the invention and information. Relationship between IPRs and green technology would be useful on the way to raise the

[3] International Centre for Trade and Sustainable Development (ICTSD) Founded in 1996 is an independent nonprofit organization based in Geneva, Switzerland. The goal of the organization is to advance sustainable development through trade-related policymaking.

awareness among people. Creation of green technologies can be determined by resilient security of IPRs raises the practice of invention and growth. The implementation of IPRs improves economic development and be responsible for increases the technological innovation and technology transfer in developing nations.

In theory, the strong transfer of IPR's long for invest in green technology transfer from developed to developing nations and they have their personal conflicting opinions in regards to the strong security of IPRs. IPR's system is achieving power and the promoters of strong IPRs system in developing nations compete that such systems long for consequences in more exports, increase in investment, innovation exchange, and increase in development. The opponents of the opinion that this one is negative in the direction of the improvement procedure through the loss of employments, formation of imposing business model authority, which at last prompts increase in costs, and above all to the innovation required for advancement.

Because of absence of protected IPR's framework and awareness about it, resources in the developing countries like Pakistan can't be transformed into useful assets and also not traded globally which results in lower technological development, stays at great hazard with no guarantee, increase in cost of obtaining, and face more prominent expenditures of economic intervention, (Williamson, 2005). IPRs employ economic development, which requires rise in efficiency, rise in efficiency requires growth in technological advancement and it needs the productive security of IPRs.

World Bank and in addition World Intellectual Property organization (WIPO)[4] and United Nations Conference on Trade and Development (UNCTAD)[5] supports that protection of IPR's can help in revenue generation, increase balance of payment (BOP), give entrance to universal markets, make certainty to investors, increase in working opportunities, and

[4] World Intellectual Property organization (WIPO) is one of the 15 specialized agencies of the United Nations (UN). WIPO was created in 1967 to encourage creative activity, to promote the protection of intellectual property throughout the world.

[5] United Nations Conference on Trade and Development (UNCTAD) was established by the United Nations General Assembly in 1964 and the primary objective of UNCTAD is to formulate policies relating to all aspects of development including trade, aid, transport, finance and technology.

productivity and give specialized knowledge to the world developing nations. Intellectual Property Rights (IPRs) have been commonly observed as a development improving factor for the global economies all in all significance of IPRs particularly Geographical Indication (GI) and Outdated Information can help in poverty reduction.

Pakistan shows an active part to decrease the emissions through the mitigation and adapts to climate change. Pakistan contributing in the universal debate: subsequently the historic Rio Earth Conference in 1992. Pakistan is the participant of Kyoto Protocol, United Nations Framework Convention on Climate Change (UNFCCC) and number of conventions. Pakistan contributed in Universal negotiation on climate change, conservation as well as sustainable growth. Kyoto protocol an International Environmental Agreement is held in December 11th 1997. The core objective of this agreement is reducing the GHGs emissions and 5-year plan by 2008-2012 in the 1st phase of the emissions decrease. The Idea of the R&D in green technology is passed on a global level and at that time the countries have no incentives for taking into account the global effects of their efforts. In Cop-8, it was decided that the developed countries will make efforts to transfer the technology to the developing countries to minimize the impact of climate change.

Fifteen members of the civil society committee for Cop 17 on 25-26 March met in Durbin to plan, strategies and developed its work plan of 2011. Objectives of the Cop 17 were minimizing climate change through education, mobilization, developed the environmental justice movement and understanding of climate change in climate justice group. The Cop 17 implementing the Strategies of the clean technology. United Nation Environment Program in the Cop 17 by the Governing Council and Ministerial of Environment Forum (GC/GMEF) held the Green Technology Exhibition showcased innovative technology including the water purification, Environment friendly cooking apparatus for rural communities, cost effective lighting solutions, energy saving lamps and bio fuel production.

GCISC[6] is also introducing the green technology and also Pakistan Council for Science and Technology advised the government to improve and developed the science and technology in

[6] Global Change Impact Studies Centre (Islamabad, Pakistan).

the country and also prepared the "Technology achievements Index" in 2009 and reviewing of 91 countries focus on the new technologies. Ministry of Environment of Pakistan is said that there is a need to introducing the green technology in all sectors that reduces the environmental challenges. Ministry of Energy, Technology and Water focused on the green Innovations in the economy.

The first objective of the study is to identify the green technologies by using the data of patents of IPO-Pakistan from 2005-2017. And the second objective is to find out the determinants of the green technology in Pakistan by applying the time series analysis. This study is helping out to figure out green innovations in sectors like Pharmaceutical, agriculture, manufacture, transport, textile sector and chemical industry. Identification of green technologies, and sectoral disaggregation is not done so far as per our knowledge.

1.2 Organization of the Thesis

Rest of the thesis is further divided in to different chapters. Chapter-II presents the literature on IPR's, technological innovation, R&D and FDI, also research gap of the study. Chapter-III presents the introduction to the IPO-Pakistan. Chapter-IV presents an overview of the patent protection in case of four south Asian countries (Pakistan, India, Bangladesh and Sri Lanka) which are the members of (WIPO) and Chapter-V presents the data description and methodology of the study, variables definition and source, analytical tools and econometrics model and its expected results. And Chapter-VI presents the descriptive statistics of the variables, estimation and results of ADF, ARDL-Bound test, auto-correlation test and OLS. Chapter VII presents the conclusion, policy recommendation and limitation of the study.

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Chapter-II

Literature review

This chapter is divided into four sections which cover thematic literature review on the previous work done on 1) Intellectual Property Rights (IPR's) 2) IP and Research and Development expenditure (R&D) 3) IP and technological innovation 4) IP and Foreign Direct Investment (FDI) and also research gap of the study.

2.1 Intellectual Property rights (IPR's)

To observe the effect of protection of IPRs on technology transfer in a selection of South Asian countries namely, Pakistan, India and Bangladesh for the period 1990-2005, show that the enforcement level of IPRs in these developing countries increases the technology transfer. (Samad & Nasir, 2014). Strong patent protection encourages permitting for the reason that it would decrease imitation risk and insecurity. There is a positive relationship between strengthen of IPR's and technology transfer to developing nations. (Sunil Kanwar, 2012). The study examines Strong patent protection of IPR's remains correlated by means of improvement and rise in RLFP by developing nations, which shows more technology transfer to these countries. The paper concludes that aggregate security variable tells that the strong overall statistical importance of the security variable is focused by the sub-index of analysis.

The protection doesn't benefit the developing countries directly, but it increases the overall well-being as stronger IPRs protection helps achieving international collaboration in developing countries. (Maskus, 2004) examine in his study by using Ginarte and Park index for patent protection, states the significance of IPRs protection in promoting revolution in developing countries.

According to existing empirical literature there is a significant correlation between IP protection and RLFP by income level, but there is non-significant correlation among IP protection and licensing for unassociated multinationals. (Gentile, 2018) addresses the query of whether the extended and strong protection of IPR promotes technology transfer to developing country or not. World Bank has collected this information from face-to-face interviews with best supervisors and professional landlords over 130,000 companies in 135

economies utilizing the Cross-section analysis by using linear probability model of the correlation among them. There is non-significant correlation among the IPR security and technology permitting for multinationals working in developing and low income nations.

To examine the effect of IPRs protection on economic growth by using Ginarte and Park index as a substitute for IPRs protection study is conducted by (Sattar & Mahmood, 2011). For estimation, balanced panel Fixed Effects Estimation (FE) method is used in this paper. The result of the study is that IPRs protection is helpful for the economic development for nations with higher earnings as related with lower earnings and developing countries. At the point when developing nations were separated into upper middle earnings nations and lower middle earnings nations, IPRs security presented a significant effect on economic progress of upper middle earnings nations, and the effect declined more when they moved to lower middle earnings countries because of bad level of protection.

There are some other studies signifying an advanced effect of a growth in the IPR protection in developing countries. (Grossman & Helpman, 2016) uses a general equilibrium model and claims that growing IPRs security in the developing countries (copying products of developed countries) can reduce international inventions and wealth in the long run. The purpose behind this result is the weak invention capability of developing countries and knowledge distribution being the central cause of technology development in the developing countries. That mean IPRs protection play vital and significant role in technology development and technology transfer in developing countries.

IPRs don't contribute to economic development in developing nations like Pakistan. (Janjua & Samad, 2007) Examine the correlation among IPRs and economic development and also find the effect of IPRs on middle income developing nations. Fixed effect and random effect models are utilized in this paper dependent on balanced data or unbalanced data. Unbalanced data is utilized for developing nations. Panel data estimation techniques are used. Average growth rate and average growth rate of population, inflation, IPRs and economic freedom of the world factors are incorporated into this study. The paper concluded that few issues as

unemployment, inflationary burden and balance of payment are measured may reason for the strong IPRs at this stage.

To found the observed relationship between protection of IPR and technological innovation by utilizing the OLS regression and fixed effect model of panel data by (S. Kanwar, 2003). IP protection was establish to have a strong positive impact on R&D investment. GDPgr displays a positive relationship among IPR's and technological variations. RLR displays negative association between IPR's and technological variations. The study resulted that Absence of an encouragement structure can be important issue for technological variation even when other limitations such as, internal funds, convenience of skills and trade location may not be compulsory.

Another study hypothetically discovers that the developing nations immediately adopt the climate change technologies Canady (2009), IPRs are a vital tool to achieve the climate change technology. Two approaches are used to achieve the climate change technologies which are climate change technology innovation strategies (CCTIS) and mutually beneficial technology transfer. The study provides five recommendations in care of endogenous weather variation, research and development, controlling of emerging country intelligent resources, development of climate change technology, awareness platform and periodic calculations.

Same as (Abbott, 2009), hypothetically absorbed the distribution of technology for talking the issue of climate change. Extensive range of technologies may be elaborate in addressing the special properties of climate change. Distribution of these novel knowledge on a universal base builds some hurdles made by rutted allocations of capital and technological capability.

IPR's such as Patents, copyrights, trademarks and trade secrets will support in addressing the challenges of climate change. This report absorbed the mitigating outcome of climate change from end to end the growth and better technologies and protected IPR's.

2.2 Intellectual Property (IP) and Research and Development expenditure (R&D)

There is hypothetical discussion taking place about the effect of IPRs in the South on the motivations of Northern firms to improve as well as exchange inventions toward the South. Although observed research exists on the effects of Southern IPRs on Northern invention exchanges, observed evidence on the impacts of Southern IPRs on Northern development is missing the investigation of (Park, 2012) seeks to fill that gap. There is a significant relationship among R&D and patent rights in developed countries is involved by the example of highly R&D intensive firm. Then again, actually local patent security is certainly not an empirically significant element of R&D achieved. Be that as it may, a helpful effect on Northern R&D would be improved R&D of firms had expanded. Rather, the reliance of their R&D is restricted to the quality of patent rights.

To observe in what way technology, transfer inside U.S. multinational firm variations in response to an arrangement of intellectual property rights developments is using the linear regression analysis. (Branstetter, Fisman, & Foley, 2005) investigates that hypothesis by studying special impacts of improvement on the RLFP and Research and development expenditures of U.S. multinational associates, along with the level and development ratio of patent filings by nonresidents. The study observes that the US firm level statistics the RLFP for technology transfer has been rise by 30% to the affiliate at the time of IPRs developments in 16 countries. The study does not reflect the effect of improvements on domestically maintained firms that might be moved afterward developments nor does it study the special effects of the developments on the pace of invention in non-reforming nations.

(Yang & Maskus, 2001) state that non-existence of an IPRs protection strategy in the developing countries can encourage innovators in the developed countries to create their technologies more challenging to copy, which will make R&D activity a more difficult task for the developing countries, leading to a smaller amount than effective technical development in the developing countries and fewer than ultimate innovation in the developed countries.

IPRs protection has a significant impact on technology transfer later observing all other factor Research and development expenditure of parent firm, size of associates, market explicit factor. (Wakasugi, 2007) examine theoretically and empirically that the inventions are resulting due to the stronger IPR's. The paper tells that the strong IPRs in the host nation and the higher Research and development expenditure of the parent firm increase the level of technology transfer. This study determines that the IPRs protection would be fortified for encouraging the global technology transfer by Multinational Corporations.

The R&D will be a vital part of the climate change, Research and development strategy alone won't work, except if the objective is too just to extend expand energy provision instead of essentially reduce the emissions. (Bosetti, Carraro, De Cian, Massetti, & Tavoni, 2013) Combing the R&D and climate policies might central to productivity advantages and helps to cover climate strategy expenses, Cost Benefit valuation of Research and development in carbon storing as a way out to climate changes. It concludes the Research and development investment concluded at improving the capture rate and capturing cost of carbon emissions.

Developing countries have not achieved their targets but successfully reduce the GHG emission through the R&D and achieved the energy efficient technologies and transformation of these new technologies in developing countries. David and Roger (2004) argues that when the new technology is transfer to these countries the economic growth will increase and the emissions will also increase. Economic freedom encourages technology transfer and faster economic growth. In developing countries low per capita emissions with huge population cannot achieve the economic growth. (IPCC) analyses that high and low ends of the range of for casts for cumulative GHG emissions and share due to developing countries. Level of productivity is built into capital and new investment in efficient technology. China and India had emission concentrations more than twice then in United State. The authors argue that when facilitate the transfer of new technology, remove the market imperfections and given the economic freedom. So, the developing countries will able to reduce the emissions. Improvements in environmental quality through adopt the environmental technology.

To control pollution less costly technologies are introduce and then novel inventions and developments are came because of the R&D. Pollution prevention, remediation, restoration, control and monitoring and assessment are better handled with Technology for sustainable future (TSF) R&D. (Williamson, 2005) discuss the key federal strategies of environmental technology programs and coordinating mechanism. Different federal agencies like DOE, NASA, EPA, NSF and ETI try to made efforts to develop environmental strategy because these agencies clearly define the environmental missions and goals. Objective of the technology is to increase the invention in economy. Most of the laboratories are conducted on the base of the

R&D. The establishment of environmental technology in different sectors increase the development through R&D and uses of environmentally friendly technologies to avoid environmental damages.

There is a long-term relationship among technical innovation, technical growth and economic development. (Çalışkan, 2015), observe whether technical development indicators, which are used as a proxy for economic development, invention and the growth level of nations, are influenced by the used variables in this study. They detected the special effects of the variables on technical Development in different sub-groups. HTE and PAF are found to be the best effective variables on technical development for Turkey. The estimated results which were found by using (MDS)[7] and (HCA)[8] techniques recommend that the variables of (R&D), (PA)[9], (HE)[10], GNI per capita (PPP), (SWE)[11], (IU)[12] and (STJ)[13] have positive Effects on technical development and innovation and should be studied all together. The study resulted that Economic development rises the demand for science and technology and increases the innovational actions that will generate a persistent relationship among technical innovation and economic development in the flora and fauna.

[7] Multidimensional scaling
[8] Hierarchical cluster analysis
[9] Patent application, non-residents
[10] Health expenditure
[11] Share of woman employed in non-agriculture sector
[12] Internet users
[13] Scientific and technical journal articles

To examine the effect of technical invention and R&D on performance of the firm in the service sector of Nigeria by use of least square model by, (Adepoju, Olomu, & Akinwale, 2017) the outcome indicates that technical achievements, training and internal R&D definitely affect technical invention however government funding and person knowledge are irrelevant.

Similarly, technical invention and R&D have positive effect on firm's performance. Management has a critical part to show the invention development by producing conductive atmosphere for multinationals like applicable policies, organizations, legal structure and instruments. It should be essential for government to create a collaboration among the university circles and the business with suitable strategies as this will help for the generation of knowledge and distribution of technology in business. Government should want to inspire firms by decreasing taxes and tariffs in an economical way.

2.3 Intellectual Property (IP) and Technological innovation

Different nations achieve technology from side to side a range of networks that contain FDI, invention, imitation and piracy. The reinforcement of IPRs protection has different impact on the transfer of technology through these networks. The total outcome of IPRs security on invention and economic growth is rational to be unclear. (Rod & Neil, 2006) examine an irrelevant impact of IPRs protection in economic development of developing nations. However strong IPR protection be able to increase rewards in terms of better national invention and improved technology distribution in developing nations with abundant capability to invent, it has insignificant impact on innovation and distribution in those developing nations lacking of such capability and may enforce surplus costs.

To observe the relationship between, innovation, IPRs security and economic development in open vs. closed economy, by taking average yearly per capita GDP as a dependent variable by the (Gould & Gruben, 1996) using the Rapp and Rozek index of IPRs protection, used for the cross country data set of 95 countries, for the year 1960 to 1988, For empirical estimation a simple OLS and instrumental variable technique is used. By using three measure for capturing the result of openness; black market premium, real exchange rate distortion, and a trade index, he finds that by encouraging innovation IPRs protection will rise economic

development and this effect will be stronger in case of an open economy. For the reason that openness provides local firms a chance to participate with the innovative foreign firms and also supports in increasing inflow of FDI.

There is a positive relationship between technology innovation and performance, (Feng, Yu, Wang, & Hao, 2017) examine the technical invention on performance of steel and iron manufacturing by using the multiple linear regression analysis and Spearman rank correlation coefficient. The significant strategies should be established and legislated by government in iron and steel industry to place an extraordinary valuation in technology innovation. Steel inventiveness should change their means of progressing, altering and advancement.

A hypothetical and empirical analysis of IPR's and technology innovation in developing nations, (Chen & Puttitanun, 2005) examines the (IPRs) and innovation in developing nations by using linear regression model. The study concluded less significant as IPR's helps imitations of foreign technologies, which decreases the market control of the foreign firms and welfares the domestic firms. The empirical proof settles both the encouraging effect of IPR's on innovations in developing nations and the occurrence of a U-shaped correlation among IPR's and economic growth.

2.4 Intellectual Property (IP) and Foreign Direct Investment (FDI)

The Paper examines importance of IPRs protection and FDI for facilitating invention and development in both developing and developed countries and how innovation leads to economic development by finding factors of innovation and observing the effect of those factors of innovation along with other explanatory variables on economic growth rate observes by the (Schneider, 2005) takes a series of Panel data for 47 industrialized and developing countries, for the year 1970-1990 and used OLS and Fixed Effects Estimation (FE) method for the four years' time period of 5 years' interval. Transfer of foreign technology have a significant effect on invention rate of both industrialized and developing countries, the influence of IPRs on invention is significant for industrialized countries and insignificant for emerging countries, GDP per capita also helps invention as it is taken as the proxy of a country's knowledge stock and a rise in nation's knowledge stock leads towards

an increase in invention rate. Furthermore, the results from economic development regression recommend a stronger effect of foreign technology on GDP per capita as compared to domestic technology and the effect of FDI is inadequate.

The outcome of IPRs protection on developing countries depend on channel through which technology transfer takes place from developed countries to developing countries. (Lai, 1998) stated that more commonly stronger IPRs protection can be interpreted as an inspiration given by the developing countries to promote developed FDI by using a "dynamic general equilibrium model" finds that result of IPR protection taking place in developing countries will be positive if technology transfer is made through FDI, as FDI will increase production and diffusion of invention, and relative wages of developing countries. But the effect of strong IPR protection in developing countries will be opposite if imitation is the source of technology transfer.

To analyzed the channels of technology, transfer in industrialized economies including FDI and international trade. (Xu & Wang, 2000) Used OLS consistent covariance estimation technique with white's heteroscedasticity. They found that capital goods trade is a channel for industrial technology transfer; whereas, for industrialized countries they found no support that FDI inflow is an important channel for global technology transfer. Making use of panel data set on twenty-one OECD countries from 1971-1990, they established that R&D spillovers, included in capital goods trade, have a substantial positive influence on TFP growth of an economy, after controlling for the contributions of local R&D spillovers. The study determined that capital goods trade is a strong determinant for global technology transmission. They also explored the role of FDI. For this they used panel data set on thirteen OECD countries from 1983-90 and concluded that MNCs transmitted imported technology back to the home country; but they found no association between inward FDI and technology spillovers.

Dynamic research and development (R&D) creates the novel invention and technology transfer. Walz (1995) used the dynamic model, as FDI plays a vital part with respect to the global development and specialization patterns. New R&D produce high quality goods.

Mature developed (country A) and low wage rate (country B) that have comparative disadvantage with low research and development (R&D) are included. It focusses on strengthens IPRs to rise the stable state invention and development level. Country A provides an improved atmosphere for R&D than B. Country B is a low wage region implicitly assumed in steady state economy. R&D increases in country B because the higher degree of technology transfers.

2.5 Research Gap of the study

Green technologies are one of the fundamentals mitigation measures to deal with worldwide increase in temperature and erratic shift in precipitation. That's why Adaptation and mitigation measures are required to cater climate change issue. The study collects the literature on IPR's, R&D, Technological innovation and FDI from the different studies conducted in national and international level. Identification of green technologies is a new topic to be addressed in the context of Pakistan that's why literature on this topic is not available. The identified green patents are used to figure out green patents determinants. The studies on determinants of green technologies which are also reason for the technology transfer in developing countries as well as developed countries shows a negative, positive and ambiguous result between the protection of IPR's and technology transfer. Some studies show a negative result (Janjua & Samad, 2007) studied that IPRs don't contribute to economic development in developing nations like Pakistan. The protection doesn't benefit the developing countries directly, but it increases the overall well-being as stronger IPRs protection helps achieving international collaboration in developing countries.

There are some other studies signifying a progressive effect of a growth in the IPR protection in developing countries. IP protection play vital and significant role in technology development and technology transfer in developing countries, (Grossman & Helpman, 2016). Strong patent protection encourages permitting for the reason that it would decrease imitation risk and insecurity. Extensive range of technologies may be elaborate in addressing the climate change.

IPR's such as Patents, copyrights, trademarks and trade secrets will help in addressing the challenges of climate change. IPRs are a vital tool to achieve the climate change technology

that’s why developing nations immediately adopt the climate change technologies, (Canady (2009). Developing countries have not achieved their targets but successfully reduce the GHG emission through the R&D and achieved the energy efficient technologies and transformation of these new technologies in developing countries (David and Bate (2004). The R&D will be a vital part of the climate change, Research and development strategy alone won't work, except if the objective is too just to extend expand energy provision instead of essentially reduce the emissions. (Bosetti et al., 2013) Combing the R&D and climate policies might significant to productivity benefits and helps to cover climate strategy expenses. Cost-Benefit valuation of research and development in carbon storing as a way out to climate changes. IPRs protection has a significant impact on technology transfer later observing all other factor Research and development expenditure of parent firm, size of associates, market explicit factor, (Wakasugi, 2007).

Identification of green technologies helps us to know the level of multinational and national corporation priorities. The determinants of green technology also help us to strengthen and prioritize underlying factors.

Chapter III

Intellectual Property Organization (IPO) Pakistan

A patent is a contribution of reserved rights for an innovation to make, and exchange just as utilize the innovation for a restricted time of 20 years. The patent grant excludes others from making, using, or selling the invention. Patent protection does not start until the actual grant of a patent. A patent holder may give the approval, or license, to different parties to use the creation for the period in which the invention is secured. When a Patent deceases, the security closes and innovation enters in the public area, that is, the patent holder never again holds limited right to the innovation which gets the opportunity to be marketable misuse by others.

The implementation of IPRs in Pakistan has been very slow. After independence the share of IPRs products in total production was very small. But, its share increased over time. In the year 2000 alone copyright activities contributed around 4.45% to the GDP (IPO-Pakistan 2009). Regardless of this contribution the demand for copyright activities in the national market is extreme bigger than the supply, consequently Pakistan was net trader of copyright based products to the tune of 787 million US$ in the year 2008.

There is a comparatively small role of IPRs in domestic invention has been produced by different factors. Firstly, the level of education in Pakistan has been very low that's why awareness concerning the public about IPR's is not enough. Secondly, manufacturers and stakeholders were concerned to maximize their own incomes through outdated and import-substitution goods, due to incentives generated by the policy makers. Thirdly, a system of incentive and penalty to protect IPRs was not efficiently developed due to weak governance. Fourthly, development of trade industry in Pakistan has been very slow which is commonly reflected as an instrument of research and development as well as invention and development.

The Government of Pakistan took several actions to protect IPRs. The Patents and Designs Office was recognized in Karachi in 1948 beneath (Act, 1911). The office accepted applications for registration and renewal of patents, industrial designs and layout designs of integrated circuits. In last 25 years the office dealt with 25000 patent cases and 15000 cases of industrial designs. Likewise, Trademarks Registry Office was also recognized in Karachi in 1948 under the

Trade Marks Act 1940. The registry dealt with trademarks and geographical indications and published a trademark journal. The examination of applications usually took 30 months which were reduced to 3 months after automation but still 18-24 months' period is required for the issuance of registration certificates.

The Copyright Office was established in Karachi in 1963 under the Copyright Ordinance 1962 and later on an area office remained opened in Lahore in 1984. The organization registers IPRs, including story book and imaginative works, cinematographic works, music, publishing as well as computer programs. Till 2009 the office registered 20124 cases, including 14249 cases for artistic works, 4728 for literary works, 1040 for recorded works and 107 for cinematographic works (IPO 2009).

In IPO-Pakistan patent data there is a 95% of the patents are international patents, only 5% are the local patents which are registered in IPO that's mean we cannot develop the technology we can transfer the technology from developed nations. Effective protection of IPRs can attract surplus investments, encourage exports, protect customers and increase estimates for economic development. Protection of IPRs can be secure through active administration of technology that contains creation and transfer of technology. IPO-Pakistan was recognized in 2005 to attain this objective. IPO recognized the following IPRs for Pakistan (IPO 2017) as given in table 3.1.

Table 3.1: Types of IPRs

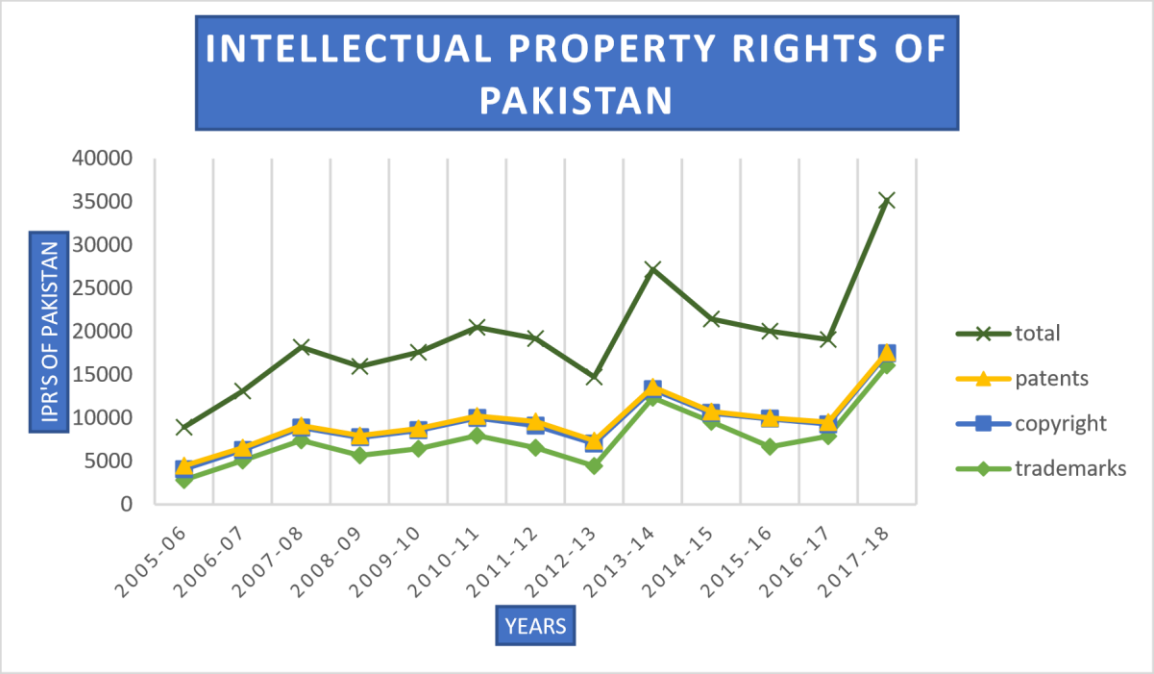
S.No	Intellectual property rights	Definition
1	**Patents**	Right of researchers and innovators to exclude others from commercialization of certain innovative products. Patents encourage innovation and enable public access to innovation.
2	**Trademarks**	These are symbols and words that differentiate goods of one industry from others. Trademarks encourage value products, promote competition, and protect industry from copying.
3	**Copyrights**	Exclusive rights of the creators to copy their workings or goods. These contain literary and artistic works, computer series, data stations, paintings, films, music, monuments, etc.
4	**Industrial designs**	These rights protect specific ornamental and artistic aspects of articles taking two or three dimensional features.
5	**Geographical indications**	These rights are used to protect certain names or symbols due to their geographic origin. These rights inspire conservation of high quality of traditional goods.

6	**Integrated circuits**	These are microcircuits or microchips used in electrical tools. These rights are similar to patents.
7	**Plant breeder rights**	These rights are used to secure the breeders for the growth of new breeds (plants). These rights encourage invention and increase the farm productivity.
8	**Genetic resources**	These rights refer to any material of plants, animal, microbial or other origin, having functional units of heredity.

(These all are the defined above are the different types of the IP rights 1-8 are administrated under some specific Acts and Ordinances. Subsequently, the focus of the study is on the patent data for the identification of green technologies)

The IPO aims to make sure combined supervision of technology and implementation management of all kinds of IPRs, which were previously under the field of different ministries and registry office. Furthermore, Federal Investigation Agency (FIA) was authorized to eradicate piracy by containing copyright law in the FIA Act 1974. Likewise, Pakistan Customs was started to control copying and piracy. Hence, IPO Pakistan has established a databank and it is cataloguing, modernizing and demonstrating IPRs in its official newsletter, journal and website. In recent times, it has presented E-Filing & Receipt System for fast and obvious acknowledgement of IPRs applications and renewal of IPRs within a specified time bound. Growth of IPR's are shown in the (Figure 3.1) as given below:

Figure 3.1: Growth of IPR's



Source - Intellectual Property Rights of Pakistan, Annual report (2017).

The graph shows the trends of granted IPR's in Pakistan, but in this study the main focus is only on the patents data (approximately 3,281 in numbers) which are used for the identification of green technologies. This graph shows a different trend in different years. In 2005-06, it shows an increasing trend, in 2012-13, it shows decreasing trend, but the most recent scenario shows an increasing trend in the registration of green technologies in IPO-Pakistan. The bumps in patent data are closely related to the destination of market size, and intellectual property protections. Patent data is used for the identification of green technologies. Identification is a rigor scientific process to find out how many technologies are green. Once the green patents are identified, then it is used to figure out green patents determinants.

3.2An overview of South Asian Economies

In most developing countries IPRs started with their participation in the International Covenant on Economic, Social and Cultural Rights (ICESCR 1996)[14], call for member

[14] The International Covenant on Economic, Social and Cultural Rights (ICESCR) is a multilateral treaty adopted by the United Nations General Assembly on 16 December 1966 through GA. It commits its parties to

countries to “Benefit from the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author.” ICESCR demands protection of both the individual and the product from the human right perception. ICESCR manages IPRs laws away from agreements and being the member state of ICESCR, Pakistan and many other developing countries also have to accept the laws implemented by it. ICESCR works in harmony with the laws created by World Trade Organization WTO[15] to protect human rights which is revealed in its IPR strategy. WTO and WIPO are the two entities which manage the laws about IPRs.

The events of “Paris Convention” (1883) for the Security of Industrialized Property and the “Berne Convention” (1886) for the Protection of Literary and Artistic Works were both controlled by WIPO and WTO. Since 1971, being the participant states of WIPO and as a party of the above stated conventions, Pakistan, Bangladesh, Sri Lanka and India have to accept the manuals about intellectual property rights by WIPO. Due to participation of WTO in other trade associated problems and non-availability of appropriate treaty about the IPRs, TRIPS was adapted. It was presented to manage problems and laws regarding IPRs during the 1986-94 Uruguay debates.

TRIPS support the protection provided by WIPO in the Paris and Berne Conventions, adding further protections to challenge shortages regarding IP protection. TRIPS agreement covers “copyright, trademarks, patents and other related areas of intellectual property including industrial design, geographical indications and trade secrets” (WIPO, 2016). Even though the implementation of IPR laws in the nominated South Asian countries was completed after the introduction of TRIPS agreement by WTO, the concept of intellectual property was introduced in these counties long back ago.

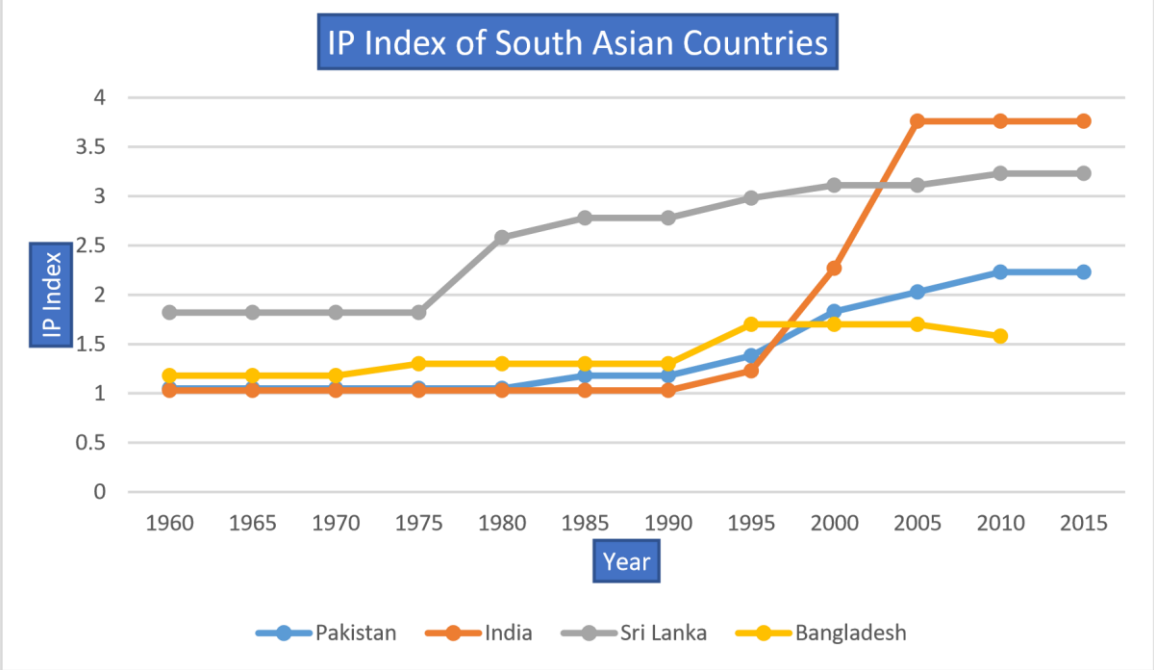
The importance of patent protection in the South Asia was acknowledged as soon as TRIPS agreement was introduced by WTO. Patent protection is significant because it provides an

work toward the granting of economic, social, and cultural rights (ESCR) to the Non-Self-Governing and Trust Territories and individuals, including labour rights and the right to health, the right to education, and the right to an adequate standard of living.

[15] The World Trade Organization (WTO) is an intergovernmental organization that is concerned with the regulation of trade between nations. It is the largest international economic organization in the world.

incentive to innovator to disclose his innovation. Disadvantaged of an incentive for innovation no one will participate in the inflated innovation process. One of the fundamental elements of the patent framework is to raise technological advancement by giving an incentive to innovative work and also works to distribute technological information and encourage technology transfer in developing countries like these South Asian countries which are the members of the WIPO. We can show the protection of patents in these countries by the help of the IP Index of these four countries as shown below in the (Figure 3.2):

Figure 3.2-Graph of Patent protection of South Asian Countries



Source: Walter Park and Ginarte Index

This graph shows an overview of Patent protection that's why we use IP index data from (Park and Ginarte index) from 1960-2015, the data for these four South Asian countries have been taken because of their membership in WIPO. The graph shows that the protection of patents is good in India and Sri Lanka as compared to Pakistan and Bangladesh, but there is much more need of the strong patent protection in these South Asian countries to raise the

green technology in developing countries which will help to reduce global warming and risk related to climate change. While, there is enormous GDP per capita development along with dramatic IPRs reforms in the South Asian countries, its economy is still facing the issue of technologically low-skilled labor. The South Asian countries like other developing countries are formulating national IPRs strategies to meet international standards of IPRs protection. This change is brought to challenge IPRs pressure coming from international trade partners and capture the possible benefit of TRIPS-level IPRs protection as a developing country.

Chapter IV

4.1 Data description and methodology

To achieve the first objective of the study that is identification of green technologies. The following methodology is used: -

4.1 Key Informant Interviews for Identification of green technologies:

The patent data of IPO-Pakistan which are 3,281 in numbers includes the patent related to different fields like chemistry, pharmaceutical, biology, biotechnologies and so on. Key informant interviews are taken from some respected teachers across the universities in Pakistan, and practitioner, who are expert in understanding functions of green technologies. Therefore experts (chemist, pharmacist, physist, biotechnologist etc.) were consulted for individual patent[16] to be considered as a green innovation or not. Based on the following definitions, green innovations are identified.

4.2 Green Technology:[17]

Green technology indicates technology that is considered environmentally friendly dependent on its creation procedure or production network. It additionally may refer to a method for energy making that is less harmful or dangerous to the environment than increasingly conventional methods for producing electricity, for example, consuming petroleum products and burning of fossil fuels that release high amount of CO_2 emissions in the environment. The central idea for the making of green technologies, which do not harm the natural assets, species and human health, using assets in a more sustainable manner, and for the purification of the waste.

[16] See the annex for patent application.

[17] Dr. Abdullah khan, DPhil oxford, Assistant Prof. Renewable energy department of environmental sciences, Q.A.U, Islamabad and Dr. Saqib Nasir, Principal Scientific Officer in Ministry of science and technology.

4.3 Green chemistry:[18]

Green chemistry, is also called sustainable chemistry, is concentrated on the designing of products and processes that reduces the use as well as generation of dangerous elements. While green chemistry centers on the impacts of polluting compounds on environment, green chemistry centers on the environmental effects of chemistry containing technological methods to avoiding pollution and decreasing use of non-renewable assets. The principal objectives of green chemistry-namely are, more resource efficient and naturally non-toxic designs of particles, materials, products and process can be followed in extensive variety of environments. Green chemistry includes the green catalyst, efficient processes, environmentally caring products, green and renewable raw material and green solvents.

4.4 Green biology:-[19]

Biology is the natural science that studies life and living organisms, including their physical structure, chemical process, molecular interactions, physiological mechanisms, development and evolution. Same as our ancestor's extracted abundant medicines from plants, which is known as green because it has no side effect on human health as these are considered in herbicidal medicines. We predict that the 21st century will witness a second Green Revolution, where current biology methodology will be used on plants and microorganism to improve innovative technologies for defending the environment degradation, solving the increasing food crises, and discovering the other energy sources which are eco-friendly e.g. solar energy as compared to traditional energy sources e.g. fossil fuels burning. In addition to the chemicals or compounds which are used in any manufacture process are less toxic or non-toxic which is consider in a green biology otherwise not.

4.5 Green Pharmacy:[20]

Green pharmacy is the plan of Pharmaceutical products and process that remove and decrease significantly use and generation of harmful elements and the reduction of environmental and

[18] Dr. Rohama Gill Ph.D in chemistry, head of the department in environmental sciences in F.J.W.U Rawalpindi.

[19] Dr. Naeem Ali, Associate Professor at department of microbiology Q.A.U Islamabad.

[20] Hussain Ali Ph.D, Assistant Professor in the department of pharmacy in Q.A.U, Islamabad.

health effects at the source. The treatment of any disease is also consider a green if the process of making medicine is safe and has no hazardous impact on human being and also for environment and the compounds which are used in procedure of making medicines are nontoxic or less toxic that does not affect the human health and also environment. The treatment of cancer does not include in green pharmacy because the rays of cancer therapy cause a harmful effect on human health. 60 % of the diseases treatment are included in the green pharmacy like skin diseases, asthma, HIV, T.B, Cardiovascular diseases and many others disease and remaining 40% are not included in green pharmacy like breast cancer, bladder cancer, blood cancer and other types of cancer. Nuclear medicines are also not considered green in pharmacy. There are also some patents which are the herbal treatment of any diseases which are the 100% environment friendly and consider as a green technology because it has no side effect on human health.

4.6 Methodology for second objective

For the second objective of the study, which is to find out the determinants of the green technologies in Pakistan. Secondary data of the variables are taken from different sources and the methodology for the second objective is given below: -

Table 4.1: Variables description.

The table briefly describe the variables used in the study and their sources from where these variables are taken for the study:

Variables	**Definition of the variables**	**Variables Source**
Green technologies	Green technologies are used as a dependent variable which includes those green technologies which are identified from the patent data of IPO-Pakistan.	IPO-Pakistan
RLFP	Royalty and license fee payment is used as an indicator to show the technical achievements.	world development indicator (WDI)
GDPgr	The GDP growth rate measures how fast the economy is growing. It does this by comparing one quarter of the country's gross domestic product to the previous quarter. GDP measures the economic output of a nation.	world development indicator (WDI),

IPindex	Intellectual property rights index based on the extent of coverage of patents, period of security, duration of participation in global patents treaties, requirements for loss of protection and enforcement system.	(Ginarte and Park index 1997)
EFW	Economic freedom of the world index which measures the security of Intellectual property right as it shows the economic developments like economic regulations and trade openness.	Fraser institute of economic freedom Annual report 2018.
CO_2 emissions	The conventional method of producing energy by burning of fossil fuels release the CO_2 emissions in the environment which causes the global warming, which effects the climate, sea level rise by melting the glaciers, and also harmful effects on agriculture sector.	Knoema database
R&D Exp	Research and development expenditure facilitates for the establishment of new technology, new varieties products and development in existing one which increasing productivity and rise the effectiveness which in turn decrease the cost and increases the economic development in the country.	UN statistical report

4.8 Econometric model and expected signs:

Green technologies = f (Royalty license fee payment, GDP growth rate, IP-index, Economic freedom of the world, carbon emissions, Research and development expenditure).

$$\mathbf{GT}it = \beta_o it + \beta_1\ \mathbf{RLFP}it + \beta_2\ \mathbf{IP\ index}it + \beta_3\ \mathbf{GDP}\text{gr}it + \beta_4\ \mathbf{EFW}it + \beta_5\ \mathbf{CO_2\ emissions}it + \beta_6\ \mathbf{FDI}it + \beta_7\ \mathbf{R\&D\ Exp}it + \varepsilon$$

In the study, different variables were used, including, count variable which is identified green technologies in Pakistan from the patent data of IPO-Pakistan. Variables are adopted after seeing the literature based on different national and international studies includes Samad & Nasir, 2014; Sattar & Mahmood, 2011, Gould & Gruben, 1996; Park & Ginarte, 1997). Table 4.2 shows the expected signs and expected results of the variables as given below:

Table 4.2 Expected results and signs

S.no	Variables	Expected signs	Expected results
1	Green Technology (GT)		It is used as a dependent variable which includes those green technologies which can identified from the patent data of IPO-Pakistan from 2005-2017
2	Royalty and License fee payment (RLFP)	Positive **(+)**	RLFP shows the positive relationship with green technologies as, if RLFP increases in Pakistan the investors want to register his invention in Pakistan, where he gets the maximum profit as compared to Indonesia where RLFP is very low.
3	Intellectual property index (IP index)	Pos. /neg. **(+/-)**	IP index may have a positive or negative relationship with green technologies as a small encouragement in IP enforcement encourages the firms and investors to invest more in developing countries like Pakistan and vice versa.
4	GDP Growth rate (GDPgr)	Positive **(+/-)**	The GDP growth rate measures how fast the economy is growing. GDP measures the economic output of a nation. The expected result of GDPgr is positive or may be negative. This expected result can be acceptable on the grounds that GDP is also a sign of income of a nation, with greater income, there will be more amount available for licensing fee which increases the market size results increase in opportunity cost then investors want to register his invention in Pakistan as compared to lower GDP countries and vice versa.
5	Economic freedom of the world (EFW)	Pos. /neg. **(+/-)**	The greater the economic freedom, the investment will be greater and trade among nations and the more will be the trade openness of Pakistan with other countries. On the opposite side, if there is limitation on investment and trade in Pakistan, it will reduce the registration of green technologies even in the presence of IPRs.

6	Carbon Emissions (CO_2 emissions)	Pos. /neg. **(+/-)**	When the CO_2 emission increases the green technologies become decreases its shows negative relationship between them but it may be a positive in a sense that if carbon emission increases in a Pakistan the interest of investors increases in Pakistan that it may possibly register their green technologies in Pakistan to reduce the global warming.
7	Research and Development Expenditure (R&D exp)	Positive **(+)**	Research and development expenditure shows a positive relationship with green technologies as it helps for the establishment of new technology, which increasing the productivity and rise the effectiveness which in turn decrease the cost and increases the economic development in the country, which increases the market size and registration of green technologies increases in Pakistan.

Dependent count variable

The dependent variable of the study is the green technologies that is count variable (a non-negative integer). Most of the data are concentrated on a few small discrete values. The Poisson, binomial and negative binomial models are used to represent the count data distribution, when it is treated as an arbitrary variable. The number of occurrences of an event predicted by the poison model, it can be used when conditional mean is equal to the conditional variance of the dependent variable, if this assumption of Poisson model is violated (conditional variance exceeds the conditional mean), we can use negative binomial model because there is an over dispersion in a data.

4.7 Time series Analysis

There is a limitation in the study for using the time series analysis. To have a realistic and significant results it's better to have the minimum 30 years' data but in the study the data available is only for 13 years 2005-2017. In this study we use a time series analysis to find out the determinants of green technology in Pakistan, That's why, we take identification of green technologies as our dependent variable and other variables, we taken are IP index,

GDPgr, RLFit, EFW, CO_2 emissions and R&D expenditure by using the time period 2005-2017. There are some important steps that we take to account to check our data: -

4.7.1 The stationarity of time series data:

From Stationary we mean, when the series is with constant mean and constant variance. From literature it is found that different test like Augmented Ducky fuller test (ADF) and Phillips-Perron test (PP) are applied to check the unit root problem in the data. Augmented Dickey-Fuller (ADF) test is used in this study for checking the stationary of the variables which are identified green technologies (dependent variable), IP index, GDPgr, RLFP, EFW, CO_2 emissions and R&D expenditure. We apply the Augmented Ducky Fuller test (ADF) for checking whether the data is stationary or non-stationary of time series data The ADF test is presented by (Fuller, 1979), presented following equation;

$$\Delta\tau t = \alpha\tau t{-}1 + \delta Xt\,' + \epsilon t$$

Whereas, $Xt\,'$ are optional exogenous regressors, these may be trend or a constant or both, and δ are parameters to be estimated, and ϵt are error term assumed to be white noise. The null and alternate hypothesis can be stated as:

$H_{0:}$ $\rho = 0$, shows there is a unit root problem (non-stationary series).

$H_{1:}$ $\rho \leq 0$, shows no unit root problem (stationary series).

4.7.2 Co-integration test

Co-integration shows the significant or long run correlation between economic variables, if the two variables are co-integrated it mean that there is Long run and significant correlation among them, when the residual is non-stationary and variable is stationary so they are co-integrated and long run relationship is there. If all variables are integrated of I (0) the stationary be in level and VAR model followed by impulse response function and variance decomposition will be used. If all the variables are integrated of I(1) then Johansen co integration analysis will be carried while if the variables are I(1) and same as I(0), then ARDL bound test for co-integration will be practical. There are two different methods used to examine the co-integration among time series data via Engle Granger approach and

Johansen approach. (Johansen, 1988) developed a method for finding that how many variables are co integrated with each other, it is one of the best test of co-integration. Johansen approach is better than Engle Granger approach as Granger approach require large sample, dependent, independent variables must be identified and also it is difficult in situation when there are more than two-time co-integrating relationship. If co-integration test confirms that there exists co-integration then we apply any of econometric model OLS, ARDL Model, ECM etc. and the regression will be not more spurious. But in this study we use ARDL-Bound test for examining the co-integration among the determinants of the green technologies in Pakistan, because the variables are stationary at I(1) and I(0).

Chapter V

Estimation and results

5.1 Result of Identified Green Technologies

After a very hectic and lengthy process[21], out of the total innovations registered in Pakistan 55 % of the innovations are green. Similarly, this study also traced out inventor address who registered their innovations in Pakistan. 95% of the patents are invented in developed nations and rest of the 5% are invented in Pakistan that's mean we are not developing or creating the technologies but importing these technologies from developed nations. Furthermore, sectoral analysis was also carried out to see which industry dominates green innovation in Pakistan. Pharmaceutical industry dominates the green patent because of its large registered innovations.

Table 5.1 and fig 5.1 tease out patent data since 2005 to see the frequency of green patens in Pakistan.

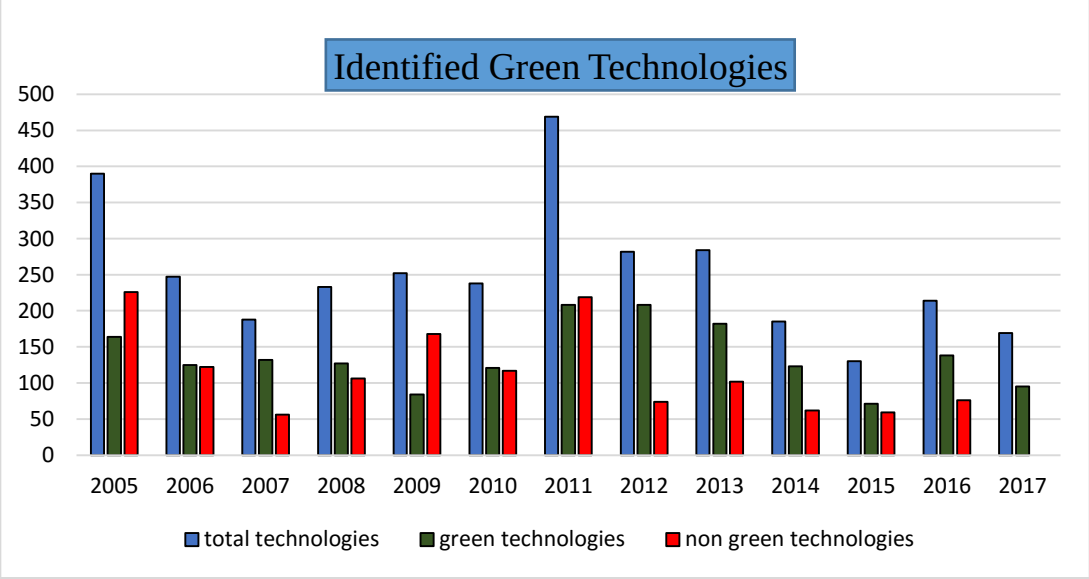
Table 5.1: Identified Green technologies.

S.no	Year	Total Technologies	Green Technologies
1	2005	390	164
2	2006	247	125
3	2007	188	132
4	2008	233	127
5	2009	252	84
6	2010	238	121
7	2011	469	250

[21] Read all the patent applications. Most of them were very technical and it was hard to understand. Consulted each of the applications with the relevant stockholders and matching with the above definition.

8	2012	282	208
9	2013	284	182
10	2014	185	123
11	2015	130	71
12	2016	214	138
13	2017	169	95
Total	**…….**	**3281**	**1820**

Figure 5.1 Identified Green Technologies:



5.2 Methodology for Time series

For the second objective of the study, which is to find out the determinants of the green technologies. Secondary data of the time series variables are taken from different sources and the methodology for the second objective is given below: -

5.2.1 Descriptive statistics

Table 5.2 Descriptive Statistics of the Variables

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Green tech	13	130.83	39.30	71	208
RLFP	13	0.0014	0.0044	0.0009	0.0022
GDPgr	13	4.35	1.84	1.59	7.66
IP index	13	2.18	0.07	2.03	2.23
EFW	13	4.32	0.37	3.79	5.06
CO_2 emissions	13	0.89	.04	0.84	0.99
R&D expenditure	13	0.28	0.16	0.09	0.63

The identified green technologies are used as dependent variable. Table 5.2 shows that the mean value of the green technologies (130.83) is not equal to the variance (1544.49), the assumption of Poisson model is violated here because there is over dispersion in a data, and the conditional variance exceeds the conditional mean. So we can use negative binomial model for our study.

Results for negative binomial Model

Table 5.3 Negative Binomial Model

Variable	Coefficient	Probability value
LnRLFP	0.0041	0.494
GDPgr	-0.1658	0.290

IP-index	-2.3707	0.560
EFW	0.0044	0.995
CO_2 emissions	-6.5804	0.216
R&D exp	1.6977	0.233
Alpha = 0.0728		

In table 5.3 a negative binomial model was estimated to examine the determinants of green technology influences the registration of green technologies in Pakistan. The result shows that the dispersion parameter is statistically significant. The result indicates that the data used in this study was influenced by the problem of over dispersion, so supporting the evidence for the use of the negative binomial regression for analyzing the data. After applying the negative binomial model we have found the following results, due to data limitation none of the variable is statistically significant in our study. There is a positive relationship between the royalty license fee payment, Economic freedom of the world, and Research and development expenditure with green technologies registrations as if one unit increase in royalty license fee payment, EFW and R&D expenditure then the number of green technology registration will rise by 0.41%, 0.44% and 169% in Pakistan. There is a negative relationship between GDP growth rate, IP-index and carbon emissions as if one percent increase in GDP growth rate, IP-index and carbon emissions, green technologies registration is decreases by 16%, 230% and 658%. The results conclude there is need of more strengthened and protected IPR's system, more economic integration, more economic development in Pakistan to rise up the green technologies registration in Pakistan.

5.2.2 Testing stationarity

Before testing co-integration, we tested unit root in order to find that whether the data is stationary or non-stationary. Augmented ducky fuller test (ADF) is applied and results are shown in the table 5.4 below: -

Table 5.4 Results of ADF (Augmented Dickey Fuller)

Variables	ADF(test statistics)	Probability values	Integrated	Results
GT	2.25	0.1990	I(0)	Accept H_0
LGT	3.74	0.0015*	I(1)	Reject H_0*
RLFP	0.714	0.9857	I(0)	Accept H_0
LRLFP	5.67	0.0012*	I(1)	Reject H_0*
GDPgr	7.11	0.0014*	I(0)	Reject H_0*
EFW	1.17	0.6460	I(0)	Accept H_0
EFW	2.86	0.0086*	I(1)	Reject H_0*
IP-index	4.38	0.0065*	I(0)	Reject H_0*
Co_2 emm	3.19	0.0515	I(0)	Accept H_0
Co_2 emm	2.97	0.0069*	I(1)	Reject H_0*
R&D exp	1.41	0.5368	I(0)	Accept H_0
R&D exp	12.086	0.0000*	I(1)	Reject H_0*

Table 5.3 illustrates that the level data for all variables was non-stationary as it can be observed that p-values of each variable is greater than 0.05 at level only two variable GDPgr and IP-index are stationary on level I(0) and other variables which are GT, RLFP, EFW, Co_2 emm and R&D exp are stationary at first difference I(1). However, stationarity is obtained at level data as well as first difference, where p-value of all variables is less than 0.05. So the ADF test confirms the

mixture of I(0) and I(1) so in this study we use ARDL model for checking the co-integration among variables.

5.3.3 Co-Integration Analysis

According to ADF, unit root test of all variables, are of I(0) and 1(1) and none of the variables is of 1(2). So the suitable technique to co-integration is the ARDL approach, which help to check the existing of long run relationship between determinants of green technology in Pakistan or not.

Table 5.5 Result of ARDL-Bound test:

Variables	Lag 1 (f-stat value)	Lag 2 (f-stat value)	Results	
LNGT LNRLFP GDPGR IP_INDEX EFW CO_EMM R_D_EXP.	0.41	2.86	No co-integration	In Conclusive

2.88-3.99, 2.27-3.28, 1.99-2.94 are the lower and upper critical values for bounds testing ARDL at 1%, 5%, and 10% significance levels, respectively.

Table 5.5 shows the result of ARDL-Bound test model, the value of F-Stat is less than the lower and upper bound so we can accept our null hypothesis concluding that there is no co- integration among variables of the study at lag 1. In lag 2 the results are in-conclusive because the value of F-stat is lies between lower and upper bound, a decision cannot be made without knowing the order of integration of the underlying regressors. The results are not good because of limited data of the variables. There is a no long-run relationship exist between the variables of the study. The results may be good and significant, when the data set is large as compared to this study which has only 13 years data.

5.3.4 Ordinary Least square (OLS)

After taking growth rate of all the variables, they become stationary at level I(0) that why we used OLS (ordinary least square) model for getting the results. The econometric form of the model is as under:

$$\mathbf{LnGTg = \alpha + \beta_1\ LnRLFPg + \beta_2\ LnGDPg + \beta_3 LnIPindexg + \beta_4\ LnEFWg + \beta_5 Lnco_2emmg + \beta_6\ LnR\&Dg + \mu}$$

Where; α = Constant

LnGTg = growth rate of green technologies,

LnRLFPg = growth rate of royalty license and fee payment.

LnGDPg = growth rate of GDP

LnIPindexg = growth rate of IP-index

LnEFWg = growth rate of economic freedom of the world

$Lnco_2emmg$ = growth rate of carbon emissions.

LnR&Dg = growth rate of research and development expenditure.

μ = Error term

Table 5.6 results of ADF after taking growth rates:

Growth rate of Variables	**ADF(test statistics**	**Probability value**	**Integrated**
LnGT	17.45	0.00	I(0)
LnRLFP	6.21	0.00	I(0)
LnGDP	6.89	0.00	I(0)
LnIP-index	3.23	0.04	I(0)
LnEFW	4.77	0.01	I(0)

LnCo$_2$emm	3.33	0.03	I(0)
LnR&D	3.63	0.02	I(0)

Table 5.6 shows the result of ADF after taking the growth rate of the variables used in the study. All variables are stationary at level I(0), as the P-value are less than 5%. So the ADF test confirms that all variables are stationary at level, so we can use OLS for further results.

5.3.4.1 Auto correlation test

Now we estimated OLS regression but after analysis we find that OLS regression result are subject to autocorrelation problem and according to CLRM if there is problem of autocorrelation it will lead to biased result. So we will remove the problem of autocorrelation by applying LM test statistic are given as under.

Table 5.7 Auto correlation test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.238158	Prob. F(1,4)	0.6511
Obs*R-squared	0.674326	Prob. Chi-Square(1)	0.4115

H_0 = there is no auto correlation.

H = there is auto correlation.

The above result confirms that there is no autocorrelation problem. In above result probability value is 0.6511 which don't reject Ho and we conclude that there is no autocorrelation problem. Now we have removed the problem of autocorrelation and we will apply OLS model which will be valid and interpretable.

Table 5.8 Results of OLS:

Growth rate of Variables	Co-efficient	T-statistics	Probability value
C	-3.6332	-0.1473	0.8886
LnRLFP	0.3575	0.3179	0.7643
LnGDP	-0.3496	-0.4874	0.6465
LnIP-index	-16.9124	-0.6194	0.5627
LnEFW	-3.4136	-1.0599	0.3376
$LnCo_2emm$	-0.0633	-0.6199	0.5373
LnR&D	0.1512	0.2151	0.8381

Table 6.8 shows the results of OLS after taking the growth rate of all variables of the study for getting the results of the determinants of the green technology in Pakistan. The values in the above table of results reveal the following. One percent increase in royalty license fee payment will increases the green technology licensing by 0.36%. Hence the relationship between the royalty license fee payment and green technology is positive, that's mean if the RLFP increases in Pakistan then the registration of green technologies also increases in Pakistan that is much needed for the country like Pakistan, which is more vulnerable to climate change and vice versa. GDP growth rate has negative relationship with the dependent variable green technology, the result shows that one percent increase in GDP growth rate will decrease the number of green technology registration by 0.34%, but in literature it has a positive relationship with green technologies, this result is negative because of limitation of data. from literature we found positive or negative results of IP index because it indicates the protection of IPR's (patents) in a country, so in Pakistan the protection of IPR's (patents) are not very strong and good that why it shows negative relationship with green technologies, as One percent increase in IP-index will reduce the green technologies registration by 16.9%. The possible reason for this negative

relationship might be the framework of the industries in the Pakistan. 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 them more instead to convert in to green inventions. Economic freedom of the world has also negative relationship with green technologies as it shows the trade openness, as Pakistan has not been efficiently involved in economic integration, so one percent increase in Economic freedom of the world will reduce the green technology registration by 3.4%. Due to its high coefficient value the impact of economic freedom of the world is highest among all variables. Carbon emissions also has a negative relationship with green technologies as one percent increase in carbon emission will reduce the green technologies registration by 0.06% in Pakistan. This can be justified as due to the lack of resources and insufficient empirical research available on the contribution and vulnerability to the hazardous impacts of CO_2 emissions to our developing economy the registration of green technology may not be in a sufficient or required number.

On the other hand, R&D expenditure plays positive role in green technologies registration. The coefficient of R&D expenditure shows that as a result of 1% increase in R&D, the green technologies registration will increase by 0.15%. Give emphasis to R&D introduces the green technologies to decrease the environmental damages. Green technologies are mostly dependent on R&D usually and green R&D. R&D expenditure develops the new inventive goods and pledges the green technologies. R&D expenditure would help in development 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 confirms sustainable development. Such products would also be useful in decreasing pollution and reducing the environmental degradation. Active R&D decreases the greenhouse gas emissions and energy efficient technologies. But due to data limitation none of the variable is statistically significant in our study.

Chapter VI

Conclusion and Policy Recommendations

6.1 Conclusion

Similarly, this study also traced out inventor address who registered their innovations in Pakistan. 95% of the patents are invented in developed nations and rest of the 5% are invented in Pakistan that's mean we are not developing or creating the technologies but transfer these technologies from developed nations. Furthermore, sectoral analysis was also carried out to see which industry dominates green innovation in Pakistan. Pharmaceutical industry dominates the green patent because of its large registered innovations.

For the second objective of the study was to found out the determinants of green technology in Pakistan by using the time series analysis for the time period 2005-2017. As above mentioned that the dependent variable of the study is count variable so we apply Negative binomial model, because there is an over dispersion in our data. The results of Negative binomial model are that all variables are the statistically insignificant because of data limitation. RLFP, EFW, and R&D exp shows positively insignificant results and GDPgr, IP-index and carbon emissions shows a negatively insignificant results that mean Pakistan has need to be increase the economic integration and economic development and also need the strengthened and protected legislation system of IPR's that will help to increase the registration of green technologies in Pakistan to combat with the rising challenge of climate change.

Furthermore, time series econometrics analysis confirm that all variables used in this study are non-stationary at level, they become stationary at different integrated orders I(0) and I(1), for that ARDL model was introduced by (Pesaran et al. 1999) in order to incorporate I(0) and I(1) variables in same estimation. The ARDL-bound test reveals that there is no co-integration and no long run relationship exist between variables of the study. After no co-integration results, we take the growth rate of all the variable and they become stationary at level I(0), OLS was applied for getting the results of the determinants of green technology. Before applying the OLS, auto correlation test was also applied to check the auto correlation problem, where the result confirms that there is no auto-correlation problem. So, we apply the OLS model, where all variables show

the insignificant results with green technology due to limitation of data, the results may be significant if the data set will be increases. RLFP and R&D expenditure shows positive relationship with green technologies, on the other hand, IP-index, GDPgr, EFW and CO_2 emissions shows negative relationship with green technologies. The results of negative binomial model and OLS was same because from the results of the both model we found that all variables are statistically insignificant, and shows positive and negative relationship with registration of green technologies.

6.2 Policy recommendations

- Pakistan IPR's legislation gradually to be enforced.
- The role of ministries (Ministry of climate change/Environment), organizations (IPO-Pakistan), and Word Intellectual Property Organization (WIPO) should emphasize on the role of IPR and Green technology development in Pakistan.
- R&D expenditure base should be strengthened, which will boost inventive efforts to develop green technologies in Pakistan.
- The royalty license fee payment for inventors of green technology should be increases in Pakistan that helps to increases the registrations of green technologies in Pakistan.

6.3 Limitation of the study

This study has a very small data set 2005-2017 (13 years), as we know that for applying the time series analysis the data required is minimum 30 years, that is the reason for getting the insignificant results. So, for the future research the large data set will be helpful to getting a significant result.

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Appendix

There are 3,281 Patent application are registered under the IPO-Pakistan from 2005-2017. Patent application of year 2006 and 2016 are attached, that shows how much lengthy and hectic process of identification of green technologies done in this study.

United States Patent [19]

Toki et al.

[11] **Patent Number: 4,773,361**

[45] **Date of Patent: Sep. 27, 1988**

[54] **OVERHEAD CAM TYPE FOUR-VALVE ACTUATING APPARATUS FOR INTERNAL COMBUSTION ENGINE**

[75] Inventors: **Susumu Toki; Takeshi Iwata; Noriaki Fujii,** all of Saitama, Japan

[73] Assignee: **Honda Giken Kogyo Kabushiki Kaisha,** Tokyo, Japan

[21] Appl. No.: **893,951**

[22] Filed: **Aug. 7, 1986**

[30] **Foreign Application Priority Data**

Aug. 8, 1985 [JP] Japan 60-174588

[51] **Int. Cl.**[4] **F01L 1/26**

[52] **U.S. Cl.** **123/90.23;** 123/90.4

[58] **Field of Search** 123/90.27, 90.6, 90.22, 123/90.23, 90.4, 90.41, 90.44

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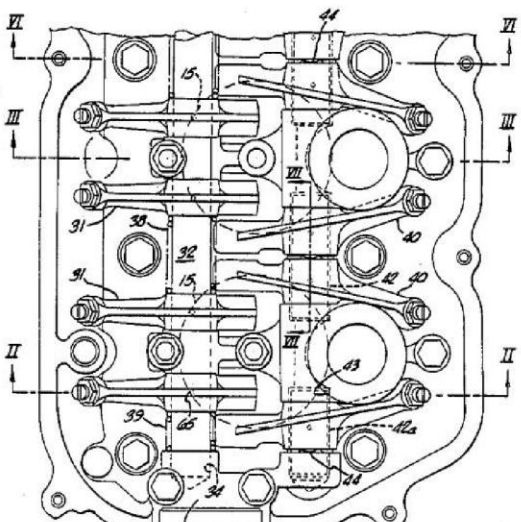
Primary Examiner—Charles J. Myhre
Assistant Examiner—David A. Okonsky
Attorney, Agent, or Firm—Lyon & Lyon

[57] **ABSTRACT**

An OHC type internal combustion engine with four valves per cylinder in which a single cam shaft extending longitudinally is engaged by individual rocker arms for each valve for pivoting those rocker arms to actuate the valves. The pairs of exhaust valves on one side of the engine are actuated by rocker arms mounted on a continuous rocker arm shaft. The intake valve rocker arms are mounted on a plurality of short shafts supported by their ends. A cam shaft holder is positioned over each cylinder and they serve to rotatably support the cam shaft, support the continuous rocker arm shaft, support the ends of the plural rocker arm short shafts, and to permit access to the spark plug for that cylinder. The spark plug has its electrodes located at the center of the combustion chamber and is inclined outwardly for access from between the intake valve rocker arms for that cylinder.

16 Claims, 4 Drawing Sheets



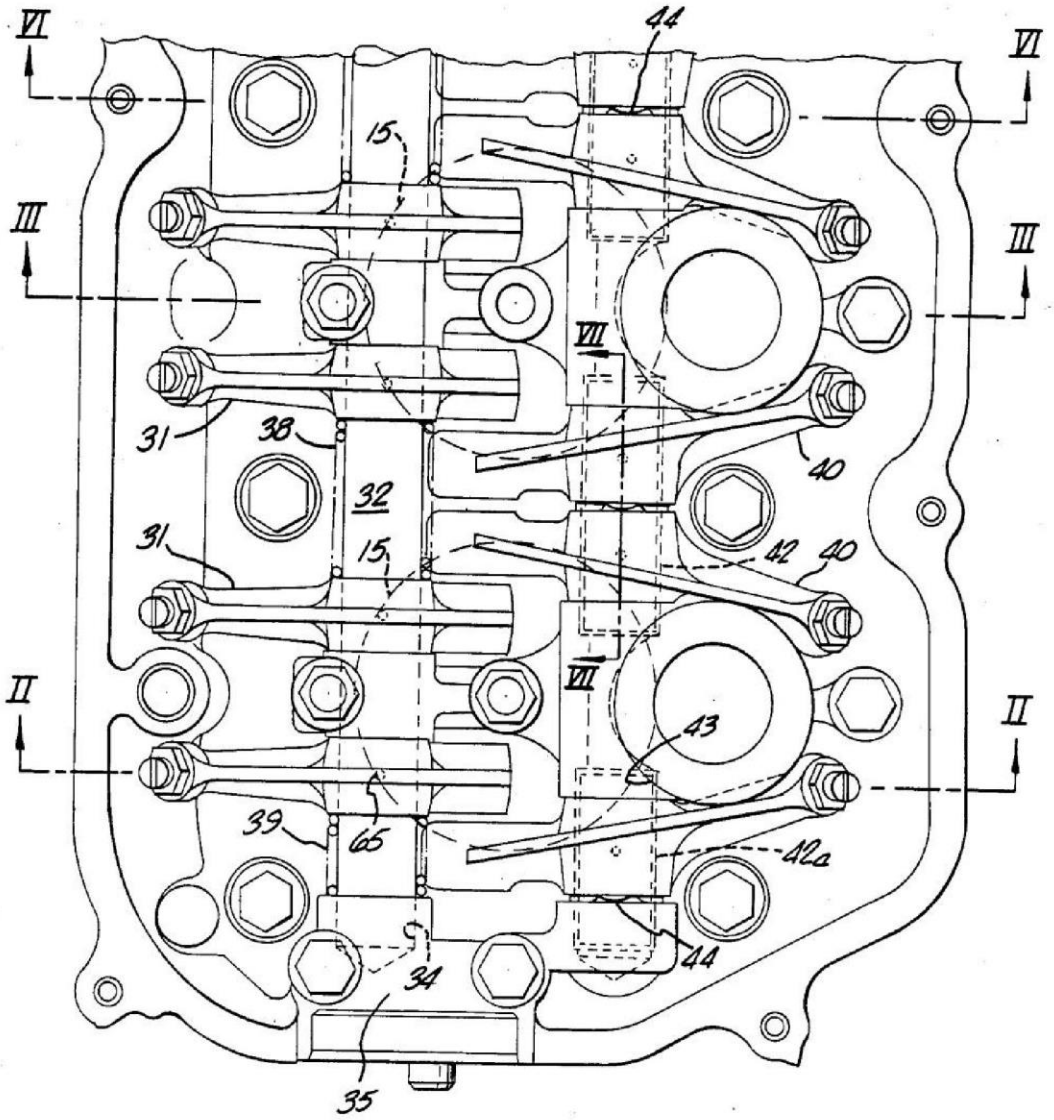

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FIG. 1

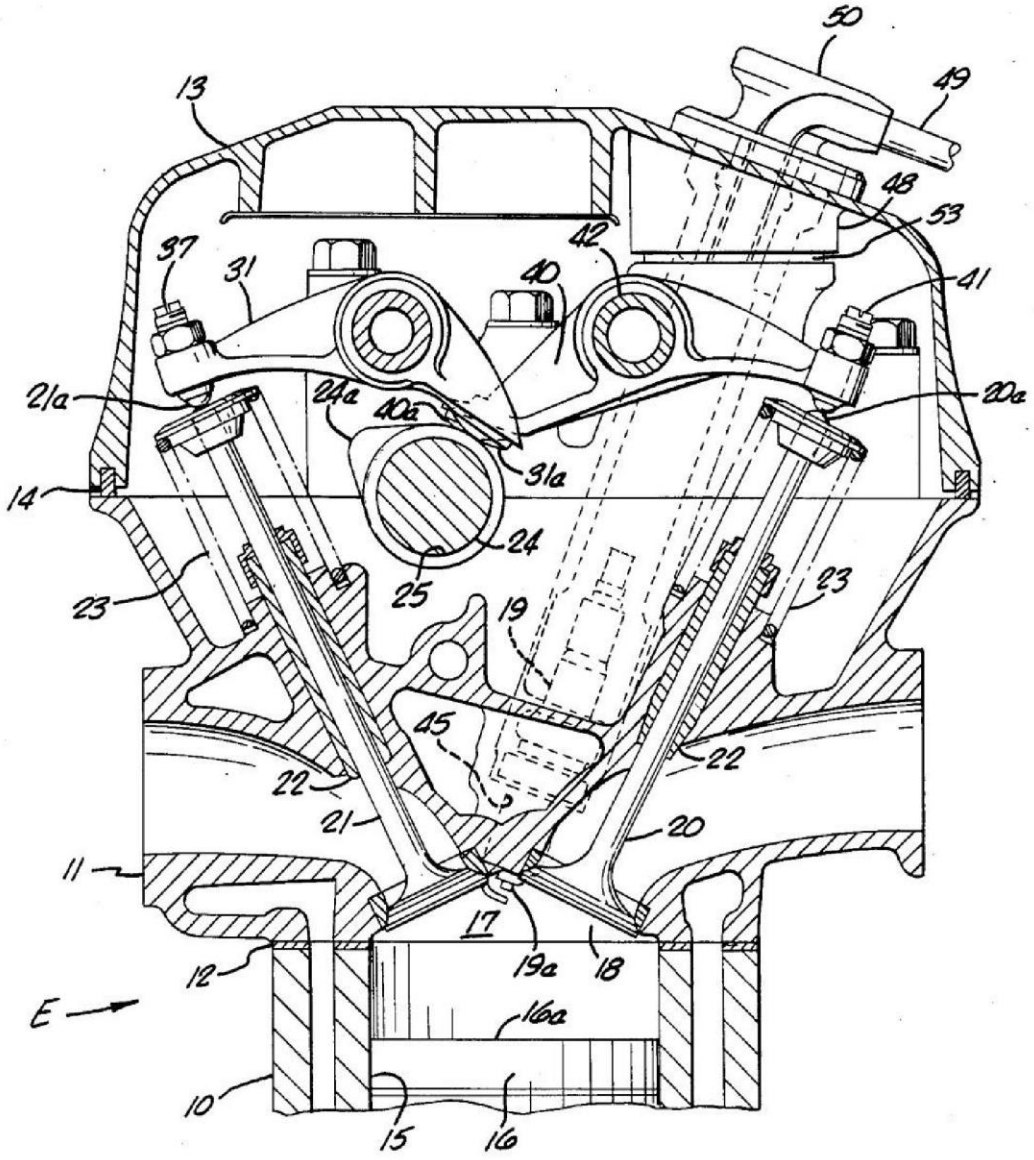
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FIG. 2.

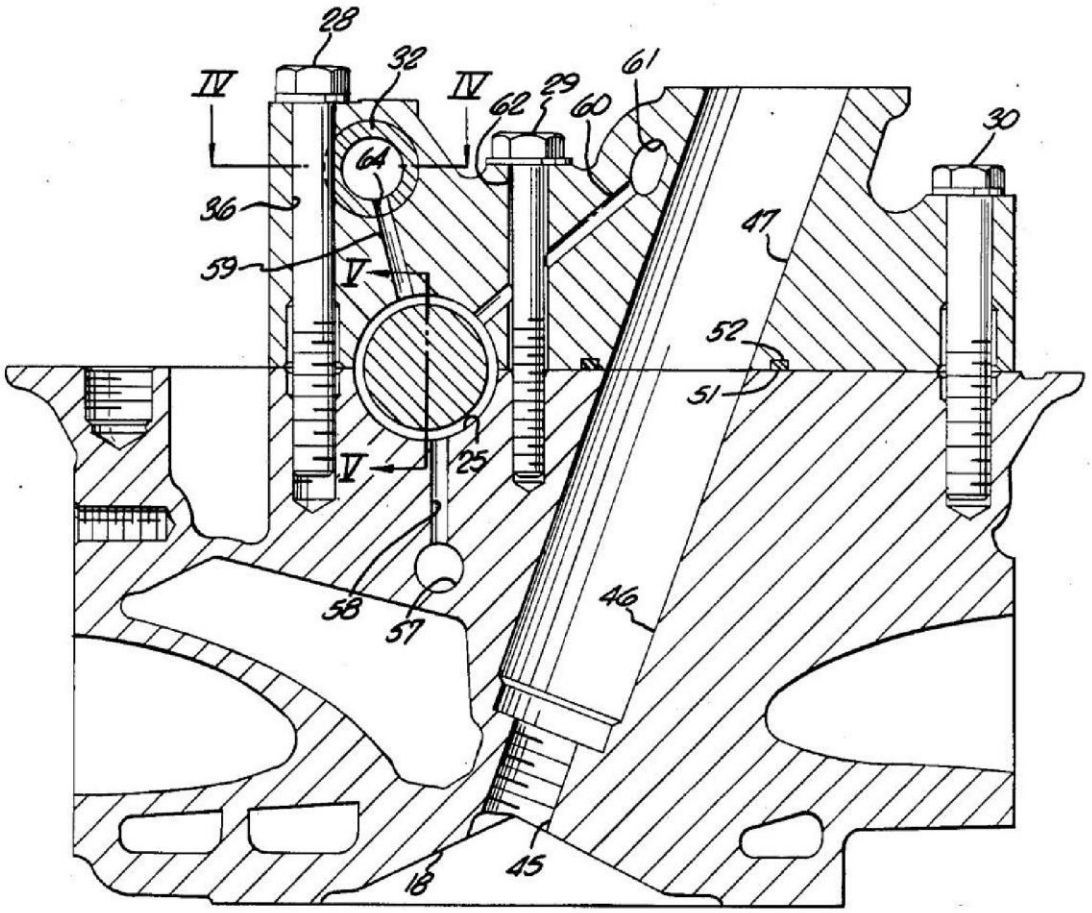

FIG. 3

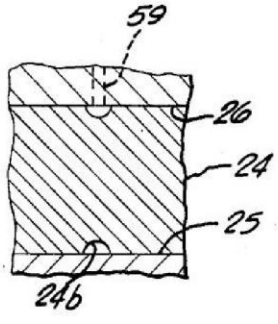

FIG. 5

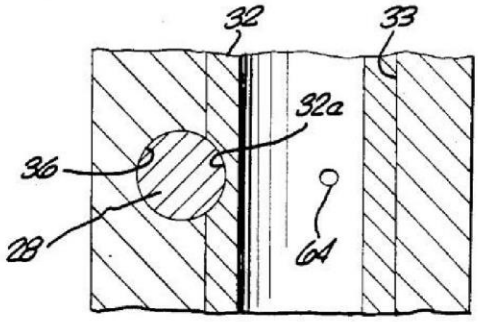

FIG. 4

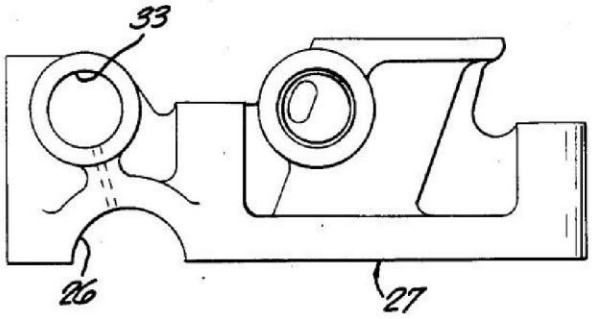

FIG. 8.

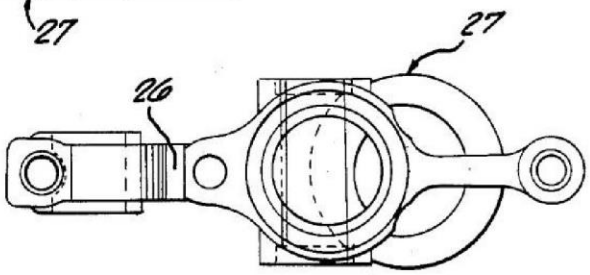

FIG. 9.

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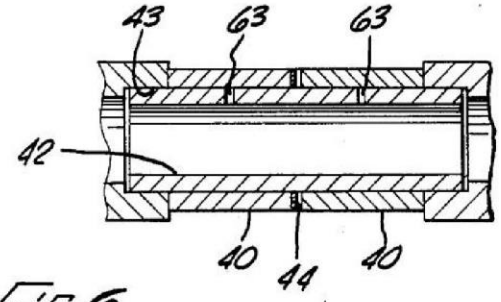
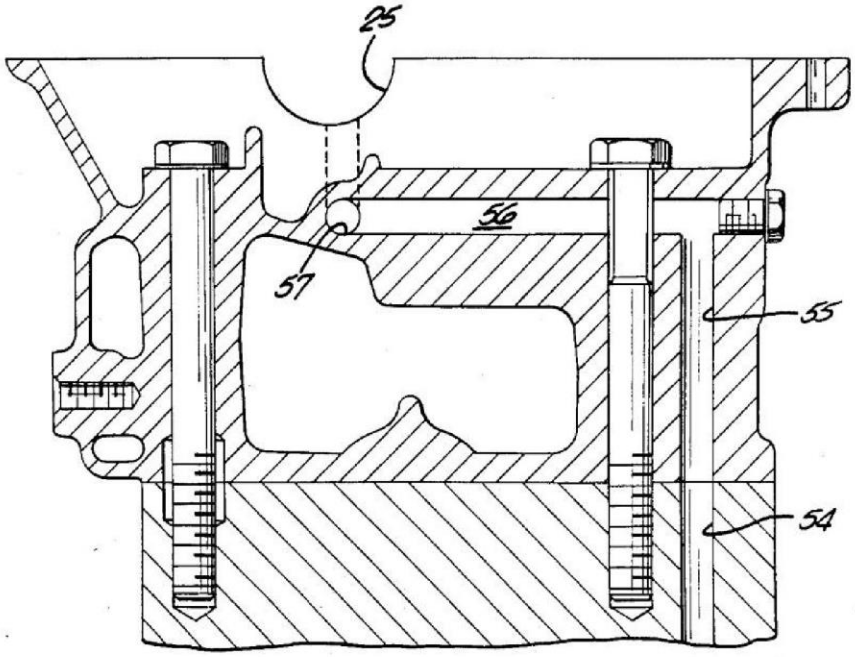


FIG. 7.

FIG. 6.



OVERHEAD CAM TYPE FOUR-VALVE ACTUATING APPARATUS FOR INTERNAL COMBUSTION ENGINE

This invention relates to an overhead cam ("OHC") type valve actuating apparatus for a four-valve type internal combustion engine having a pair of intake valves on one side of each cylinder and a pair of exhaust valves on the other side of each cylinder.

There are various arrangements of valve operating apparatus in a OHC type internal combustion engines, such as, dual cams with each cam positioned over a row of valves for directly actuating those valves or positioned to one side with rocker arms for indirectly actuating those valves, or a single cam with rocker arms for actuating one or both rows of valves indirectly. An arrangement using rocker arms has the advantage of ready access to the valve lifter adjusting devices but requires rocker arm pivotal supports, either rocker shafts or individual supports for each rocker arm, and therefore the number of components required normally increases and the space becomes crowded. This is particularly true of an OHC internal combustion engine having four main valves per cylinder.

Another factor to consider in the design of an internal combustion engine is that it is desirable for the electrodes of the spark plug to be disposed centrally in the ceiling of the combustion chamber in order to propagate the combustion flame of the fuel-air mixture induced by the spark discharge of the spark plug throughout the whole area rapidly and evenly from the center of the combustion chamber to all the marginal portions to thereby prevent knocking and improve the combustion efficiency.

However, as noted above, in conventional OHC type valve actuating devices in four-valve internal combustion engines, the space is very crowded since at least one valve actuating cam shaft is rotatably supported in the cylinder head and normally separate intake and exhaust rocker arm shafts or support means are fixed on both sides of the valve actuating cam shaft with intake and exhaust rocker arms pivotably mounted on those rocker arm shafts thereby interconnecting the intake and exhaust valve actuating cams on the valve actuating cam shaft to the intake and exhaust valves. Therefore, the space above the central part of the combustion chamber is occupied by a number of valve actuating members leaving very little space available for positioning the electrodes of the spark plug centrally in the combustion chamber and for easily installing and removing the spark plug. Consequently, it has heretofore been necessary to dispose the spark plug in a position to one side of the combustion chamber adjacent the valve actuating members or at least substantially inclined to one side. However, the installation and removal of the spark plug is still difficult and the numerous components of the valve actuating device causes the apparatus to become very large. Further, the reduction in space caused by the spark plug creates a problem for properly supporting the rocker arms on that side of the engine.

Moreover, since the OHC valve actuating apparatus includes numerous moving components that must be lubricated such as bearing portions for supporting the rotation of the valve actuating cam shaft, the rocking support portions for the rocker arms, and the interengagement between the cams and the rocker arms, the oil supply system for forcibly supplying oil to all those components is extremely important and can become complicated in construction, thus leading to increases in cost. Further, because of the need for an effective oil supply system, the components of the valve actuating mechanism are restricted to some degee in their arrangement and mounting, which is an obstacle to having a more compact valve actuating mechanism.

Thus, it is an object of the present invention to provide a valve actuating apparatus for a OHC type four-valve internal combustion engine in which the spark plug can be disposed centrally in the combustion chamber and easily installed and removed, and in which the valve actuating mechanism is compact and yet structurally effective to attain a reduction in size and in cost of the mechanism.

A further object of the present invention is to provide a lubricating system for an OHC type four-valve actuating mechanism in an internal combustion engine of a simple construction and capable of supplying lubricating oil precisely, consistently and forcibly to each portion required to be lubricated of the valve actuating mechanism.

The preferred embodiment of the present invention is illustrated in the accompanying drawings, wherein:

FIG. **1** is a top plan view of a portion of an internal combustion engine having the valve actuating mechanism of this invention with the valve cover removed.

FIG. **2** is a sectional elevation view taken substantially on the line II—II in FIG. **1** with some components shown in elevation for clarity of illustration.

FIG. **3** is a sectional elevation view taken substantially on the line III—III in FIG. **1**.

FIG. **4** is an enlarged, fragmentary sectional plan view taken substantially on the line VI—VI in FIG. **3** and illustrating a portion of the lubricating system.

FIG. **5** is an enlarged, fragmentary sectional plan view taken substantially on the line V—V in FIG. **3** and illustrating another portion of the lubricating system.

FIG. **6** is a sectional elevation view taken substantially on the line IV—IV in FIG. **1** and illustrating another portion of the lubricating system.

FIG. **7** is an enlarged, fragmentary sectional elevation view taken substantially on the line VII—VII in FIG. **1** and illustrating another portion of the lubricating system.

FIG. **8** is an elevation view of the cam shaft holder removed from the engine for clarity.

FIG. **9** is a bottom view of the cam shaft holder of FIG. **8**.

While the present invention will be described in detail with respect to a specific embodiment thereof incorporated in an in-line engine with all of the cylinders in a single row rather than a V-type or other type engine, and with specific components of one conventional type engine, it will readily appear to those skilled in the art that the invention is equally applicable and adaptable to various other engine types and components.

Referring now in detail to FIG. **2** of the drawings, an internal combustion engine body E for an in-line, OHC engine includes a cylinder block **10** and a cylinder head **11** attached thereto in sealed relation through a gasket **12**. A valve cover **13** is mounted on top of the cylinder head **11** in sealed relationship through a gasket **14**. A plurality of cylinders **15** are provided in the cylinder block **10** in a longitudinal row. A piston **16** is provided in each cylinder **15** and connected to a crankshaft (not shown) in the conventional manner to reciprocate within the cylinder **15**. A combustion chamber **17** is

formed between the top surface **16***a* of the cylinder and a ceiling **18** formed in the cylinder head **11**. A spark plug **19** is mounted in cylinder head **11** in a manner described more fully hereinafter and has its electrodes **19***a* positioned in approximately the center of the ceiling **18** of the combustion chamber **17** to provide the most desirable location for ignition of the combustible mixture. A pair of intake valves **20** are positioned to one side of the center of each cylinder and a pair of exhaust valves **21** are positioned to the other side with the faces of the four valves **20** and **21** comprising a portion of the ceiling **18** of the combustion chamber **17** when the valves are closed. Although it is not essential to this invention, the intake valves **20** may be larger than the exhaust valves **21** for enhancing the intake of the fuel-air mixture into the cylinder **15**. Each of the valves **20** and **21** is slidably mounted in its own valve guide **22** and continually urged toward a closed position by a spring **23** in a conventional manner.

A cam shaft **24** is rotatably mounted on the cylinder head **11** by semi-cylindrical bearings **25** formed at longitudinally spaced locations in the top of the cylinder head **11** at the location of each cylinder and at each extreme end of the cylinder head. Conventional bearing caps **35** are provided at each extreme end of the cylinder head to cooperate with the bearing portions **25** to rotatably support the ends of the cam shaft **24**. A downwardly facing semi-cylindrical bearing surface **26** is provided in cam shaft holders **27** to rotatably support and confine the cam shaft **24**. A cam shaft holder **27** is provided above each cylinder **15** and is mounted to the cylinder head by three bolts **28**, **29** and **30**. The cam shaft **24** is provided with four cam lobes **24***a* for each cylinder to engage each of the four rocker arms, as described below that actuate each of the four valves **20** and **21** for each cylinder.

Each of the exhaust valves **21** is actuated by a rocker arm **31** that is pivotally supported on a rocker arm shaft **32** extending the length of the engine. Rocker arm shaft **32** is supported in a bore **33** provided in the longitudinal direction through each cam shaft holder **27** and a blind hole **34** in the end bearing caps **35**. The bore **33** and vertical hole **36** for bolt **28** in each cam shaft holder **27** may intersect, as shown in FIGS. **3** and **4**, and the rocker arm shaft **32** be provided with an external notch **32***a* at the location of each bolt **28** to prevent rotational or longitudinal movement of the rocker arm shaft **32** relative to the cam shaft holders **27**. Each rocker arm **31** is provided with a slipper portion **31***a* for engaging the exterior of the cam shaft **24** and being moved by the lobe **24***a*. Further, each rocker arm **31** has an adjustment screw **37** on its opposite end for engaging the top **21***a* of the exhaust valve **21** in a relatively conventional manner. As shown in the plan view FIG. **1**, the exhaust valve rocker arms **31** are positioned immediately adjacent the cam shaft holders **27** and extend substantially straight from the point of engagement with the cam shaft **24** to the point of engagement with the top **21***a* of the exhaust valve **21**. A compression spring **38** surrounds the rocker arm shaft **32** and extends between the rocker arms **31** of adjacent cylinders to resiliently maintain the proper longitudinal position of the rocker arms. Similarly, a compression spring **39** extends between the last rocker arms **31** and the end bearing caps **35**.

Each of the intake valves **20** is actuated by a rocker arm **40** pivotally supported in a manner hereinafter described for a slipper portion **40***a* to engage the cam shaft **24** and be pivoted by a cam lobe **24***a* with an adjustment screw **41** on the opposite end engaging the top **20***a* of the intake valve **20** for actuating that valve. Each intake rocker arm **40** is pivotally supported on a short shaft **42** with adjacent rocker arms **40** of adjacent cylinders **15** being mounted on a single short shaft **42** while the rocker arms **40** at the extreme ends of the engine are separately mounted on a separate short shaft **42***a* supporting only a single rocker arm **40**. Each short shaft **42** has its ends supported by two different cam shaft holders **27** by means of the countersunk bores **43** provided in each longitudinally facing side of each cam shaft holder **27**. The end short shaft **42***a* has one end supported in a bore in the end bearing cap **35**. As shown in plan view FIG. **1**, the intake rocker arms **40** have a relatively straight portion extending from their pivotal mounting on the short shaft **42** to the slipper portion **40***a* engaging the cam shaft **24** but have an angled portion extending to the top **20***a* of the intake valve **20** since the rocker arms **40** are pivotally supported at a location offset from the locations of the intake valves **20**. The pivotal support of rocker arms **40** by the short shaft **42** is extremely stable and accurate since each short shaft **42** is supported at both ends rather than being cantilevered from a bracket. The use of a plurality of short shafts **42** as the intake rocker arm support means rather than a single continuous shaft similar to the exhaust valve rocker arm shaft **32** is necessary to provide space between the intake valves for the spark plug and access to the spark plug. However, structural integrity is not sacrificed by the arrangement of this invention. A spring washer **44** is provided on the rocker arm shafts **42** and **42***a* between each pair of adjacent rocker arms **40** and between the end bearing caps **35** and the last rocker arm **40** for resiliently maintaining the proper longitudinal position of the rocker arms **40**.

The spark plug **19** is threadedly mounted in a bore **45** in the cylinder head **11** located at the center of the ceiling **18** to position the spark plug electrodes **19***a* at the center of the combustion chamber **17** for the best ignition performance, as noted above. The threaded bore **45** and the enlarged upward extension bore **46** thereof are inclined at an angle to the vertical but in a plane perpendicular to the longitudinal axis of the engine. Another cylindrical bore **47** is provided in the cam shaft holder **27** of the same size and in axial alignment with the bore **46** to extend even further upwardly. A tubular boss **48** is provided in the valve cover **13** in alignment with the bores **45**, **46** and **47** whereby access to the spark plug **19** is possible from outside the valve cover **13**. An ignition wire **49** is connected to the spark plug through a cap **50** that mates with the tubular boss **48** to enclose the axis opening to the spark plug. The bores **45**, **46** and **47** may be positioned at any convenient angle to miss the other components of the valve actuating mechanism but it is preferred that the spark plug be as close to vertical as possible. In the embodiment illustrated the spark plug axis bores **46** and **47** are at approximately 20 degrees from vertical. An O-ring **51** is positioned in the groove **52** in the bottom surface of the cam shaft holder **27** and surrounds the bores **46** and **47** to seal those bores from the interior of the valve cover **13** and cylinder head **11** to exclude lubricating oil. A gasket **53** is provided between the boss **48** and the top surface of the cam shaft holder **27** surrounding the bore **47** to similarly seal the interior of bore **47** from the interior of the valve cover **13**. It should be noted that the bore **47** intersects the longitudinal projection of the multiple rocker arm short shafts **42** which, as previously noted, is

the reason for using a series of short shafts rather than a single shaft that would interfere with the desired location of the spark plug and access to the spark plug.

Lubrication of the aforedescribed valve actuating mechanism is provided in a convenient and unique manner which will now be described. An oil supply passage **54** in the cylinder block **10** from the conventional oil pump (not shown) communicates with a vertical passage **55** and lateral horizontal passage **56** and in turn to a longitudinally extending main oil passage **57** in the cylinder head **11**. The main oil passage **57** is immediately below and parallel to the cam shaft **24** and riser ports **58** connect the main oil passage **57** to each semicylindrical bearing portion **25** rotatably supporting the cam shaft **24**. At least one of the cam shaft holders **27**, for example, one of the cam shaft holders toward the middle of the engine, is provided with a port **59** extending from the cam shaft bearing surface **26** to the bore **33** that supports the rocker arm shaft **32** and another port **60** extending from bearing portion **26** to a passage **61** extending between the longitudinally facing bores **43** that support the rocker arm short shafts **42**. Port **60** actually intersects the bore **62** for mounting bolt **29** but an annular space or clearance is provided between the bolt **29** and bore **62** for allowing the lubricating oil to flow pass that location from the bearing portion **26** to the passage **61** in the cam shaft holder **27**. The short shafts **42** are tubular, as shown in FIG. **7**, to communicate the lubricating oil throughout the length of the intake valve rocker arm shaft means comprised of the short shafts **42** and cam shaft holders **27**. The short shafts **42** are provided with radial ports **63** for communicating the lubricating oil to the bearing surface between the short shafts **42** and the rocker arms **40**. The continuous rocker arm shaft **32** is tubular and is provided with a port **64** in alignment with port **59** for supplying lubricating oil to the interior of the shaft **32**. Shaft **32** is provided with a port **65** at the longitudinal location of each rocker arm **31** to lubricate the bearing surface between the rocker arm shaft **32** and each rocker arm **31**. The cam shaft **24** is provided with a circumferential groove **24***b* at the location of the oil ports **59** and **60** of the cam shaft holder **27** to conduct the lubricating oil from the riser port **58** to the ports **59** and **60**. In this manner, the cam shaft **24** and all of the rocker arms **31** and **40** are forcibly and continuously lubricated.

Thus, according to this invention, a valve actuating mechanism is provided that employs a single overhead cam for operating rocker arms to actuate four valves for each cylinder and yet the spark plug is properly located with its electrodes in the center of the combustion chamber and is accessible for routine maintenance without removal of any of the valve actuating mechanism or valve cover. The rocker arms are supported in a structurally reliable manner through a single rocker arm shaft for all of the exhaust valve rocker arms and a plurality of short shafts for all of the intake valve rocker arms with each such short shaft being supported from both ends. Further, a lubricating system is provided for lubricating the cam shaft and each of the rocker arms from the inside of the rocker arm shafts with pressurized lubricating oil.

The invention claimed is:

1. In a four-valve, overhead cam internal combustion engine having plural cylinders in a line and a pair of valves on each side of said line for each said cylinder, a valve actuating apparatus, comprising: a single cam shaft rotatably mounted between said pairs of values above and extending longitudinally along said line of cylinders, a first rocker arm shaft means mounted parallel to said cam shaft and having a plurality of rocker arms pivotally mounted thereon and engaging said cam shaft for actuating the pairs of valves on one side of the line of cylinders, a second rocker arm shaft means mounted parallel to said cam shaft and having a plurality of rocker arms pivotally mounted thereon and engaging said cam shaft for actuating the pairs of valves on the other side of the line of cylinders, said second rocker arm shaft means including a plurality of separate short shafts with each short shaft pivotally supporting two rocker arms of which one rocker arm operates one valve for one cylinder and the other of said two rocker arms operates one valve for an adjacent cylinder, each said short shaft having two ends which are supported in spaced relation from the ends of each adjacent short shaft, and means mounted directly above each cylinder for supporting each of the two ends of each short shaft with said rocker arms pivotally supported thereon between said ends.

2. The apparatus of claim **1** wherein said support means includes a cam shaft holder mounted directly above each cylinder with longitudinally facing bores on each side for receiving and supporting the respective ends of two said short shafts.

3. The apparatus of claim **2** wherein said short shafts are tubular and passage means connect the two said longitudinally facing bores of each said cam shaft holder for conducting lubricating oil to all the short shafts and thereby the entire said second rocker arm means.

4. The apparatus of claim **3** wherein each said cam shaft holder includes port means for conducting lubiricating oil to said passage means.

5. The apparatus of claim **2** including a plurality of longitudinally spaced cam shaft holders overlying said cylinders and wherein each said cam shaft holder includes a longitudinally extending bore therethrough for receiving and supporting said first rocker arm shaft means.

6. The apparatus of claim **5** wherein, said first rocker arm means is tubular, and at least one of said cam shaft holders includes port means for conducting lubircating oil to the interior of said tubular first rocker arm means.

7. The apparatus of claim **2** wherein said cam shaft holder includes a spark plug mounting means for mounting a spark plug at approximately the center of the top of the cylinder, said spark plug mounting means providing access to the spark plug on the side of and between the pair of rocker arms for that cylinder that are pivotally supported on said short shafts.

8. The apparatus of claim **7** wherein said spark plug mounting means includes an inclined tubular portion extending partially between the ends of adjacent short shafts.

9. The apparatus of claim **7** wherein each said cam shaft holder includes a longitudinally extending bore therethrough for receiving and supporting said first rocker arm shaft means.

10. The apparatus of claim **1** including a cam shaft holder mounted directly above each cylinder, said cam shaft holder comprising a bearing cap for rotatably supporting said cam shaft, mounting means for supporting both the first rocker arm shaft means and the said ends of the short shafts of the said second rocker arm shaft means, and an access opening for a spark plug mounting means.

11. The apparatus of claim 1, wherein a spring washer is provided on each said short shaft between said two rocker arms mounted on that short shaft for resiliently urging said rocker arms against said supporting means.

12. In an OHC four-valve actuating apparatus of an internal combustion engine having a cylinder head and plural cylinders in a line with a pair of exhaust valves on one side of the line of cylinders and a pair of intake valves on the other side for each cylinder, a cam shaft above the cylinders, rocker arms and rocker arm shaft means for actuating the valves from the cam shaft, the improvement comprising, a separate cam shaft holder mounted a top the cylinder head directly above each cylinder and extending laterally of the line of cylinders, said cam shaft holder having means for partially encircling the cam shaft and supporting the rocker arm shaft means, and said cam shaft holder having an opening therethrough for access to a spark plug mounting for the cylinder below that cam shaft holder.

13. The apparatus of claim 12, wherein said cam shaft holder includes passages therein for receiving lubricating oil from the engine and conducting the lubricating oil to the rocker arm shaft means for lubricating the rocker arms.

14. The apparatus of claim 12, wherein the rocker arm shaft means for the rocker arms for the intake valves is comprised of a plurality of short shafts with each said short shaft extending between and supported at both ends by a pair of said cam shaft holders.

15. The apparatus of claim 14, wherein said spark plug mounting opening in each said cam shaft holder has a portion located between the ends of the short shafts supported by that cam shaft holder,

16. The apparatus of claim 14, wherein a spring washer is mounted on each said shaft between a pair of rocker arms on said short shaft for resiliently urging said rocker arms away from each other.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,773,361

DATED : September 27, 1988

INVENTOR(S) : Susumu Toki, Takeshi Iwata, Noriaki Fujii

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 5, line 68 change "values" to --valves--.

Signed and Sealed this

Twentieth Day of March, 1990

Attest:

JEFFREY M. SAMUELS

Attesting Officer

Acting Commissioner of Patents and Trademarks