# IPRs, Level of Technology and Exports: Empirical Evidence

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***Abstract***

*Since the passage of agreement on Trade-Related Intellectual Property Rights (TRIPS) under the World Trade Organization (WTO) in 1995, the policy makers and researchers have been focusing on the study of potential impact of Intellectual Property Rights (IPRs) on international trade and investment. IPRs regime is a significant policy tool that drives innovations by firms and subsequently the technological change in an economy. This study proposes an alternative perspective concerning the channel through which countries gain from IPRs as it influences the level of technology of a country that further stimulates its exports. Therefore, it is interesting to study the relationship between IPR and exports, by the level of technological activities of the source countries and examine the effect of IPR protections on the level of technology and concomitantly on high technology exports. This study computes a technology index through principle component analysis to analyze the level of technological activity across countries. This study uses two-stage least square equation models during 1996-2014 of 67 countries. The empirical results exhibit that the host countries' IPR positively influences the level of technology and that further stimulates exports.*

**Keywords: IPRs; Level of technology; Exports.**

## 1. Introduction

There is a tremendous rise in trade and investment flow between countries – specifically, the flow of technology and technology-intensive products (Shin et al., 2016). Since the passage of Agreement on Trade-Related Intellectual Property Rights (TRIPS) under WTO in 1995, the policy makers and researchers are focusing on the study of the potential impact of Intellectual Property Rights (IPRs) on international trade and investment. IPRs have been internationalized with the agreement of TRIPS that requires developing countries to devise IPR laws including patent rights as per the minimum standards. These minimum standards are expected to bring benefits to the developing countries by creating the incentive structure essential for knowledge generation and diffusion, technology transfer and private investment flows (Braga, 1995; Fink and Braga, 2005). IPRs regime is a significant policy tool that drives innovations by firms and subsequently the technological change in an economy. The history of patent system reveals that developed economies formulated IPRs regime according to the strategic trade policy (Kaufer, 2012).

Enormous theoretical and empirical literature predominantly study the impact of changes in IPRs regime on countries' economic growth including different channels of growth, namely to stimulate research and development (R&D), productivity growth and technology transfer (Gould and Gruben, 1996; Park and Ginarte, 1997; Thompson and Rushing 1996; Yang and Maskus, 2001; Kanwar and Evenson, 2003; Schneider, 2005; Chen and Puttitanun, 2005; Falvey et al. 2006; Allred and Park, 2007; Kim et al., 2012; Awokuse and Gu, 2015; Sweet and Maggio, 2015). Gould and Gruben (1996) suggest that IPRs protection is a significant determinant of economic growth. Park and Ginarte (1997) provide differential effects of IPRs on economic growth as they find that strong IPRs influence the R&D activities of the developed countries and not of the developing economies. Thompson and Rushing (1996) also empirically evaluate the influence of IPRs on economic growth. They estimate that there is a significant positive relationship between IPRs and economic growth in developed countries. Kanwar and Evenson (2003) show stronger IPRs protection can help spur innovation and technological progress, which in turn should impact growth positively. Schneider (2005) finds that stronger patent rights have a positive effect on innovation in developed countries, while Chen and Puttitanun (2005) confirm the U-shape relationship exist between innovation and IPRs protection of a developing country. Moreover, Falvey et al. (2006) find that the effect of IPRs on growth for low and high-income countries is positive and statistically significant but not for middle-income countries. Thus, these studies suggest that there is an ambiguous relationship between IPRs and economic growth including different channels of growth in a cross country framework.

Country and firm specific technological advantage emerges as a result of perceived market opportunities (Vernon, 1966) and it also comes out from essentially unpredictable and immeasurable entrepreneurial activities (Lindbeck, 1981). Both Vernon (1966) and Lindbeck (1981) stress the importance of technology factor in international competition, which is based on country-specific advantage. The determinants of national pattern of innovative activities reflect very different statements about their nature of technology advantage. There are very few advanced economies, as US, Japan and Germany that are identified as technology leaders and such economies are moving towards the world technology frontier, by original innovation and invention (Holfmann, 2013; Shin et al., 2016). Earlier theoretical and empirical literatures emphasize the contribution of technology to trade. The neo technology theories[1] underline the role of the technology gap, particularly in determining the trade pattern across countries (Posner, 1961; Vernon, 1966; Krugman, 1979). According to neo-technology theory of international trade, technology[2] is recognized as an important component of the international competitiveness of high-wage countries (Pavitt, 1985, 1988). However, Kumar and Siddharthan (1994) argue that the technology factor also plays an important role in explaining the export performances of Indian enterprises. Moreover, export performance and IPRs protection differ across countries due to the level of technology, innovation, patent right, market structure, and product specification. Shin et al. (2016) suggests “the levels of technology (using patent data) vary between developed

[1] The principles of new technology theories are adapted for describing the trade behavior of developing country enterprises (Kumar and Siddharthan, 1994).
[2] That is knowledge of design, production, and sale of product, process, systems and services.

and developing countries, which raises questions about the derivation of economic benefits from TRIPS, such as the ability to gain export markets" (p.775). Against this backdrop this study measures the level of technology by computing a technology index, including both input and output indicators of innovation (which will be discussed in detail later). Therefore, it is interesting to study the relationship between IPR and exports, by the level of technological activities and innovative capacity of the source countries, and examine the effect of IPR protection on the level of technology in high technology exports.

This is the first paper, in our knowledge, which studies the effects of source countries' IPRs on the level of technology and further how the level of technology influences the high technology exports of the country. Our approach to the problem from the source country perspective is significant as it will introduce the variation in terms of host country factors after these economies implemented patent policy changes to comply with TRIPs. Thus, it is pertinent to study from their perspective the gain through improvement in the level of technology and concomitantly via high technology exports. This paper uses a large panel dataset consisting of 67 countries for the recent period 1996-2014[3]. The empirical results based on two stage least square model exhibit that the source countries' IPRs index positively influences the level of technology. The coefficient of IPRs with respect to exports is larger for high income countries than it is for middle income countries. This result implies that high income countries' technological activities are possibly the major beneficiaries of a strong IPR system. The level of technology is positively related to high technology exports. We find that the present IPRs system has a distribution bias, in which a strong IPRs regime favours the expansion of high income countries' exports related to that of middle income country exports. This study also provides a strategic role of IPRs and its different weights for countries' exports performances.

The rest of the paper is organized as follows. The next section sets the background by reviewing the existing evidence on technology capabilities, IPRs and exports by describing their inter-relationship. Section 3 provides the econometric estimation and construction of the model. The empirical results are presented in section 4. Section 5 summarizes and concludes the paper.

## 2. Conceptual framework

Endogenous growth theory postulates that technology adaptation, innovation and imitation are the key factors for the technological progress in a country. In the major part of developed as well as developing countries, technology adaptation and imitation are the important sources for technological progress and a successful catching-up process (Romer, 1990; Hofman, 2013). Technological capability is required to enable a country to efficiently buy, use, modify, adapt and improve the original technology and also to screen and examine the foreign technology advances (Lall, 2000; Kumar and Siddharthan, 2013). Moreover, Pavitt (1987) puts the technological development as:

[3] The choice of the dataset is based on the introduction of TRIPs and the availability of data.

*"Most technology is specific, complex. . .[and] cumulative in its development. . . It is specific to firms where most technological activity is carried out, and it is specific to products and processes, since most of the expenditures is not on research, but on development and production engineering, after which knowledge is also accumulated through experience in production and use on what has come to be known as 'learning by doing' and 'learning by using'." (p. 9)*

Internalist and externalist theories also explain the development of technology. Internalists argue that technological development is an evolutionary process, in which future is determined by the past. Whereas, externalists postulate that technology is determined by the economic need, by stimulating invention (Mokyr, 2010). Lall (1992) classifies the determinants of technology development under incentives, factor market and institutions. Incentives arise from macroeconomic environment, trade policy, domestic industrial policy and domestic demand that influence investment in technology capabilities. Factor market in technological development is technical skill, finance for technological activity, and access to information, domestic and foreign. Institutions that support industrial technology are education and training, R&D, technical extension, technology and export information (Lall, 2000).

Many empirical studies bring to light the role of technology in advanced countries' trade. Gruber et al. (1967) suggest technology plays an important role in explaining trade and find that US industries related with high R&D activities have proportion of the output as exports. Sveikauskus (1983) finds technology play a major role in explaining US competitiveness. Caves et al. (1980) find that industry's R&D intensity is positively related to net exports of Canadian industries. Moreover, Soete (1981, 1987) studies OECD countries' 40 industries and suggests that patents play a significant role in a country's export performance. Van Hulst et al. (1991) find that there is a positive association between the pattern of export specialization and the technology specialization in the case of Germany, The Netherlands and Sweden. Verspagen and Wakelin (1993) argue that trade is mostly influenced by technology (either R&D or patents) and labour cost.

Archibugi and Pianta (1992) investigate the determinant of the technological specialization of advanced countries, using patent count and citation as technology indicators. The study finds an inverse relationship between countries' technological size, as measured by cumulative R&D expenditure and degree of specialization. However, in the context of developing countries, many studies find that technology is not significant in explaining trade performance of such economies. Dasgupta and Siddharthan (1985) suggest that largely goods of Indian exports consist of low technology. Kumar (1990) observes that R&D intensity and technology imports do not significantly influence export performance of Indian industries. Moreover, in case of Brazil, Willmore (1992) finds that R&D expenditure has no significant effect on its exports.

The literatures cited above confirm the importance of technology in explaining the trade performance in advanced countries. However, in the case of developing countries, technology variables have a limited success in explaining export performance in the neo-technology model. Kumar and Siddharthan (1994) suggest that the principles of new technology theories are adapted for describing the trade behavior of developing country enterprises and they find that the technology factor plays a significant role in explaining the export behavior in case of medium and low technology industries of Indian enterprises. Krugman (1979) develops the technology gap model where he explains the North-South trade by the technology diffusion. Primarily, North innovates that gets diffused to the South. These creations and diffusions of technology shape the possibility of trade. In the South, the diffusion of technological innovation occurs through a certain level of imitative, adaptive and absorptive capability. However, there is a variation in terms of own technological capability for imitation, adaptation or absorption across developing countries. The amount of technology-intensive exports from the developing countries is overestimated because of the presence of multinational corporations (MNC), which engage in exporting. Moreover, IPRs protection and export performance differ across countries due to the level of technology, innovation, market structure, and product specification (Schneider, 2005; Kim et al., 2012; Shin et al., 2016).

## 2.1 IPRs Protections, Level of Technology and Exports

IPRs influence international trade particularly, the flow of knowledge-based and high technology product (Fink and Braga, 2005). Developing countries' exporters face many problems in order to enter into the global market and access information, due to higher production cost with a view to meet higher standard of IPRs. The tough global IPRs may work as a hurdle for the entry of developing economy's exporters into advanced markets, if those countries' product is found to be imitative under the IPR regime of the destination market (Helpman, 1993; Schneider, 2005).
Many studies conclude that there is an ambiguous relationship between strong IPRs and trade flows, because of their two opposing effects, such as market expansion effects and market power effects (Flam and Helpman, 1987; Taylor, 1993; Muskas and Penubarti, 1995; Smith 2001). Strong IPRs, through 'market expansion effect', allow firm to increase the market in the host country by reducing imitation. On the other hand, strong IPRs may also result in a 'market power effect' that induces the firm to restrain their production. The market power effect reduces elasticity of demand for a firm that ordinarily induces firms to export less of its patentable product (Taylor, 1993; Muskas and Penubarti, 1995; Smith 2001). As patent rights secure protection of the firms' knowledge assets, the strength of such protection affects the firms' decision about servicing the market. Thus, patent rights affect bilateral trade by reducing imitation and ensuring the return on the R&D investment of the source country's firms.

Ivus (2010) suggests that strong IPRs increase the value of developed countries' exports in patent-sensitive industries or high technology industries. Ivus (2015) studies the impact of strengthening patent rights in developing countries on product variety of US exports. This study finds that strong IPRs do not affect existing exports, rather it is driven by an expansion of product variety. Boring (2015) finds that the implementation of a minimum standard of patent protection increases US exports of pharmaceutical product to non-advanced countries. In a recent literature, Shin et al. (2016) study the interaction effect of a destination country's IPRs protection and a source country's level of technology on exports. They argue that foreign IPRs influence the marginal contribution of technology to export performance and how the innovative capacity of the source country influences the relationship between IPRs and trade. They find that the effect of an importer's IPR on a source country's exports is highly dependent on the exporting country's level of technology. When importing country's level of IPR rises, the marginal net effects of technology on exports fall. They also suggest that within the developing countries there are high and low levels of technology country. The impact of destination countries' IPRs varies according to the magnitude of high technology product country exports, where the impact is negative for high levels of technology country and no impact for low levels of technology country.

High technology countries' impact is negative and low technology countries' impact does not matter, as the impact of IPRs varies

These studies do not examine source countries' IPRs protection on their level of technology and patent is not the only measure of technological development. As suggested in the promotional channel of gains from IPRs, a strong regime is expected to stimulate domestic innovation, where a firm may invest more in R&D with the expectation of more profit from the newly developed technology. A nation's innovation capabilities, technology growth, and knowledge capital improve through effective R&D activities. Moreover, as countries with patent protection develop technology, such protections further stimulate domestic innovation (Green and Scotchmer, 1990; Grossman and Helpman, 1991; Diwan and Rodrik, 1991; Gould and Gruben, 1996; Ginarte and Park, 1997; Fosfuri, 2000; Park. 2008; Chen and Iyigun, 2011). Therefore, it is interesting to study the relationship between IPR and exports along with the level of technological activity of the source country, and examine the interaction effect of IPR protection and the level of technology on exports.

Studies show that the share of high technology product in the exported countries increases tremendously after the introduction of the product patent, influencing its export performance and the global competitiveness (Chen and Puttinan, 2005; Ivus, 2010; Zhang and yang, 2016). Technology intensive products that are exported by high technology group within the developing countries need not be new to the world product that may not be requiring patent protection. They may be middle level of technology product which may or may not be influenced by IPRs of destination country. Thus, we hypothesize that IPRs influence the level of technology of a country that further influences its exports. Our approach to the problem from the source country perspective is significant as it will introduce the variation in terms of host country factors. Further, as these economies have implemented patent policy changes to comply with TRIPs, such a study will provide empirical evidence about the impact of the agreement. Thus, it is pertinent to study from such countries' perspective the gain through improvement in the level of technology and concomitantly in high technology exports.

## 3. Methods

### 3.1 Model Specification

For empirical purpose, we propose to use Simultaneous Equation Model (SEM) techniques to analyse the relationship between IPRs, the level of technological activities and innovative capacity of the source countries and exports.

**System of equation in SEM:**

$$\mathrm{TI}_{it} = C_1 + \beta_{11}\mathrm{IPR}_{Sit} + \alpha_{11}LP_{Sit-1} + \alpha_{12}Size_{Sit-1} + \alpha_{13}OPN_{Sit-1} + u_{it} \quad (1)$$

$$\begin{aligned} Exp_{it} = C_1 + \beta_{21}\mathrm{TI}_{Sit} + \alpha_{21}GDP_{Dit-1} + \alpha_{22}OPN_{Dit-1} \\ + \alpha_{23}EXR_{Sit-1} + \alpha_{24}IPR_{Dit} + \alpha_{25}\mathrm{TI}_{Sit} * IPR_{Dit} + \epsilon_{it} \end{aligned} \quad (2)$$

Where *i* denotes country (*I* = 1, 2,3, ……*n*), and *t* is time(years), d stands for destination country and s stands for source country in equation 1 and 2. TI is the technology index and Exp is high technology exports as percentage of manufacturing industries on the left hand side. On the right hand side, based on the literature we introduce control variables and also IPR which is the prime factor for the study. The detailed reasons for introducing these variables are given later along with the construction of variables. IPR is the intellectual property rights index, LP is the labour productivity per person, and Government size is the Government consumption expenditure as a percentage of GDP. OPN is the trade openness, GDP is the gross domestic product per capita growth and EXR is the official exchange rate per unit U.S. dollars taken as a year average.

There is a evident that the model represented in equation 1and 2 has a problem of endogeneity that is the correlation of the right-hand side variables and the error terms. In such cases, ordinary least square (OLS) parameter estimates are inconsistent due to the endogeneity problem and it requires instrumental variable method such as two stage least square (2SLS) to get consistent parameter estimates (Baltagi, 2008). This study uses 2SLS equation models for the econometric specifications and also includes a lag of right-hand side variables to curb the endogeneity problem. Random effect two stage least square equation model (RE2SLS) is applied to estimate the coefficients. Basically, the choice of RE2SLS model is based on Hausman test. Hausman test decides between the fixed and random effect model, where the null hypothesis is that the preferred model is random effect vs. the alternative fixed effect model (Hausman, 1978). We estimate the results from both equations (1) and (2) for full sample by introducing all countries[4],

[4] 67 countries are included in this study based on the data availability.

and further this study split the sample into high-income and middle-income economies[5]. These classifications help us to understand the varying level of technology, high technology exports and their IPRs in a different income group.

### 3.2 Variable Constructions

The core idea of this study is to examine the relationship between level of technology and IPR, and further the effects of the level of technology on its exports. The description of the variables is as follows:

*Technology Index:* There is a set of growing literature, focusing on developing technological capabilities to produce capital goods and support domestic production of capital goods that enhance a country's export performance (Rosenberg, 1976; Fransman, 1982; Kim, 1993). However, technological concentrate of similar exports can vary among countries, due to their amount and level of inputs components, equipment and technical knowledge. For example, a high technology exports in a country may be based on the local imported components, with few local inputs, physical or technological. At the same time, it may come from substantial local equipments, components, design, developments, and engineering (Lall, 1994, 2000). Moreover, firms that are engaged in R&D are capable of developing new products and creating knowledge assets that enable them to establish a space in the international market (Jagadeesh and Sasidharan, 2014). However, R&D and education data capture only inputs into technological efforts but not the technological output (Lall, 2000). Dodgson (2000) argues that R&D expenditure provides only one indicator of a nation's technological capabilities. In case of Hong Kong, industrial development is based on more imaginative use of technology development and less on R&D. Griliches (1990) establishes R&D as an input into the knowledge production function that leads to output in the form of the patent.

Lall and Albaladejo (2003) develop an index of technology intensity, based on national technological activity which is derived from two variables, such as R&D financed by productive enterprises and the number of patents taken out internationally. Recently, Shin et al. (2016) measure a country's level of technology by its patents. As these indicators capture either input or output in knowledge production function, this may not be true representative of the actual innovative activity of a country. Thus, there is a need to use a different indicator to capture or quantify the technological activity. Against this backdrop, this study computes a technology index by principle component analysis[6]. Five variables are included to construct the index, such as R&D as % of GDP, researchers in R&D per billions and number of the patent application by

[5] Middle-income economies are those whose GNI per capita is more than $1,006 but less than $12,235 and High-income economies are those whose GNI per capita is $12,235 or more (World Bank 2010).

[6] Principal component analysis (PCA) is a statistical procedure which converts an original set of observations possibly correlated variables into a substantially smaller set of uncorrelated variables, represents most of the information in the original set of variables (Hotelling, 1933). Moreover, PCA reduces the dimensionality of the variable set and decompose the total variance.

non-residents are the input indicators and number of the patent application by residents, and scientific and technical journal articles are the output indicators of innovation. The last three variables are standardized by real GDP to adjust for the economic size of a country. The technology index, range in value from 0 to 5.37. Higher values of the index indicate high innovation activity.

Scientific and technical journal articles and patents capture output produced due to investments made in R&D. Patents, though frequently viewed as output indicators can also be viewed as input indicators as data in patents are used by subsequent inventors for information (Griliches 1990). A country's production of new technology is captured by its patents and it is an important indicator of technological activities of the firm in the country (Basberg, 1987; Archibugi and Planta, 1996). There exists a complementary relationship among foreign patenting, exports, FDI and licensing. Consequently, foreign patent filing helps to study the new technology which is introduced in the market (Branstetter, 2004; Lerner, 2002).

This study uses Park (2008) and property right alliance (2016) IPRs Index to quantify IPRs protection across countries. In equation (1), we put source country's IPRs index and in equation (2) IPRs protection is the weighted average of destination countries' IPR index with top 20 trading partner's export share. IPRs have played a major role in raising the knowledge-based or high technology product in the international market (Fink and Primo Braga, 2005). Strong IPRs is expected to stimulate domestic innovation, where firms may invest more in R&D with the expectation of more profit from the newly developed technology. Moreover, countries with patent protection use more of technology, so strong IPRs regime is expected to stimulate domestic innovation and technology (Green and Scotchmer, 1990; Grossman and Helpman, 1991; Diwan and Rodrik, 1991; Gould and Gruben, 1996; Ginarte and Park, 1997; Fosfuri, 2000; Park. 2008; Chen and Iyigun , 2011). Exports are taken as the high technology exports as a percentage of manufacturing industries. Shin et al. (2016) suggest that there is a positive relationship between strong IPRs and the volume of high technology exports. Technology growth is positively correlated with export performances, wherever, it is providing innovation friendly environment especially through the enforcement of IPRs. In the manufacturing industries, the effect of patents on exports is strongest and plays a leading role in such industries' patenting activities (Balasubramanian and Sivadasan, 2011).

We have taken growth rate of GDP per capita growth, measuring economic activity of the sample countries (Barro, 1996). GDP is also used to proxy the overall market size, which affects incentives to patent (Alled and Park, 2007). Trade openness (OPN) is equal to exports plus imports divided by GDP. There is a positive association between trade openness and technology adoption (Caselli and Coleman II, 2001; Comin and Hobijn, 2004) or R&D investments (Lederman and Maloney, 2003) in the cross country studies. Labour Productivity (LP) is the GDP per person employed. Usually, in the production function, technology is presented as a single labour augmenting factor. The change in the distribution of labour productivity is explained by the change in technology (Bernard and Jones, 1996). The effect of innovation on employment growth is determined by the rate of change in efficiency in the production of an old and new product (Hall et al., 2008). Government Size (Size) is the government consumption expenditure as a percentage of GDP. The role of government expenditure is as an input for private production and this productive role creates a productive linkage between endogenous growth and government (Barro, 1990). Exchange Rate (EXR) per unit U.S. dollars is taken as a year average. The exchange rate is relative prices of tradable to non-tradable products, having a potentially strong impact on the incentive to allocate resources between sectors producing such goods. It is also a measure of real competitiveness, as it captures the relative prices, costs, and productivity of one specific country vis-à-vis the rest of the world (Dornbusch, 1976; Auboin and Ruta, 2013) (See Table 1 for details).

Table 1 provides the variables' definition, basic statistics and data sources. The total numbers of observations are 335 as there are 67 countries and 5 time periods. It makes the present dataset a balanced short panel. In this study, we have three endogenous variables such as technology index, IPRs and exports, and a set of the control variables, such as GDP per capita growth, openness index, labour productivity, govt. size and exchange rate. Countries' average technology index is 1.2. The technology index measures the level of technological activities across the countries. Average high technology exports as a percentage of manufacturing industries is 13.96. Moreover, 3.73 is the average IPR index of the source country. Interestingly, average destination country IPRs protection is 4.72. Multicollinearity is not a significant problem in the panel data analysis.

**Table 1: Variables Definition, basic statistics and data sources**

| Variable Name | Definition | Mean | Std. Dev. | Data Source |
|---|---|---|---|---|
| **Technology Index** | Measure the level of technology by computing a technology index including both input and output indicators of innovation | 1.2 | 1.16 | WDI, WIPO |
| **Exports** | Exports are taken as the high technology exports as a percentage of manufacturing industries | 13.96 | 13.14 | UN Comtrade, WITS |
| **IPRs_S** | Park (2008) and Property Alliance (2016) IPRs Index: protecting patentable innovations (Source country) | 3.73 | .86 | Park (2008) |
| **IPRs_D** | IPRs protection is the weighted average of destination countries' IPR index with top 20 trading partner's export share | 4.72 | 6.87 | Park (2008) |
| **GDP_D** | GDP is the weighted average of destination countries' GDP per capita growth of top 20 trading partner | 2.32 | 0.82 | WDI |
| **Govt. size** | Government size is the government consumption expenditure as a percentage of GDP | 59.51 | 12.18 | WDI |
| **LP** | Labour productivity is the GDP per person employed | 50893 | 34133 | WDI |
| **EXR** | Official exchange rate per unit U.S. dollars are taken as a year average | 204.93 | 1084.32 | WDI |
| **OPN_S** | Trade openness is exports plus imports divided by GDP | 0.9 | 1.01 | UN Comtrade, WITS, WDI |
| **OPN_D** | Openness is the weighted average of destination countries' trade openness of top 20 trading partner | 0.8 | 0.18 | UN Comtrade, WITS, WDI |

## 3.3 Data

This study uses panel data analysis to understand the effect of IPR protection on the level of technology and further its influence on exports. Following Thompson and Rushing (1999), we have taken data as a five year average during 1996-2014 of 67 countries. All these data are collected from various sources such as, World Bank's World Development Indicators, World Intellectual Property Organization, UN Comtrade and IPRs Index data from Ginarte and Park (2008) and Property Right Alliance (2016).

Table 2 shows the correlation matrix, where IPRs index is positively related to technology index and exports. Moreover, technology index and IPRs are also positively related to high technology exports. Table 3 provides an average value of technology index, IPRs and high technology exports. In 1996, the average technology effort indices of all the high income and middle income countries are 0.7, 1.13 and 0.18 respectively. In 2014, the average technology effort index of all countries, high income and middle income countries has increased to 1.57, 2.44 and 0.49, respectively. These figures depict that the level of technological activity is higher in high income countries than middle income countries. Moreover, both IPRs index and high technology exports are also higher in developed countries than in developing countries. Interestingly, there is a closing of gap between high income and middle income countries' average IPR values. The possibility implies that a number of developing countries export high-technology product and such countries are called newly emerging economies. This finding is closely related to Srholec (2007). The high technology exports are declining from 2000 in middle income countries. A possible justification for the same is that the year 2000 was the deadline to comply with TRIPS for middle income countries and most of these countries were in transition. Therefore, 2000 can be treated as the initial year for measuring the effects of IPRs as also suggested by Shin, et al. (2016).

**Table 2: Correlation Matrix**

| Variables | IPR_D | IPR_S | Exports | TI | IPR_D*TI | GDP_D | OPN_D | Size | LP | EXR |
|---|---|---|---|---|---|---|---|---|---|---|
| IPR_D | 1 | | | | | | | | | |
| IPR_S | 0.37 | 1 | | | | | | | | |
| Exports | 0.11 | 0.26 | 1 | | | | | | | |
| TI | 0.32 | 0.61 | 0.33 | 1 | | | | | | |
| IPR_D*TI | 0.38 | 0.61 | 0.32 | 1.00 | 1 | | | | | |
| GDP_D | 0.01 | 0.00 | 0.19 | 0.05 | 0.04 | 1 | | | | |
| OPN_D | 0.15 | 0.08 | 0.00 | 0.04 | 0.04 | -0.26 | 1 | | | |
| Size | -0.06 | -0.25 | -0.33 | -0.43 | -0.43 | -0.15 | 0.17 | 1 | | |
| LP | 0.31 | 0.64 | 0.33 | 0.70 | 0.70 | 0.05 | -0.06 | -0.42 | 1 | |
| EXR | -0.03 | -0.13 | -0.02 | -0.11 | -0.11 | 0.01 | 0.04 | 0.00 | -0.12 | 1 |

**Table 3: Average value of TI, IPR and Exports**

| | TI | | | IPR | | | Export | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | ALL | HI | MI | ALL | HI | MI | ALL | HI | MI |
| 1996 | 0.7 | 1.13 | 0.18 | 3.15 | 3.09 | 2.2 | 11.6 | 13.98 | 8.65 |
| 2000 | 1.03 | 1.65 | 0.26 | 3.64 | 4.18 | 2.95 | 14.96 | 16.8 | 12.61 |
| 2005 | 1.24 | 1.98 | 0.33 | 3.87 | 4.39 | 3.24 | 15.01 | 17.02 | 12.51 |
| 2010 | 1.45 | 2.29 | 0.46 | 3.96 | 4.42 | 3.39 | 14.23 | 15.93 | 12.14 |
| 2014 | 1.57 | 2.44 | 0.49 | 3.96 | 4.41 | 3.42 | 13.37 | 14.55 | 11.85 |

Table 4 provides the standard deviation of TI, IPR and exports. In 1996, standard deviation of TI is 0.1, 0.14 and 0.07 of all countries, high income countries and middle income countries respectively. In 2014, TI has slightly increased to 0.16, 0.18 and 0.086 respectively. These figures also depict that technology activity has more deviation among the high income countries than middle income countries. But over a period of time the deviation of IPRs index and exports are declining and it shows that middle income countries have more deviations in comparision to high income countries.

**Table 4: Standard deviation of TI, IPR and Exports**

| | TI | | | IPR | | | Export | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | ALL | HI | MI | ALL | HI | MI | ALL | HI | MI |
| 1996 | 0.1 | 0.14 | 0.071 | 0.14 | 0.1 | 0.15 | 1.56 | 2 | 2.4 |
| 2000 | 0.12 | 0.15 | 0.066 | 0.11 | 0.08 | 0.14 | 1.81 | 2.05 | 3.17 |
| 2005 | 0.14 | 0.17 | 0.068 | 0.09 | 0.06 | 0.1 | 1.74 | 1.87 | 3.12 |
| 2010 | 0.15 | 0.18 | 0.071 | 0.08 | 0.07 | 0.9 | 1.57 | 1.68 | 2.83 |
| 2014 | 0.16 | 0.18 | 0.086 | 0.08 | 0.06 | 0.9 | 1.3 | 1.3 | 2.46 |

## 4. Results and Discussions

### 4.1 Empirical results of Technology Index Equation

The RE2SLS Model is applied to estimate the coefficients. Basically, the choice of RE2SLS model is based on Hausman test. In Table 5, we present the results of the impact of IPRs on the level of technology. Interestingly, the result shows that the IPRs index coefficient is positive and statistically significant in all equations. It indicates that strong patent protection could stimulate domestic innovation and technology in the source country. This result implies that high income countries' technological activities are possibly the major beneficiaries of a strong IPR system. This study finds that labor productivity is negatively associated with the level of technology in high income countries. It implies that high income countries' labour intensive process negatively influences their own innovation activity. The openness index is also positively influence countries' innovation activity. It depicts that country's trade openness is motivating the technology adaptation of such countries. This result is closely related to the findings of Almeida and Fernandes (2008).

**Table 5: Results of the Technology Index Equation**

| Variables | All countries | High Income | Middle Income |
|---|---|---|---|
| IPR_S | 0 .73*** | 6.78*** | 0.56*** |
| | ( .20) | (1.52) | ( .21) |
| LP | -0.000005 | -.00005*** | 0.000002 |
| | ( 0.000003) | (.00002) | ( 0.000004) |
| Size | -0.001 | -0.05 | .003* |
| | ( .003) | (.054) | ( .001) |
| OPN_S | .24* | -.57 | -0.12 |
| | ( .14) | ( .68) | (.12) |
| Constant | -1.51** | -25.29*** | -0.93* |
| | ( .76) | ( 5.91) | ( .55) |
| Wald Test | 36.88*** | 22.91*** | 308.31*** |
| | (0.00) | (0.00) | ( 0.00) |
| Hausman test | 4.04 | 1.12 | 0.00 |
| | ( 0.26) | ( 0.77) | (1.00) |
| R2 | 0.54 | 0.11 | 0.74 |
| Observation | 340 | 185 | 155 |

Note: Numbers in parentheses are standard errors.
*, ** and *** denote significance at 10, 5 and 1 percent levels

### 4.3 Results of the Export equation

Results of the export equation are presented in Table 6. The technology index is highly significant with positive sign. The level of technology is positively related to high technology exports. It specifies that countries' technology level increases the likelihood that countries are more motivated to explore high technology exports. The empirical result is closely related to the finding of Shin, et al. (2016). The destination countries' IPRs index is positively significant in all the cases. Thus, this empirical result indicates that the expansion and enforcement of global IPRs play an important role in economic development, by contributing to high technology export growth.

**Table 6: Result of the Export equation**

| Variables | All countries | High Income | Middle Income |
|---|---|---|---|
| Technology Index | 32.65*** | 53.09* | 188.16* |
| | (17.25) | (33.83) | (119.88) |
| IPR_D | 6.96*** | 11.75* | 16.21** |
| | (2.89) | (7.34) | (8.14) |
| IPR_D*TI_S | -7.59** | -12.26* | -47.19* |
| | (3.97) | (7.85) | (30.16) |
| GDP_D | -0.32 | -0.45 | -0.29 |
| | (.28) | (.40) | (.81) |
| Exchange Rate | -0.0001 | .0001 | -0.0001 |
| | (.0004) | (.001) | (.0006) |
| OPN_D | 3.65** | 1.01 | 5.26* |
| | (1.60) | (3.82) | (3.36) |
| Constant | -15.38 | 17.131 | -51.36* |
| | (12.47) | (2.420) | (31.48) |
| Wald Test | 20.64*** | 4.87 | 9.25 |
| | (0.00) | (0.56) | (0.27) |
| Hausman Test | 0.01 | 0.51 | 2.65 |
| | (1.00) | (1.00) | ( 0.75) |
| R2 | 0.09 | 0.17 | 0.02 |
| Observation | 340 | 185 | 155 |

Note: Numbers in parentheses are standard errors.
*, ** and *** denote significance at 10, 5 and 1 percent levels

We also examine the interaction effect between source countries' level of technology and destination countries' IPR index. The advantage of having the interaction effects of IPRs and level of technology on exports is no longer restricted to coefficient of IPRs, but the sum of the two terms, which provide the direct impact and the interaction impact. Interestingly, interaction coefficient is negatively related to exports for the entire sample. The coefficient is higher for middle income countries than it is for high income countries. These contrasting empirical results support the view of the present IPRs system that has a distribution bias, in which a strong IPRs regime favours the expansion of high income country's exports related to that of middle income country exports. The empirical result is closely related to the finding of Shin, Lee and Park (2016). The openness index is also positively related to exports in middle income countries. It indicates that high technology exports of a country increase with their trade openness. The openness of an economy to international trade captures *ex-ante* market structure.

## 5. Conclusion

This study empirically examines the effect of IPR protection on the level of technology and concomitantly via high technology exports, using a 2SLS model from 1996 to 2014 for 67 countries. This study measures the level of technology by computing a technology index including both input and output indicators of innovation. The empirical results exhibit that the source countries' IPRs index positively influences the level of technology. It indicates that strong patent protection could stimulate domestic innovation and technology in the source country. This result implies that high income countries' technological activities are possibly the major beneficiaries of a strong IPR system. This study also finds that labor productivity is negatively associated with the level of technology in high income countries. It implies that high income countries' labour intensive process is not stimulating their innovation activity. The openness index is also positively related to countries' innovation activity. It depicts that country's trade openness is motivating the technology adaptation of such countries.

The level of technology is positively related to high technology exports. It specifies that country's innovation activity increases the likelihood that countries are more motivated to explore high technology exports. Interaction coefficient is negatively related to exports for the entire sample and the coefficient is higher for middle income countries than it is for high income countries. These contrasting empirical results may support the view of the present IPRs system that has a distribution bias, in which a strong IPRs regime favours the expansion of high income countries' exports related to that of middle income country exports. Now, the empirical results also supports that IPRs regime is a significant policy tool that drives innovations and subsequently the technological change in an economy and it provides different weights for countries' strategic trade policy.

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