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Implications of Intellectual Property Protection, and Science and Technological Development in the Manufacturing Sector in Selected Economies

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Abstract

Several studies have measured the influence of socioeconomic factors, IPRs, science and technology, and innovation-related activities, and government policies on economic growth in developed and developing economies. However, the manufacturing sector contributes a large share in the GDP of most economies. Growth of the manufacturing sector depends upon socio-economic factors, science and technological change associated variables, and IPRs related activities. For this, limited studies could investigate the influence of aforesaid factors on the manufacturing sector across countries. This study, therefore, provides a vital technique to develop the intellectual property protection index (IPPI), science and technological development index (STDI), and socio-economic development index (SEDI) using composite Z-score technique in selected 41 developed and developing economies during 2005–2013. IPPI, STDI, and SEDI are the combined indexes of 7, 7, and 15 associated factors respectively. The aforementioned indexes identify the relative position of selected economies in IPRs, science and technological development, and socio-economic development. As per the assessed values of IPPI, STDI, and SEDI, this study reports that there is a high diversity in intellectual property awareness, science and technology development, and socio-economic development in 41 economies. Accordingly, it measures the influence of aforesaid indexes on manufacturing value-added using country-wise panel data. Linear and log-linear regression models are used to estimate the regression coefficients of explanatory variables. Empirical results indicate that science and technological development, socio-economic development, and intellectual property protection-related activities have a positive and statistically significant impact on manufacturing value-added. It facilitates several policy suggestions to increase the growth of the manufacturing sector worldwide.

Keywords: developed and developing countries, economic growth, India, intellectual property protection index, manufacturing sector, science and technological development index, socioeconomic development index.

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Introduction

Technology consists of the use of science for industrial or commercial purpose and it helps to attain commercial or industrial goals (Çaliskan, 2015). Technology can be defined as an idea or knowledge that may be useful to produce goods and services for manufacturing firms. Technological development has a significant contribution to increasing economic growth and development in several ways in a country. It is a vital driver to create several substitutes to sustain human livelihoods. Technological development improves as an increase in the involvement of scientists in research and development (R&D) activities (OECD, 2014). Moreover, the use of technological development in production activities brings new techniques to reduce human efforts to achieve their desired goals.

Technological development is supportive to increase resource productivity [i.e., human, environmental, financial, social, physical, institutional] (Toader et al., 2018). Consequently, it is useful to maintain the livelihood security of people. Further, technological applications in production activities will be useful to maintain economic efficiency of resources. Also, it is useful to create cheaper goods, increase capital accumulation and maintain the global competitiveness of a country (Çaliskan, 2015). Adoption of advanced technologies is imperative to create employment, new market and infrastructural development in a nation. Hence, it seems that technological development is a key driver to increase economic, human and social development (Çaliskan, 2015; Toader et al., 2018).

Furthermore, science and technology and innovation (S&TI) provide an incentive for entrepreneurs to use existing technologies in the production of goods (Çaliskan, 2015; Satyanarayana, 2008). Hence, innovation has a significant contribution to economic growth (Raghupathi, Raghupathi, 2017). Innovation is scientific knowledge and technological know-how which may be used by manufacturing firms to produce valuable goods and services. It is helpful to construct more startups and nurture a conducive business ecosystem in a country (OECD, 2014). Effectiveness and sustainability of new startups depend upon the ability of entrepreneurs to produce useful goods for consumers. For this, S&TI would be effective to produce more innovative products. Moreover, technological advancement would be useful to increase the efficiency of a mechanical instrument in manufacturing firms. Afterwards, the creation of high-tech goods and services through extensive R&D activities are supportive to create new industries/business firms, market and extensive jobs for skilled and non-skilled workers. More employment for people would be beneficial to increase their contribution to economic development in a country. Henceforth, R&D is a significant driver to improve economic growth and development, social welfare of a nation (Çaliskan, 2015). Furthermore, it is perceived that there is a positive relationship between researchers, research organizations/universities, S&T and innovation, R&D, startups/business, product development, new market, employment and economic development (Çaliskan, 2015; Gould, Gruben, 1997; OECD, 2000).

Researchers and scientists can get legal protection of their research output through an IPRs regime which is implemented by a government (Saini, Mehra, 2014). IPRs regime is a legal rule prescribed by a government to protect the output of researchers and scientists in a country (Adams, 2009; Williams, 2013). Patents, copyrights, trademark, trade secrets, geographical indicators are the various types of intellectual property (IP). Strong IPRs regime provides systematic and legal ways for the use of technologies by manufacturing firms (Adams, 2009; Shugurov, 2015). IPRs protection is profitable in terms of greater domestic innovation for manufacturing firms, which promotes more investment in R&D by public and private players in a country (Cho, Kim, 2017). Consequently, IPRs protection is supportive to increase technological transmission in the public domain within and across countries (Falvey, Foster, 2006; Gold et al., 2019; Hossain, Lasker, 2010; Yueh, 2007).

Furthermore, IPRs regime provides an incentive to discover new technologies and knowledge in scientific fields (Williams, 2013). Also, it helps entrepreneurs to recover their R&D expenses (Laik, 2015; Saini, Mehra, 2014). Strong IPRs regime is useful to maintain technology transfer and technology commercialization in a country (Shugurov, 2015). Moreover, effective IPRs regime is supportive to attract the foreign direct investment (FDI) inflow in a country (Hindman, 2006; Sharma, Saxena, 2012). FDI inflow is useful to create a business ecosystem and additional employment and increase money flow, capital formation and infrastructure development in a country. Consequently, FDI inflow is positively associated with per capita income of a nation

(Hossain, Lasker, 2010). Aforesaid review shows that intellectual property protection is a crucial driver to increase the economic growth of a country (Gould, Gruben, 1997; Lahsen, Piper, 2019).

Furthermore, IPRs regime is a part of the institutional infrastructure which encourages private investments in R&D activities (Yueh, 2007). Several studies have theoretically and empirically have proved that IPRs have a positive influence on economic growth in developed and developing economies (Hudson, Minea, 2013; Janjua, Samad, 2007; Odilpova, 2016; Sattar, Mahmood, 2011). Chang (2011) have reviewed that property right regime has positive implications on economic development. However, Adams (2009) have found a negative impact of IPRs on economic growth in developing economies. Few studies have claimed that the positive effect of IPRs on economic growth is higher in developed economies than developing economies (Schneider, 2005; Yang et al., 2014). Since imitation rate of technologies is high in developing economies, thus IPRs may harm economic growth in these economies. In the aforesaid perspective, existing researchers could not provide systematically acceptable and concrete information on the influence of IPRs and technological change on economic growth in developing economies. Gold et al. (2019) have claimed that the impact of IPRs on economic growth in developed and developing economies are not clear. However, few researchers produce a cause and effect relationship between IPRs and economic growth (Schneider, 2005). Therefore, the impact of IPRs and technological change on economic growth in developing economies is debatable (Azevedo et al., 2012).

In most economies manufacturing sector has a greater contribution to gross domestic product (GDP) (Singh et al., 2019a). Growth of manufacturing sector depends upon socio-economic factors, science and technological change related variables and IPRs regime (Singh et al., 2019a). However, limited studies could investigate the influence of IPRs and science and technological factors on manufacturing value-added across economies. This study, therefore, includes large numbers of factors related to IPRs, science and technological development, and social-economic development to investigate their impact on manufacturing value-added in selected 41 economies. This study addressed the following research questions:

1. What is the association of manufacturing sector with IPRs and S&T related indicators?
2. Which country has a better position in IPRs and S&T as compared to others?
3. How global economies can increase their position in IPRs, S&T and socio-economic development?
4. With regards to aforesaid research questions, this study is achieved the following objectives:
5. To create intellectual property protection index (*IPPI*), science and technological development index (*STDI*) and socio-economic development index (*SEDI*) using *Composite Z-score* techniques for selected 41 economies.
6. To assess India's position in intellectual property protection, science and technological development and socioeconomic development among the undertaken economies.
7. To investigate the influence of *IPPI*, *STDI* and *SEDI* on manufacturing value-added using country-wise panel data during 2005–2013.

Research Method and Material

Selection of Countries

This study compiles IPRs, science and technological development and socioeconomic development related factors using country-wise panel using 2005-2013. The selection of countries is based on the availability of data for prescribed variables. Total 41 countries are found suitable to undertake the proposed research. These economies are categorized in 28-high income; 9-upper middle income; and 4-lower middle-income economies (See Table 1).

Table 1. List of selected economies

Countries	Income group
Austria, Belgium, Croatia, Czech Republic, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Japan, South Korea, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Singapore, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom and the United States	High income
Argentina, Brazil, China, Colombia, Malaysia, Mexico, Romania, South Africa and Thailand	Upper middle income
India, Moldova, Pakistan and Ukraine	Lower middle income

Source of Data

Essential data for this study is derived from World Development Indicators (World Bank); National Accounts Main Aggregates Database; World Economic Forum; Cornell University and INSEAD; The World Intellectual Property Organization (WIPO); and United Nations Development Programme Database (UNDP).

Process to Create a Desire Index

(i) Selection of Variables: Inter-linkage of variables with desire output is useful to choose the key indicators for socioeconomic development, science and technological development and IPRs regime (Ashraf, Singh, 2019; Singh, Issac, 2018; Singh et al., 2019).

(ii) Classification of Variables: Group-wise distribution of selected variables is a second task for index estimation (Ashraf, Singh, 2019; Kumar et al., 2017; Singh, Issac, 2018; Singh et al., 2019).

(iii) Valuation of Composite-Index or Standardization-Index: *Composite Z-score* technique is used to create a *composite-index* (Ashraf, Singh, 2019; Kumar et al., 2017; Singh, Issac, 2018; Singh et al., 2019). It converts all values for a specific variable between 0–1 to make a reliable comparison across entities. *Composite-index* is calculated using the below formula for those variables that have a positive association with output:

$$SI_{ic} = \{[X_{ic} - Min(X_{ic})]/[Max(X_{ic}) - Min(X_{ic})]\} \quad (1)$$

Here, SI_{ic} is *standardization-index* for i^{th} variable; c is cross-sectional country. $Min(X_{ic})$ and $Max(X_{ic})$ are the lowest and highest values respectively in each series of a variable across countries.

(iv) Assessment of Weight for Each Arbitrary Variable: Weight of each variable is useful to make a study rational with unbiased finding. It also increases the consistency of constituted index. Whereas, weight for each factor is estimated as:

$$Wi = \frac{K}{\sqrt{Var(SI)}} \quad (2)$$

Here, Wi stands for the weight ($0<W>1$ and $\sum_{i=1}^{m} Wi = 1$) that is allocated to the i^{th} variable (Ashraf, Singh, 2019; Kumar et al., 2017; Singh, Issac, 2018; Singh et al., 2019). $Var(SI)$ is a statistical variation across *standardization-indices* for all variables. In equation (2), weight reveals the significance of an individual variable. K is assessed as:

$$\text{Here, } K = \frac{1}{\left\{\sum_{i=1}^{n}\left(\frac{1}{\sqrt{Var(SI)}}\right)\right\}} \quad (3)$$

(v) Final Index: It is a linear sum of all *standardization-index* that is multiplied by the weight of a specific variable. It is calculated as:

$$(FI)_{ct}=W_1*(X)_{1,ct}+W_2*(X)_{2,ct}...+W_n*(X)_{n,ct} \quad (4)$$

Here, FI is the final index; W_1, W_2, W_3,..., W_n are the weights for associated variables. X_1, X_2,..., X_n are the *composite-index* of associated variables which are considered to estimate the desired index; c is the cross economy and t is time period. The present study includes 29 different to investigate *IPPI*, *STDI* and *SEDI* during 2005–2013. Hence, the aforementioned procedures are recursively applied for an individual variable with each year for 41 economies.

Theoretical Perspectives of Index-Based Estimation

Formation of Intellectual Property Protection Index (*IPPI*)

Several factors can be used to assess the strength of IPRs regime (Singh et al., 2019b). Previous studies have used different factors for measuring the strength of IPRs regime. For instance, Adams (2009) have considered patent rights index as a proxy for IPRs. Saini and Mehra (2014) have used Ginarte and Park index as a representative for IPRs in developed and developing economies. Gold et al. (2019) have also introduced an index to measure the strength of IP protection in developing economies. Li et al. (2020) have used Ginarte-Park index as a proxy for intellectual property protection to estimate its impact on renewable energy in 102 economies. In this study, intellectual property rights protection index (*IPPI*) is created to assess the relative performance of undertaken economies in IPRs regime. In this study, *IPPI* is defined as the integrated value of most factors which are essential to strengthen the IPRs regime of undertaken countries. Intellectual property protection can be measured in terms of patents applications filed, registered industrial design, published scientific & technical articles, charges for use of intellectual property (IP) payments, charges for use of IP receipts and IP protection score (Raghupathi, Raghupathi, 2017; Singh et al., 2019a,b; Singh, Ashraf, 2019; Yang et al., 2014). Accordingly, *IPPI* is an integrated index of aforesaid factors that are specified as:

$$(IPPI)_{ct}=w_1*(SI\_PaFiPTRe)_{ct}+w_2*(SI\_InDePTRe)_{ct}+w_3*(SI\_TrPTRe)_{ct}+w_4*(SI\_STJAPTRe)_{ct}+w_5*(SI\_CUIPRPPRe)_{ct}+w_6*(SI\_CUIPRRPRe)_{ct}+w_7*(SI\_IPPS)_{ct} \quad (5)$$

Here, *IPPI* is intellectual property protection index; *SI* is a *standardization-index* of associated variables and $w_1 \ldots w_7$ are the weight of corresponding variables in equation (5). The detail description of the variables is presented in Table 2.

Table 2. Factors related to intellectual property protection index (IPPI)

Explanation of variables	Symbol	Unit
No. of patents filed per 1000 researcher	PaFiPTRe	Number
No. of industrial design registered per 1000 researcher	InDePTRe	
No. of trademarks registered per 1000 researcher	TrPTRe	
No. of scientific and technical journal papers published per 1000 researcher	STJAPTRe	
Charges for the use of IP payments per researcher	CUIPRPPRe	Current US$
Charges for the use of IP receipts per researcher	CUIPRRPRe	
IP protection score (1-7 best)	IPPS	Number

Source: Williams (2013); Yang et al. (2014); Singh, Ashraf (2019); Singh, Ashraf, 2019; Singh et al. (2019a, b).

Formation of Science and Technological Development Index (STDI)

Previous studies have discussed that science and technological development is directly associated with R&D expenditure, number of researchers and scientists, number of research institutions and universities, number of scientific research articles, high-tech industries, association of research organizations with exiting industries, technology transfer and commercialization (Williams, 2013; Singh et al., 2019a,b). Aforementioned factors are useful to boost the science and technological development of a country. Existing studies, therefore have claimed that single factor may be ineffective to evaluate the science and technological development of a nation. Thus, the progress of science and technological development can be observed through R&D expenditure, researchers in R&D, R&D expenditure per researcher, high-technology exports, high-technology exports per researcher, ICT goods exports and ICT goods imports (Ashraf, Singh, 2019; Sattar, Mahmood, 2011; Singh et al., 2019a,b; Singh, Ashraf, 2019; Toader et al., 2018; Yang et al., 2014). Hence, this study creates science and technological development index (*STDI*) to assess the relative strength of undertaken economies in science and technology. *STDI* is defined as a simple number which includes most factors related to science and technological development. This index identifies the relative position of a country in science and technological development as compared to other economies. In this study, *STDI* is an integration of aforesaid factors, which is assessed as:

$(STDI)_{ct}=w_1*(SI\_R\&DInt)_{ct}+w_2*(SI\_RePMP)_{ct}+w_3*(SI\_R\&DExPRe)_{ct}+w_4*(SI\_HTExMEx)_{ct}+w_5*(SI\_HTExPRe)_{ct}+w_6*(SI\_ICTGEx)_{ct}+w_7*(SI\_ICTGIm)_{ct}$ (6)

Here, *STDI* is science and technological development index. *SI* is a *standardization-index* and $w_1,\ldots, w_7$ are the weights of corresponding variables which are described in Table 3.

Table 3. Factors related to science and technological development index (STDI)

Explanation of variables	Symbol	Unit
R&D expenditure (% of GDP)	R&DInt	%
No. of researchers in R&D (per million people)	RePMP	Number
R&D expenditure per researcher	R&DExPRe	Current US$
High-technology exports (% of manufactured exports)	HTExMEx	%
High-technology exports per researcher	HTExPRe	Current US$
ICT goods exports (% of total goods exports)	ICTGEx	%
ICT goods imports (% total goods imports)	ICTGIm	%

Source: Sattar, Mahmood (2011); Yang et al. (2014); Toader et al., 2018; Singh, Ashraf, 2019; Singh et al. (2019a); Ashraf, Singh (2019).

Formation of Economic Development Index (*EDI*)

The economic development of a county may not be defined by a single variable. However, previous studied have claimed that economic growth may be helpful to improve human well-being and social welfare of a country. Economic growth is a situation in which production activities are supportive to satisfy the human requirement (e.g. employment, purchasing power, income, consumption, food security, education, health and social security, cultural security, and sanitation) in a country (Çaliskan, 2015). Economic growth increase as an increase in production scale of a nation (Adejumo, Adejumo, 2014). It is specified that economic development may not be explained by a single variable of a country. Therefore, factors related to economic development must be integrated into an index to measure its strength in a country. GDP per capita, gross capital formation, manufactured exports and imports, exports and imports of goods and services, and foreign direct investment (FDI) and FDI outflow are the necessary drivers of economic development (Adejumo, Adejumo, 2014; Raghupathi, Raghupathi, 2017; Singh et al., 2019b; Toader et al., 2018).

Previous studies have argued that economic growth may be defined through capital accumulation, technological advancement and working population (Çaliskan, 2015; Toader et al., 2018). In this study, therefore economic development index (*EDI*) is created to measure the relative position of countries in economic development. *EDI* is defined as a combined large number of related factors which are associated with economic development in this study. *EDI* is a combined index of aforesaid variables, which is assessed as:

$(EDI)_{ct}=w_1*(SI\_GDPPC)_{ct}+w_2*(SI\_RMVAGDP)_{ct}+w_3*(SI\_GCF)_{ct}+w_4*(SI\_MME)_{ct}+w_5*(SI\_MMI)_{ct}+w_6*(SI\_RMVAEGS)_{ct}+w_7*(SI\_RMVAIGS)_{ct}$ (7)

Here, *EDI* is economic development index; *SI* is *composite-index* of associated variables; w_1, ..., w_7 are the weights for related variables which is presented in Table 4; and *c* and *t* are cross-sectional economies and time-period respectively in equation (7).

Table 4. Factors related to economic development index (EDI)

Description of variables	**Symbol**	**Unit**
GDP per capita (Constant 2005 US$)	GDPPC	US$
Ratio of manufacturing value added (Constant 2005 US$) with GDP at market price (Constant 2005 US$)	RMVAGDP	Number
Gross capital formation (annual % growth)	GCF	%
Manufactures exports (% of merchandise exports)	MME	
Manufactures imports (% of merchandise imports)	MMI	

Ratio of manufacturing value added (Constant 2005 US$) with exports of goods and services (Constant 2005 US$)	RMVAEGS	Number
Ratio of manufacturing value added (Constant 2005 US$) with imports of goods and services (Constant 2005 US$)	RMVAIGS	

Source: Adejumo, Adejumo (2014); Adams (2009); Toader et al. (2018).

Formation of Social Development Index (SDI)

Social development is complex and multi-dimension interacting component of the society, which is positively and negatively associated with several activities of a nation. Since scientific research community could not produce a uniform and internationally accepted factor to measure the strength of countries in social development. However, previous studies like (Duasa, Afroz, 2013; Singh et al., 2019; Singh et al., 2019b) have used different factors such as education index, literacy rate, female literacy rate, gender ratio, female labour participation rate, infant mortality rate and other variables as a substitution for social development. Aforesaid factors have a significant influence on social development, these factors, therefore, must be integrated into a single number to assess the relative or absolute position of a country in social development. Social development shows the equal distribution of available services among the society and it improves as education level, political literacy, human health, economic capacity and communication of people increase (Adejumo, Adejumo, 2014). Furthermore, social development depends upon employment for female, female GDP per person employed, female labour force participation rate, population growth, age dependency ratio, and unemployment rate, female literacy rate, and education index (Adejumo, Adejumo, 2014; Singh et al., 2019; Singh et al., 2019b). In this study, therefore social development index (*SDI*) is formed to identify the relative position of undertaken economies in social development. *SDI* makes the cross-comparison of economies in social development. The relationship of *SDI* with its associated variables is specified as:

$$(SDI)_{ct}=w_1*(SI\_GDPPC)_{ct}+w_2*(SI\_RMVAGDP)_{ct}+w_3*(SI\_GCF)_{ct}+w_4*(SI\_MME)_{ct}+w_5*(SI\_MMI)_{ct}+w_6*(SI\_RMVAEGS)_{ct}+w_7*(SI\_RMVAIGS)_{ct}+w_8*(SI\_GDS)_{ct} \quad (8)$$

Here, *SDI* is social development index; *SI* is *composite-index* of all associated variables; $w_1,\ldots, w_8$ are the estimated weights of associated variables that are described in Table 5. *c* and *t* are the cross-sectional countries and time-period respectively in equation (8).

Table 5. Variables related to social development index *(*SDI*)*

Explanation of variables	Symbol	Unit
Employment in industry (% of total employment)	EMPI	%
GDP per person employed	GDPPPE	Constant 1990 US $
Total labour force participation rate (% of total population ages 15-64)	LPR	%
Population growth (annual %)	PGR	
Age dependency ratio (% of working-age population)	ADR	
Unemployment rate for youth (% of total labour force ages 15-24)	UYT	
Education index	EDIN	Number
Urbanization	UR	%

Source: Duasa, Afroz (2013); Milenkovic et al. (2014); Adejumo, Adejumo (2014); Singh et al. (2019).

Measurement of Socioeconomic Development Index *(SEDI)*

As the socio-economic development may be an integration of economic and social development related variables (Milenkovic et al., 2014). Therefore, socio-economic development index (*SEDI*) is considered as a linear sum of *EDI* and *SDI* in this study and estimated as:

$$(SEDI)_{ct} = (EDI)_{ct} + (SDI)_{ct} \quad (9)$$

Here, *SEDI* is socioeconomic development index, *EDI* is an economic development index, and *SDI* is the social development index in equation (9).

Formulation of Empirical Models

The present study explores the relationship between intellectual property protection, science and technological development and socioeconomic development with the manufacturing sector in selected economies. For the aforesaid investigation, manufacturing value-added is used as the dependent variable and it is regressed with *IPPI*, *STDI* and *SEDI*. Previous studies have also used created indexes as a dependent and independent variable for different empirical investigations (Adams, 2009; Ashraf, Singh, 2019; Duasa, Afroz, 2013; Kumar et al., 2015; Kumar, Sharma, 2013; Saini, Mehra, 2014; Sharma, Singh, 2017; Singh et al., 2019; Singh, 2018; Singh, Issac, 2018; Singh, Jyoti, 2019; Singh, Sharma, 2018). The functional relation of manufacturing value-added with *IPPI*, *STDI* and *SEDI* are explained as:

$$MVACon = f\,(IPPI, STDI, SEDI) \tag{10}$$

Here, *MVACon* is manufacturing value-added; *IPPI*, *STDI* and *SEDI* are the intellectual property protection index, science and technological development index and socioeconomic development index respectively in equation (10). For empirical analysis, the aforesaid relationship is used as:

$$(MVACon)_{ct} = \alpha_0 + \alpha_1\,(IPPI)_{ct} + \alpha_2\,(STDI)_{ct} + \alpha_3\,(SEDI)_{ct} + \mu_{ct} \tag{11}$$

Here, α_0 is constant term; α_1, α_2 and α_3 are the regression coefficients of associated explanatory variables; μ_{ct} is the error term in the equation (11).

Since this study comprises manufacturing value-added as the independent variable; and *IPPI*, *STDI* and *SEDI* as explanatory variables for 41 economies during 2005–2013. So, there are needed to estimate another test like country-level fixed effects that are quite beneficial in capturing unobserved heterogeneity across the country. Year-specific effects model is useful to control for the annual difference in output across. Country-by-year fixed effects model is quit beneficial to capture the unobserved heterogeneity and to control annual difference in manufacturing value added (Gold et al., 2019). After incorporating these variables, equation (11) is used as:

$$(MVACon)_{ct} = \beta_0 + \beta_1\,(IPPI)_{ct} + \beta_2\,(STDI)_{ct} + \beta_3\,(SEDI)_{ct} + \xi_{1(c\text{-}1)}CD_{(s\text{-}1)} + €_{1(t\text{-}1)}TD_{(t\text{-}1)} + \psi_{1(c\text{-}1)+(t\text{-}1)}CD_{(c\text{-}1)} \times TD_{(t\text{-}1)} + \mu_{ct} \tag{12}$$

Here, $CD_{(c\text{-}1)}$ is the vector for countries dummies; $TD_{(t\text{-}1)}$ is the vector for time dummies; $\xi_{1(c\text{-}1)}$ is the estimated regression coefficient for country-wise dummies; $€_{1(t\text{-}1)}$ is the vector of estimated regression coefficients for time dummies. Country and time dummies are also used to capture the country-level fixed effects and to control for the annual difference in manufacturing value-added across countries. $CD_{(s\text{-}1)} \times TD_{(t\text{-}1)}$ is the vector of combine countries and time dummies, and $\psi_{1(c\text{-}1)+(t\text{-}1)}$ is the vector of estimated regression coefficients for countries and time dummies to country-by-year fixed effects to capture the unobserved heterogeneity. In this study, the log-linear regression model is also applied to check the consistency of regression coefficients of explanatory variables. Random-effects and fixed effects regression models provide better results, thus the interpretation of results based on both the models are given (Sattar, Mahmood, 2011; Singh, Issac, 2018).

Discussion on Descriptive Results

Position of Economies in Intellectual Property Protection

Figure 1 shows the position of undertaken economies in intellectual property protection that is estimated through *IPPI*. The average values of *IPPI* for two time periods (i.e. 2005-2008 and 2009-2013) are included in this figure. It infers that Switzerland, Luxembourg, Ireland, Netherlands and Sweden have 1st, 2nd, 3rd, 4th and 5th position in intellectual property protection according to estimated values of *IPPI* during 2009-2013. These economies are in a better position in intellectual property protection. Since, these economies have a better position in patents filings, industrial design registration, trademarks registration, payments and receipts for intellectual property, and IPRs protection score than other economies. Lithuania, Thailand, Pakistan, Moldova and Ukraine have the 37th, 38th, 39th, 40th and 41st position respectively in intellectual property protection as per the estimated values of *IPPI* for the abovementioned period. The rank and estimated values of *IPPI* for all economies are presented in Table 6. Cross comparison of countries in *IPPI*, *STDI* and *SEDI* during 2009-13 is presented in Figure 4. India have the 33rd position in intellectual property protection as per the estimated values of *IPPI*, thus it has a poor position in intellectual property rights regime. Hence, it is suggested that Indian researchers need to increase their involvement in IPRs activities. For this, Indian policymaker also must be implemented a policy to maintain the strong IPRs regime. Consequently, it would be beneficial for researcher and research institutions to get a better return from R&D activities. Also, IPRs regime would be beneficial to increase technology transfer from research institutions to industries, thus it will be helpful to maintain technology commercialization in India.

Position of Countries in Science and Technological Development

The relative position of selected economies in science and technology-based on mean values of *STDI* during 2005-2018 and 2009-2013 is presented in Figure 2. Values of *STDI* indicate that Singapore, Malaysia, South Korea, Switzerland and Japan have 1st, 2nd, 3rd, 4th and 5th position respectively in science and technology during 2009-2013. R&D expenditure, number of researchers in R&D, R&D investment/researcher, and high-technology exports/researcher is high in these economies. Therefore, these economies could maintain a better position in science and technology. India, Colombia, Ukraine, Moldova and Pakistan have 37th, 38th, 39th, 40th and 41st rank respectively in science and technological development (See Table 6). These countries are highly lagged in science and technological development. India could not increase R&D investment, researchers and scientists, R&D expenditure/researcher, and high-technology exports per researcher. India, therefore could not produce high-production technologies and it has a poor position in science and technological development.

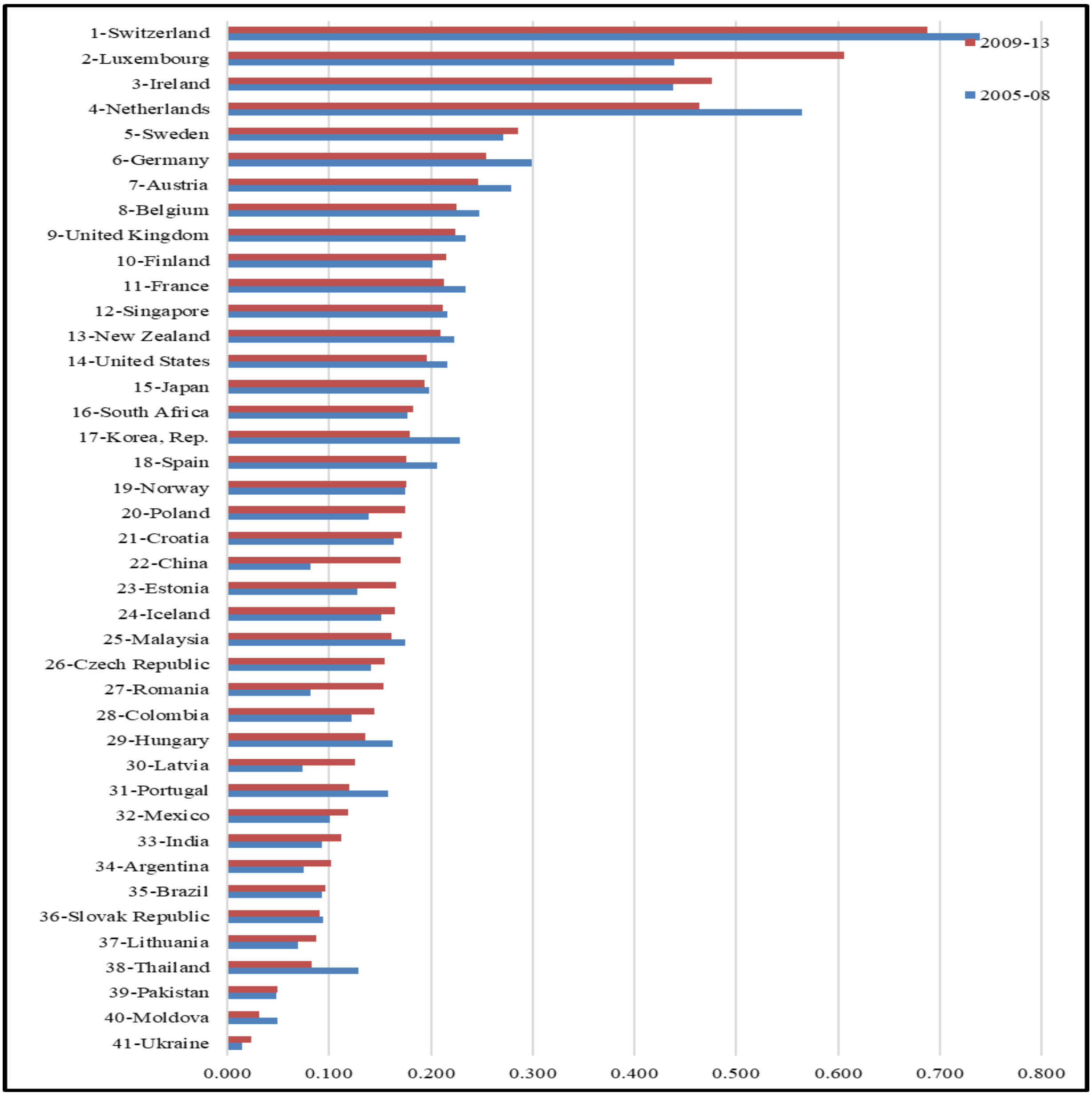

Fig. 1. Performance of economies in intellectual property protection
Source: Author’s Estimation.

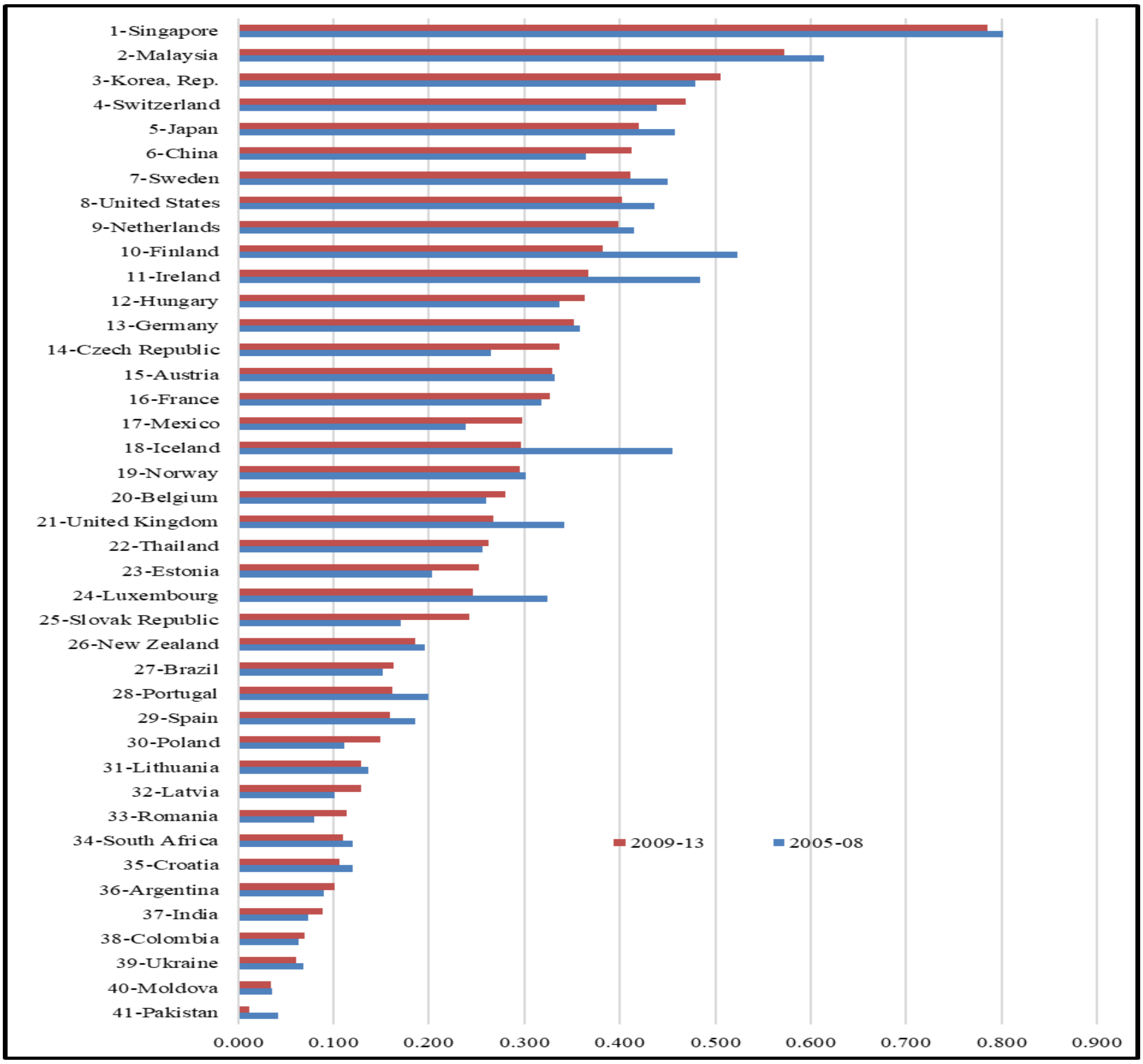

Fig. 2. Performance of economies in science and technological development
Source: Author's Estimation.

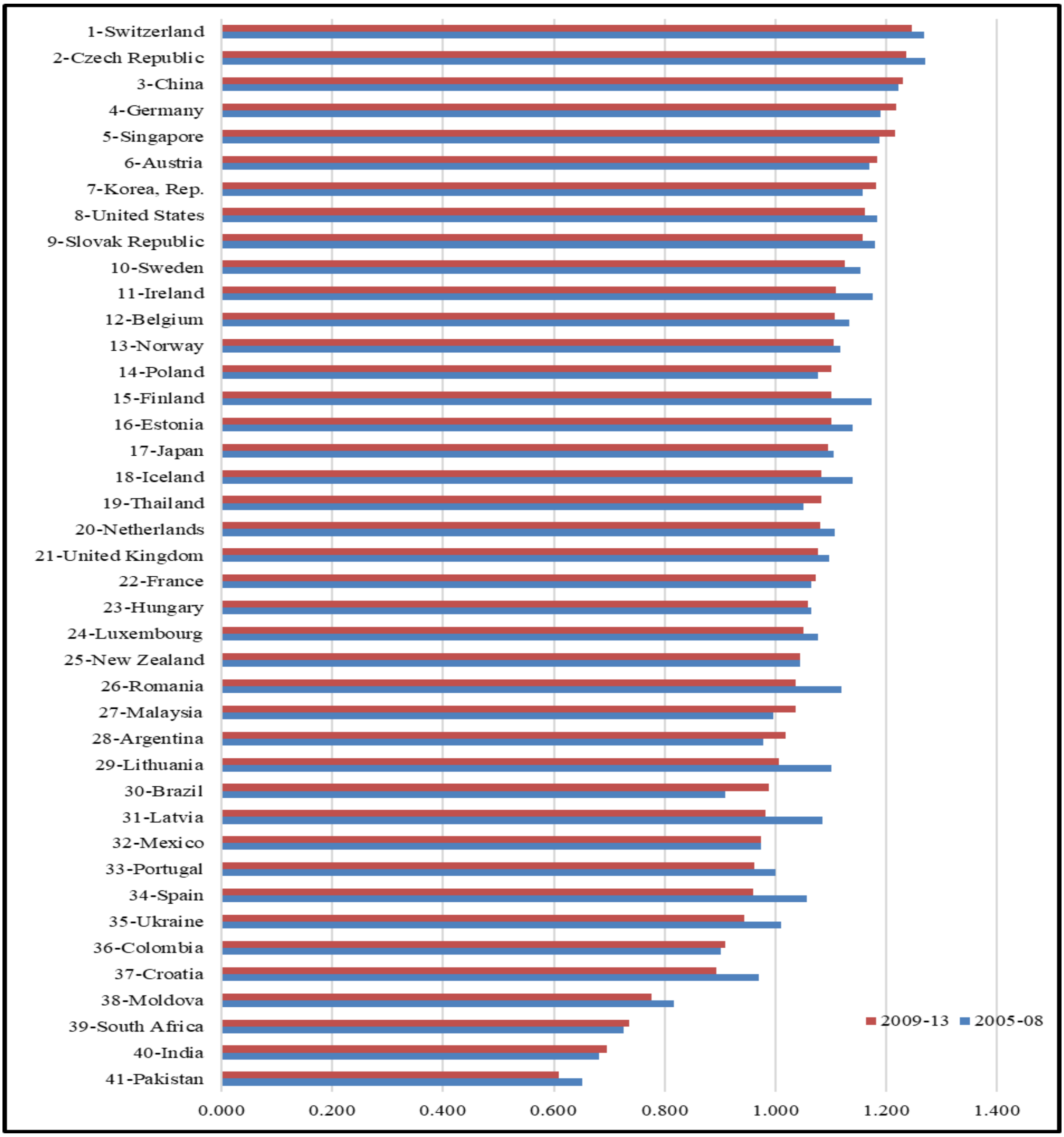

Fig. 3. Performance of countries in socio-economic development
Source: Author's Estimation.

Performance of Economies in Socioeconomic Development

Descriptive results which ascertain the socioeconomic position of undertaken economies is presented in Figure 3. The average values *SEDI* during 2005–2008 and 2009–2013 are included in this figure. It demonstrates that there exists a high diversity in socio-economic development across economies due to high disparity in socio-economic related activities in these economies. The estimated value of *SEDI* showed that Switzerland, Czech Republic, China, Germany and Singapore have 1st, 2nd, 3rd, 4th and 5th position respectively in socioeconomic development during 2009–2013. As estimated values of *SEDI* comprises several factors like GDP per capita, ratio of manufacturing value-added with GDP, gross capital formation, manufactures exports and imports, ratio of manufacturing value-added with exports of goods and services, manufacturing value-added with imports of goods and services, employment in industrial sector, GDP per person employed, labour force participation rate, and education index. Switzerland, Czech Republic, China, Germany and Singapore are in a better position in aforesaid factors, therefore these economies could maintain their better position in socio-economic development. Croatia, Moldova, South Africa, India and Pakistan have 37th, 38th, 39th, 40th and 41st position respectively in socioeconomic development as per the values of *ESDI* during 2009-2013 (See Table 6 and Figure 4).

Table 6. Estimated value of *IPPI*, *STDI* and *SEDI* for selected economies during 2009–13

IPPI			STDI			SEDI		
Country	Rank	Value	Country	Rank	Value	Country	Rank	Value
Ukraine	41	0.023	Pakistan	41	0.012	Pakistan	41	0.608
Moldova	40	0.032	Moldova	40	0.034	India	40	0.696
Pakistan	39	0.049	Ukraine	39	0.061	South Africa	39	0.735
Thailand	38	0.083	Colombia	38	0.070	Moldova	38	0.777
Lithuania	37	0.087	India	37	0.089	Croatia	37	0.894
Slovak Rep.	36	0.090	Argentina	36	0.101	Colombia	36	0.911
Brazil	35	0.096	Croatia	35	0.107	Ukraine	35	0.944
Argentina	34	0.101	South Africa	34	0.110	Spain	34	0.960
India	33	0.112	Romania	33	0.114	Portugal	33	0.961
Mexico	32	0.118	Latvia	32	0.129	Mexico	32	0.974
Portugal	31	0.119	Lithuania	31	0.129	Latvia	31	0.982
Latvia	30	0.125	Poland	30	0.149	Brazil	30	0.988
Hungary	29	0.135	Spain	29	0.159	Lithuania	29	1.006
Colombia	28	0.144	Portugal	28	0.162	Argentina	28	1.018
Romania	27	0.153	Brazil	27	0.162	Malaysia	27	1.036
Czech Rep.	26	0.154	New Zealand	26	0.186	Romania	26	1.037
Malaysia	25	0.161	Slovak Rep.	25	0.243	New Zealand	25	1.045
Iceland	24	0.165	Luxembourg	24	0.246	Luxembourg	24	1.051
Estonia	23	0.165	Estonia	23	0.252	Hungary	23	1.058
China	22	0.170	Thailand	22	0.262	France	22	1.074
Croatia	21	0.171	UK	21	0.268	UK	21	1.077
Poland	20	0.175	Belgium	20	0.280	Netherlands	20	1.081
Norway	19	0.176	Norway	19	0.296	Thailand	19	1.083
Spain	18	0.176	Iceland	18	0.297	Iceland	18	1.084
South Korea	17	0.179	Mexico	17	0.297	Japan	17	1.095
South Africa	16	0.183	France	16	0.326	Estonia	16	1.101
Japan	15	0.193	Austria	15	0.329	Finland	15	1.102
United States	14	0.196	Czech Rep.	14	0.336	Poland	14	1.102
New Zealand	13	0.210	Germany	13	0.352	Norway	13	1.106
Singapore	12	0.212	Hungary	12	0.363	Belgium	12	1.108
France	11	0.213	Ireland	11	0.367	Ireland	11	1.109
Finland	10	0.215	Finland	10	0.382	Sweden	10	1.125
UK	9	0.223	Netherlands	9	0.399	Slovak Rep.	9	1.157
Belgium	8	0.225	United States	8	0.402	United States	8	1.162
Austria	7	0.246	Sweden	7	0.412	South Korea	7	1.182
Germany	6	0.254	China	6	0.413	Austria	6	1.184
Sweden	5	0.286	Japan	5	0.419	Singapore	5	1.215
Netherlands	4	0.464	Switzerland	4	0.469	Germany	4	1.218
Ireland	3	0.476	South Korea	3	0.505	China	3	1.231
Luxembourg	2	0.606	Malaysia	2	0.572	Czech Rep.	2	1.236
Switzerland	1	0.688	Singapore	1	0.785	Switzerland	1	1.247

Source: Author's Estimation.

India's 40th position in socioeconomic development indicates that it has the poorest position in social development. There are several reasons such as low per capita GDP, low literacy rate, high population growth, and high unemployment rate, and high urbanization, low rate of capital formation, low FDI inflow and high inflation and extensive dependency of population on agriculture sector are responsible for India to make its poor position in social development. It is suggested that there is necessary to give substantial attention to increasing the socioeconomic status of people through implementing proper social development policies in India.

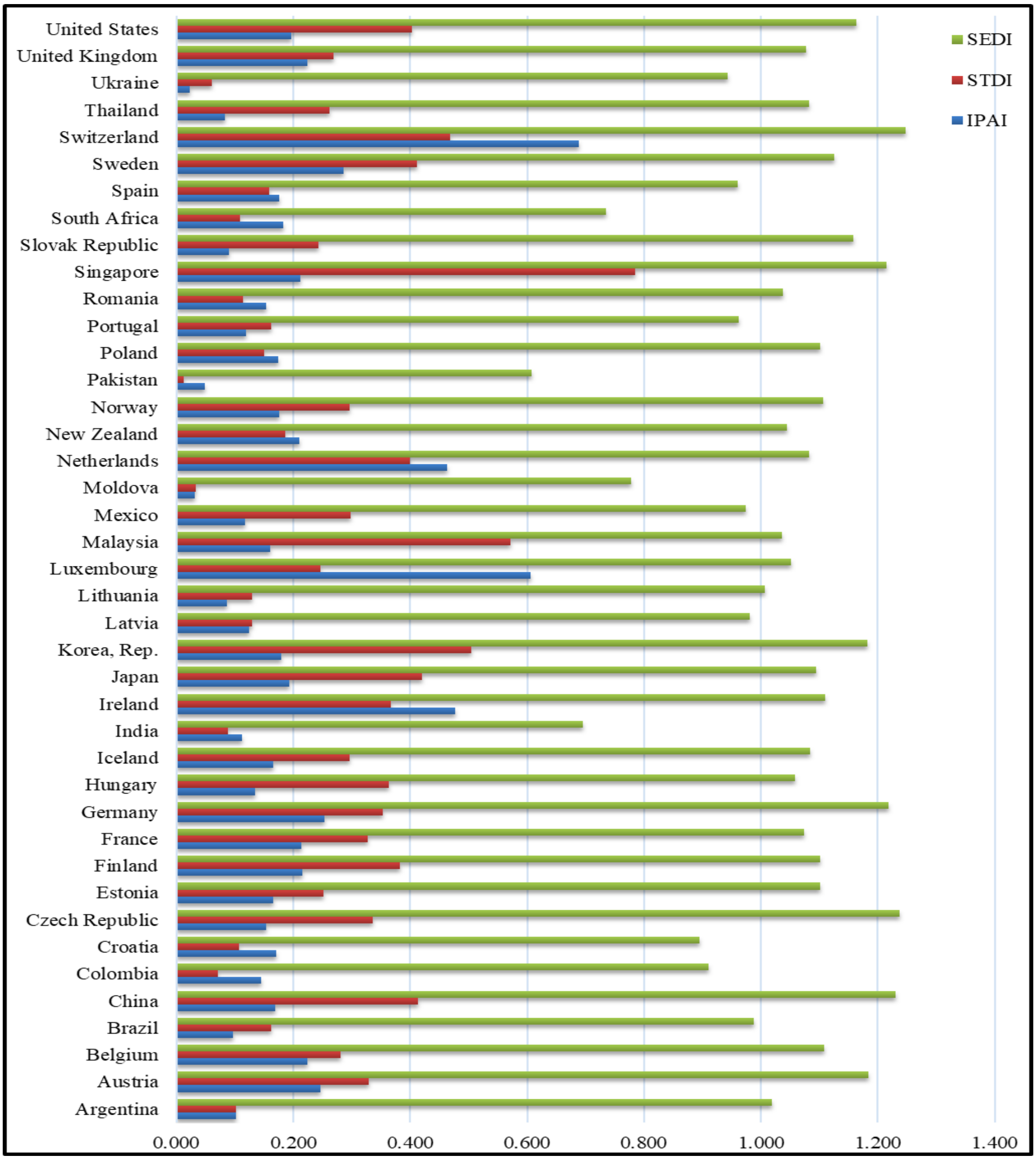

Fig. 4. Cross comparison of countries in IPPI, STDI and SEDI
Source: Author's Estimation.

Validity and Practical Viability of Estimated Indexes

Validation of an index is compulsory to increase the unanimity among the various stakeholders (Ashraf, Singh, 2019; Kumar et al., 2017; Singh, Issac, 2018). Moreover, it useful to increase the legitimacy and practicability of an index for considering it in empirical exploration. An index has validity if it is positively or negatively correlated with its associated indexes or variables (Ashraf, Singh, 2019; Kumar et al., 2017; Singh, Issac, 2018). So, Karl-Pearson correlation coefficients among the constructed indexes are taken into account for authentication of these indexes (See Table 7). Correlation coefficients of IPPI with science and technological development index (STDI), economic development index (EDI), social development index (SDI) and socio-economic development index (SEDI) are found positive and statistically significant. Science and technological development index have positive and statistically significant association with manufacturing value added (MVA), gross domestic product (GDP), IPPI, EDI, SDI and SEDI. Here, it is sensible that intellectual property protection improves as science and technological development in a country increases. EDI, SDI and SEDI are also positively correlated with manufacturing value added, GDP, IPPI and STDI. As all indexes have a statistically significant association with each other, therefore results show that these have validity and consistency.

Table 7. Karl-Pearson correlations coefficients among the indexes

Indicators	MVA	GDP	IPPI	STDI	EDI	SDI	SEDI
MVA	1						
GDP	0.884**	1					
IPPI	0.011	0.036	1				
STDI	0.274**	0.228**	0.453**	1			
EDI	0.221**	0.132*	0.318**	0.495**	1		
SDI	0.219**	0.185**	0.301**	0.521**	0.332**	1	
SEDI	0.266**	0.199**	0.373**	0.619**	0.721**	0.893**	1

Source: Author's Estimation.
Note: ** and * show that the correlation coefficient is significant at the 1 % and 5 % significance level respectively.

Statistical Inference of Empirical Results

Empirical results which investigate the influence of intellectual property protection index (IPPI), science and technological development index (STDI), and socio-economic development index (SEDI) on manufacturing value-added is presented in Table 8 and Table 9. Regression coefficients of explanatory variables with manufacturing value-added are estimated using random-effects and fixed-effects models. The results indicate that IPPI, STDI and SEDI have a positive association with the manufacturing value-added. It emphasis that intellectual property protection is useful to increase the growth of the manufacturing sector. Intellectual property protection index is an integration of patents files, industrial design, trademark, scientific and technical research articles, and charges for use of intellectual property payments and receipts/researcher. Aforesaid activities, therefore, would be effective to increase the contribution of the manufacturing sector in these economies. Science and technological development have a positive impact on manufacturing value-added. Science and technological development is a compilation of R&D expenditure, researcher and scientist, high-tech exports, and ICT exports and imports, thus aforesaid variables would be essential to increase the growth of manufacturing sector across economies.

Table 8. Empirical results with Random-effects GLS regression model

Model's Name	Linear Regression Model		Log-linear R Regression Model	
No. of Obs.	368		368	
No. of Countries	41		41	
No. of Obs./Country	8		8	
R-Sq: within	0.0438		0.1487	
Wald Chi^2	16.40		58.45	
Prob>Chi^2	0.0009		0.0000	
Variables	Reg. Coef.	P>|z|	Reg. Coef.	P>|z|
IPPI	2.75e+11*	0.003	0.053718**	0.039

STDI	1.82e+11**	0.048	0.0494378	0.126
SEDI	1.30e+11***	0.068	0.8218875*	0.000
Con. Coef.	-6.32e+10	0.524	10.69385*	0.000

Source: Author's estimation; Note: *, **, and *** indicate the parameter is statistically significant at the 1 %, 5 % and 10 % significance level respectively

The regression coefficient of *SEDI* with manufacturing value-added is found positive, therefore socioeconomic development is valuable to boost the growth of the manufacturing sector. Since, socioeconomic development index is an integration of GDP per capita, ratio of manufacturing value-added with GDP size, gross capital formation, manufactures exports and imports, ratio of manufacturing value-added with exports and imports, employment in industry, GDP per person employed, labour force participation rate and education rate. Thus, it is proposed that a country needs to focus on aforesaid factors to sustain the growth of manufacturing sector.

Table 9. Empirical results with Fixed-effects (within) regression model

Model's Name	Linear Regression Model		Log-linear R Regression Model	
No. of Obs.	368		368	
No. of Countries	41		41	
No. of Obs./Country	8		8	
R-Sq: within	0.0441		0.1488	
F(3,324)	F(3,324)=4.99		F(3,324)=18.88	
Prob > F	0.0021		0.0000	
Variables	Reg. Coef.	P>|z|	Reg. Coef.	P>|z|
IPPI	2.96e+11*	0.002	0.0514899**	0.048
STDI	1.61e+11***	0.091	0.0432855	0.180
SEDI	1.24e+11***	0.088	0.8143014*	0.000
Con. Coef.	-5.46e+10	0.516	10.69167*	0.000

Source: Author's estimation; Note: *, **, and *** indicate the parameter is statistically significant at the 1 %, 5 % and 10 % significance levels respectively.

Conclusion and Policy Suggestions

The present study creates intellectual property protection index (*IPPI*), science and technological development index (*STDI*) and socio-economic development index (*SEDI*) for selected 41 developed and developing economies using a *composite Z-score* technique. It also highlights India's position in intellectual property protection index, science and technological development and socioeconomic development among the 41 economies. Thereupon, it assesses the association of *IPAI*, *STDI* and *SEDI* with manufacturing value-added using linear, log-linear and non-linear regression models. Descriptive results show that there is high diversity in intellectual property rights regime, science and technological development and socioeconomic development across economies. This diversity exists due to the high gap in factors which are associated with IPRs, S&T and socioeconomic development.

Moreover, empirical results infer that intellectual property protection is a crucial driver to increase the growth of the manufacturing sector in these economies. Science and technological development show a positive impact on manufacturing value added. Socioeconomic development is seemed positive to boost the growth of the manufacturing sector. Intellectual property protection will provide an incentive for the researcher to do more research in the scientific field. So, it may be helpful to increase the position of global economies in patent, industrial design and trademark. Global economies are required to give significant focus on IPRs regime, science and technological and socio-economic development associated factors to boost the growth of manufacturing. For this, IPRs related courses must be included in the syllabus of research institutions for high learning of researcher towards IPRs (Janjua, Samad, 2007). Many industries are bound to produce a low quality of products due to use of poor technologies in production activities in developing economies (Sattar, Mahmood, 2011).

In India, the manufacturing sector is well dominated by capital and skill intensive enterprises which have limited scope for unskilled workers. India has a large population with unskilled labours and it is one of the youngest labour force which includes around 54 % of its population under the age of 25 years (GoI, 2015). Also, the current size of India's formal skilled workforce is around 2 % (GoI, 2014) and 2.3 % skilled workforce received formal skills training. Thus, India needs a large quantity of skilled workforce to utilize the indigenous technologies in the manufacturing sector (GoI, 2015). It is also expected that there would be a requirement of 120 million skilled workforces in India by 2022. In India, the labour force is expected to be increased by 32 %, while labour force would be declined by 4 % in the industrialised world in the next 20 years (GoI, 2015). It is, therefore essential to increase skills workforce to boost the growth of the manufacturing sector in India.

Furthermore, India have a several challenges such as low technological advancement, high reliance of manufacturing sector on foreign technologies, low level of instruments to produce goods in industries, low capacity of workers to use advance technologies in industries, research organizations do not have conducive R&D ecosystem, technologies are not being transfer from research organizations to industries, research organizations are not generating enough revenues through technology commercialization, government have low spending on R&D, ineffective partnership across manufacturing firms, low number of high-tech industries, low trust of foreign investor to invest in domestic firms due to fruitless mechanism of government policies, and instability in financial markets, existing industries are not in a better position to increase their production scale, low demand of goods and services in domestic market and large segment of society are in poverty trap to increase the contribution of their youth population in national building. Hence, the Indian government needs to give more focus on R&D activities, thereby India would be strong in domestic technologies. There must be mandatory for industries and research institutions to work together to solve aforesaid problems in India. The Indian government also needs to formulate effective policies to increase the demand of goods and service through improving the purchasing power of consumers especially in an unorganized sector that involves more than 90 % of the informal labour force of India (Kalyani, 2015; Sakthivel, Joddar, 2006).

China and South Korea are greater competitors for the Indian manufacturing sector. However, India have a lower labour cost than China and South Korea, therefore India has better opportunities to utilize their youth population (skilled, semi-skilled and unskilled workforce) in the manufacturing sector. It is proposed for India to contribute the stock of knowledge to improve human skills, discover new products, and upgrade the quality of products to enhance the growth of Indian manufacturing sector (Singh et al., 2019a). For this, science and technological advantage would be an option to enhance technological cheapness in India. Furthermore, India requires a greater effort in technological up-gradation, for this extensive investment in R&D would be indispensable. There must be policy with a special focus on attracting private sector’s investment in R&D which would be useful to create innovative ideas and discover more technologies for the manufacturing sector in India. Consequently, an increase in R&D expenditure and researchers in emerging research areas would be beneficial to meet the industrial requirements in India. Industry-research academia partnership, the establishment of more technology transfer offices (TTOs) at institute level would be supportive to increase the diffusion of existing technologies across industries (Singh et al., 2019a).

Moreover, research institutions must be more transparent and systematic in the sharing of technologies with industries in India. Then, industries would be efficient to develop high-tech products and generate employment for the skilled workforce. Subsequently, it would be helpful to create a new market for capital and financial investment. Hence, technology-driven growth for the labour surplus country like India would be useful to increase the growth of the manufacturing sector and to create more jobs. Also, the Indian government must be conscious to implement strong IPRs regime to protect the IP of researchers and scientists (Adams, 2009). Thereafter, IPRs would work as a key driver to increase technology transfer and commercialization in India (Hossain, Lasker, 2010; Sharma, Saxena, 2012).

In India, commercial banks and other financial institutions give more preference to deal with larger companies which involve low transaction cost and minimum risks. So, there is difficulty in accessing bank credit for small and medium enterprises in India. Hence, appropriate credit facilities with low-interest rate must be provided to SMEs, business organizations and new industries in India. India’s corporate taxes for domestic and foreign companies are 33.99 % and 43.26 % respectively. These are higher than China, South Korea, Thailand, Malaysia, Indonesia and

Singapore (KPMG, 2013). In recent years, most Asian countries have brought down corporate tax rates, while tax rates due to GST have increased in India. Hence, India's high corporate tax rate is less attractive for foreign investors as compared to other countries. Also, high inflation is caused to increase price variability of goods, which have an adverse impact on profits and investment of manufacturing firms in India. High inflation is also negatively associated with the productivity of resource and economic growth (Sattar, Mahmood, 2011). India thus needs to control high inflation to increase the consciousness of entrepreneurs to invest more in the manufacturing sector (Toader et al., 2018). It is also observed that high population growth is poised to reduce capital production per worker. Thus, high population growth and rapid urbanization have negative implications on economic growth. There are many factors like trade openness, public expenditure, foreign direct investment which have positive implications on economic growth and manufacturing sector (Adams, 2009; Toader et al., 2018). Hence, India is required to consider aforesaid aspects of policy formulation to enhance the growth of the manufacturing sector.

Limitations of the Study and Further Research Directions

In this study, economies are classified based on estimated values of IPAI, STDI and SEDI. These indexes are useful to increase the consciousness to policymakers and economic agents to take an effective and conducive policy action for developmental outlook in a country. These indexes show the comparative status of a nation in a specific indicator as compared to other economies. Though, there is one criticism for these indexes as it puts arbitrary weights and ranking which always change with every minor data revision. Therefore, it is not useful for inter-temporal comparisons of economies based on estimated indexes. Furthermore, the present study includes 28-high income; 9-upper middle income; and 4-lower middle-income economies in empirical investigation. The results of the study, therefore may not be generalized for developing countries due to the low number of countries.

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Conflict of Interest

Authors do not have any conflict of interest.

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