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Impact of Technology Transfer on Environmental Degradation in the World Economy

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Introduction

The transfer of technology is an essential tool for economic development of an economy. Global efforts were undertaken to foster sustainable development in the Rio "Earth Summit" UNCED Conference in 1992. At Rio, agreement on the Rio Declaration and Agenda 21 sought to define principles and an "action plan" for global sustainable development. It was aimed at fostering sustainable development through domestic and international actions of technology transfer. The development had aggravated the problem of environmental degradation. It could be identified from the following statistical evidences. Among the top five countries of CO₂ emissions in the world economy, United States was the top most country in emitting the CO₂ till the year 2005. From the year, 2006 onwards, China was the top most country in emitting the CO₂. The CO₂ emission of United States was ranged between 4.99 billion tonnes to 5.94 billion tonnes for the period 1990 -2011. In 1990, the CO₂ emission was only 2.51 billion tonnes in China. It had increased to 9.7 billion tonnes in 2011. In India also, the growth rate of CO₂ was higher. It was on account of higher growth rate of gross domestic product in these countries. In 2011, China was the top most country in emitting the CO₂. It was around 9.7 billion tonnes. It was also observed that, in future, China and India will become the first two top most countries in emitting CO₂, if the same trend is going to continue. Various studies had established the adverse impact of development through liberalization on environmental degradation. Antweiler et al. (2001) postulate a Factor Endowments Hypothesis (FEH), which predicts that trade liberalization will lead to an increase in carbon emissions in capital-abundant countries and a reduction in capital-scarce countries.

They test this hypothesis using panel data on city-level ambient SO₂ concentrations and find evidence that concentrations of SO₂ are increasing in a country's capital to labour ratio. They calculate the composition elasticity and find that one percent increase in a nation's capital-to-labour ratio holding scale, income and other determinants constant leads to one percent-point increase in pollution. Cole et al (2013) replicate Antweiler *et al.*'s (2001) study for SO₂, and extend the analysis to consider CO₂, NO₂, and Biological Oxygen Demand (BOD) as well. Their estimated composition elasticities are 2.3 and 0.45 for SO₂ and CO₂, and statistically indistinguishable from zero for NO₂ and Biological Oxygen Demand. Using Chinese data, Shen (2007) calculates com-

position effects for SO₂, Dust fall, Chemical Oxygen Demand (COD), Arsenic and Cadmium, in each case finding that higher capital/labour abundance corresponds to more pollution. In this backdrop, an attempt was made to analyse the impact of technology transfer on environmental pollution in the world economies with the following objectives.

Objectives

1. To assess the expenses on technology transfer in the world economies
2. To evaluate the carbon emissions in the world economies
3. To estimate the impact of technology transfer on environmental pollution.

Methodology

The data for the study is secondary in nature. The data on payment on intellectual property rights is taken as an indicator for the technology transfer between countries. The data CO₂ emissions and area under forest in various countries specified in World Bank Report 2013 are considered as the indicators of environmental indicators. Hence data on payment of intellectual property rights, CO₂ emissions and area under forest in various countries of the world economies were collected from the World Bank Report, 2013. Multiple regression analysis and discriminant analysis are used to fulfill the objectives of the study.

Specification of Empirical Models

1. Multiple Regression Analysis

- (a) To assess the impact of technology on gross domestic product of the world economy, the following form of the regression equation was estimated

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + U$$

X_1 = Intellectual payments, X_2 = Industrial share to the gross domestic product
 X_3 = Foreign Direct investment, U = Random term

- (b) To assess the impact of technology on carbon emission, the following form of the equation was estimated

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + U$$

X_1 = Intellectual payments (\$US) X_2 = Share of Industrial gross domestic product to the total gross domestic product (In percentage) X_3 = Foreign Direct investment(\$US),
 U = Random term.

2. Discriminant Analysis

To identify the relative contribution of technology transfer on environmental degradation, multiple discriminant analysis was employed. In the discriminant analysis, the countries in the world economy were classified as the country of high carbon emitting countries and countries of low carbon emitting countries based on the world average carbon emission. The

high carbon emitting countries were grouped together as group I countries and the low carbon emitting countries were grouped as group II countries. The factors such as the intellectual payments, industrial share to the gross domestic product and foreign direct investment were hypothesized as the factors classifying the countries into high carbon emitting countries and low carbon emitting countries. Hence they were put into the linear discriminant analysis.

$$Z = l_1X_1 + l_2X_2 + l_3X_3$$

Z = Total distance from the selected independent factors to the discriminant function

X_1 = Intellectual payments, X_2 = Industrial share to the gross domestic product

X_3 = Foreign Direct investment.

As the area of forest is one of the environmental indicator, the relative contribution of the technology transfer on the area under forest was estimated through linear discriminant analysis. The countries were classified as the countries of high forest endowed and low forest endowed countries based on the average forest endowment. The factors such as intellectual payments, industrial share to the gross domestic product and foreign direct investment were hypothesized as the factors classifying the countries into high forest endowed countries and low forest endowed countries. Hence they were put into the linear discriminant analysis.

$$Z = L_1X_1 + L_2X_2 + L_3X_3$$

Z = Total distance from the selected independent factors to the discriminant function

X_1 = Intellectual payments, X_2 = Industrial share to the gross domestic product

X_3 = Foreign Direct investment.

l_1, l_2, l_3 are the discriminant coefficients

Results and Discussion

The indicators of development was considered as the gross domestic product and industrial gross domestic product. The payment on intellectual property rights was taken as the indicator of technology transfer. The environmental indicators were the area under forest, CO₂ emissions, methane emissions and energy use. The results pertaining to the world average of technology transfer, industrial development and environmental indicators are shown in Table-1.

Averages estimated from the data given in World Bank Report, 2013.

The payment on intellectual property rights was amounted to \$ 6315400000, the percentage of industrial gross domestic product to gross domestic product was 21.04 percentage, the average forest area was 1068178.28 square kilo meter, the average per capita CO₂ emissions was 4.4988 metric tonnes. The average gross domestic product was \$ 1753490000000 and the average per capita energy use was 30548.37 Kilo Gram oil equivalent. The technology transfer was hypothesized to determine the economic development. Hence the indicator of technology transfer such as the payment on intellectual property rights was assumed to determine the gross domestic product along with the industrial gross domestic product and foreign direct investment. The above explanatory variables were put into the gross domestic product of the world economy equation. The results of the gross domestic product equation is shown in Table 2.

Table 1 World Average of Technology Transfer, Development and Environmental Indicators

Variables	Average
Payment on intellectual property (US \$)	6315400000
Industrial Gross Domestic Product (Percentage of industrial GDP to GDP)	21.0395
Forest Area (Square Kilo meter)	1068178.28
CO ₂ Emissions (Metric tonnes per capita)	4.498750996
Gross Domestic Product (US \$)	1753490000000
Methane emissions (Kt of CO ₂ equivalent)	2309506
Energy use (kg of oil equivalent per capita)	30548.37

Table 2 Relationship Between Trade Related Variables and Development in the World Economy - Regression Analysis

Variables	Regression Co efficient	't' value	Level of significance
Constant	-1.094E11	-.306	Insignificant
Intellectual payments	35.234	2.399	Significant at five percent level
Industrial GDP	-1.705E10	-1.261	Insignificant
Foreign Direct Investment	20.059	8.477	Significant at one percent level
R ²	0.40		
F Value	52.927		

Estimation based on the data from World Bank Report, 2013

The *F* value was statistically significant at one percent level indicating better fit of the model. The selected explanatory variables are strong enough to explain the model. Among the selected variables, the intellectual payments and foreign direct investment were statistically significant to determine the gross domestic product. The additional payment on intellectual property rights and the foreign direct investment had contributed to additional gross domestic product of the world economy. The industrial gross domestic product was statistically insignificant. The results revealed that the technology transfer and the foreign direct investment had increased the gross domestic product of the world economy significantly.

The economists argued that the important factor behind the environmental degradation was the development. The earlier studies had established a strong relationship between the Gross Domestic Product and CO₂ emissions. As the technology transfer was one of the strong factor behind the development, an attempt was made to analyse the relationship between the CO₂ and Gross Domestic Product.

The following Table 3 shows the results of regression analysis showing the relationship between the CO₂ emissions and intellectual property rights.

Among the selected variables, intellectual property rights was statistically significant at one percent level. The intellectual property rights had positive relative relationship with the CO₂ emissions. The additional CO₂ could increase the CO₂ emissions. The other factors were statistically

insignificant. The value of F was statistically significant to determine the CO₂ emissions equation. Hence the estimated model had better fit.

Table 3 Relationship Between CO₂ Emissions and Intellectual Property Rights

Variables	Regression Co efficient	't' value	Level of significance
Constant	0.058	1.240	Insignificant
Intellectual payments	5.180E-11	2.286	Significant at one percent level
Industrial GDP	.006	0.219	Insignificant
Florien Direct Investment	-4.504E-12	1.108	Insignificant
R ₂	0.43		
F Value	53.927		

Estimation based on the data from World Bank Report, 2013

Impact of Technology Transfer on Carbon Emissions in the World Economy

From the above regression equation, it was confirmed that the intellectual property rights was one of the factors to determine the Gross Domestic Product and thereby the carbon emissions of the world economy. To identify the relative contribution of each variable to the carbon emission, the countries in the world economy was classified as the high CO₂ emitting countries and low CO₂ emitting countries based on the world countries' average CO₂ emission. The countries emitting carbon above world average were classified as the high carbon emitting countries and the countries emitting carbon below the world average were classified as low carbon emitting countries. The intellectual property along with the other trade related variables were put into linear discriminant analysis to identify the relative contribution of the technology transfer on the CO₂ emission. Initially to find out the mean difference in the selected variables, the means of selected variables in high CO₂ emitting and low CO₂ emitting countries were estimated and are given in Table 4.

Table 4 Group Means of Selected Variables Pertaining to High Co₂ and Low Co₂ Emitting Countries in the World Economies

Variables	High carbon emitting countries	Low carbon emitting countries
Foreign Direct Investment	14891000000	103870000000
Payment on intellectual property rights	100590000	16290000000
The share of Industrial Gross Domestic Product to Gross Domestic Product	20.2108	22.4149

Estimations based on the data from World Bank Report, 2013

The table shows that the average foreign direct investment was \$ 103870000000 in high carbon emitting countries and was \$ 14891000000 in the low carbon emitting countries. The payment on intellectual property rights was \$ 16290000000 in high carbon emitting countries and \$ 100590000 in the low carbon emitting countries. The share of industrial gross domestic product to total gross domestic product was 22.4149 percent in high carbon emitting countries and 20.2108 percent in

low carbon emitting countries. It showed that the foreign direct investment, payment on intellectual property rights and industrial gross domestic product were higher in high carbon emitting countries than in low carbon emitting countries. To test whether the mean differences in the selected independent factors were statistically significant the Wilks Lambda, the univariate statistic was calculated. The estimated results of Wilks Lambda are shown in Table 5.

Table 5 Wilks Lambda - Univariate Statistics

Variables	Wilks Lambda	Level of Significance
Foreign Direct Investment	.944	Significant at 1% level
Payment For intellectual property rights	.939	Significant at 1% level
Industrial Gross Domestic Product	.996	Significant at 1% level

Estimations based on the data from World Bank Report, 2013

If the Wilks lambda approaches one, greater is the difference between the group means. If it approaches zero, it indicates lower mean difference between the groups. The value of Wilks lambda was statistically significant for all the selected variables such as the foreign direct invest, payment for intellectual property rights and the share of industrial gross domestic product. It revealed that all the selected variables differed significantly between the high carbon emitting countries and low carbon emitting countries.

The magnitude of the standardized canonical discriminant function shows the order of the variable's contribution to the total difference in the discriminant function. The Table 6 shows the standardized canonical discriminant function.

Table 6 Standardized Canonical Discriminant Function Coefficients

Variables	Canonical discriminant function coefficients	Rank
Foreign Direct Investment	.325	2
Payment for intellectual property rights	.683	1
Industrial Gross Domestic Product	.189	3

Estimations based on the data from World Bank Report, 2013

The table shows that the payment for intellectual property rights was the first important factor discriminating the countries as high carbon emitting countries and low carbon emitting countries. The next important factor was the foreign direct investment followed by the industrial gross domestic product. The Table 7 shows the pooled correlation between the discriminating variables and canonical discriminant function.

Table 7 Pooled Within-Groups Correlations Between Discriminating Variables and Standardized Canonical Discriminant Functions Variables Ordered by Absolute Size of Correlation within Function

Variables	Canonical Correlation	Rank
Foreign Direct Investment	0.944	2
Payment for intellectual property rights	0.945	1
Industrial Gross Domestic Product	0.901	3

Estimations based on the data from World Bank Report, 2013

The table shows that the magnitude of foreign direct investment and payment for intellectual property right in the pooled correlation between the discriminating variables and standardised discriminant function was around 0.94. It revealed that the foreign direct investment and payment on intellectual property rights were the most important factors in classifying the countries into high and low carbon emitting countries. The relative contribution of selected variables in determining carbon emissions were calculated and are given in Table 8.

Table 8 Relative Contribution of Selected Variables

Variables	Relative contribution	Rank
Foreign Direct Investment	64.6	1
Payment for intellectual property rights	34.2	2
Industrial Gross Domestic Product	1.2	3

Estimations based on the data from World Bank Report, 2013

Foreign direct investment was the dominant factor determining the carbon emission. It alone contributed 64.6 percent in differentiating the countries into high and low carbon emitting countries. It was followed by payment for intellectual property rights which contributed to 34.2 percent. The industrial gross domestic product was the least important factor in classifying the countries into high and low carbon emitting countries.

Impact of Intellectual Property Rights on the Forest Endowed in the World Countries

The endowment of forest in a country is a strong indicator of environment. The countries in the world economy were classified as the high forest endowed and low forest endowed countries based on the average area of forest in the world countries. If a country is endowed above the average area of forest, they were classified as the high forest endowed country. If a country is endowed below the average level of forest, they were called as the low forest endowed country. The foreign direct investment, payment on intellectual property rights and industrial gross domestic product were selected as the independent factors in classifying the countries as the countries with high forest endowed and low forest endowed countries. The Table 9 shows the mean difference of the selected variables between high forest endowed and low forest endowed countries.

Table 9 Group Means of Selected Variables Pertaining to High Forest Endowed and Low Forest Endowed Countries

Variables	Group I Mean	Group II Mean
Foreign Direct Investment(\$US)	7355000000	372990000000
Payment on intellectual property rights(\$US)	811300000	50286000000
Share of Industrial Gross Domestic Product (Percentage)	21.0211	29.0022

Estimations based on the data from World Bank Report, 2013

The foreign Direct Investment was \$ 372990000000 in high forest endowed countries while the same was \$ 7355000000 in low forest endowed countries. The payment on intellectual property

rights was \$ 50286000000 in the high forest endowed countries while the same was \$ 811300000 in low forest endowed countries. The share of industrial gross domestic product was 29.0022 percent in high forest endowed countries and 21.0211 percent in low forest endowed countries.

Through, Wilks lambda the statistical significant difference in the means of selected variables between the groups was estimated. The results of Wilks lambda are shown in Table 10.

Table 10 Group Means of Selected Variables Pertaining to High Forest Endowed and Low Forest Endowed Countries

Variables	Wilks Lambda	Level of significance
Foreign Direct Investment	.598	Significant at one percent level
Payment For intellectual property rights	.769	Significant at one percent level
Industrial Gross Domestic Product	.976	Significant at one percent level

Estimations based on the data from World Bank Report, 2013

The value of Wilks lambda was statistically significant. It indicates that the mean of the variables such as the foreign direct investment, payment for intellectual property rights and industrial gross domestic product differed significantly between high forest endowed and low forest endowed countries. The results of canonical discriminant function and the pooled correlation between the selected discriminating variables and the discriminant function are shown in Table 11.

Table 11 Standardized Canonical Discriminant Function Coefficients

Variables	Canonical discriminant function coefficients	Rank
Foreign Direct Investment	1.233	2
Payment For intellectual property rights	-.336	1
Industrial Gross Domestic Product	.144	3

Estimations based on the data from World Bank Report, 2013

The Table 12 shows the pooled correlation between the discriminating variables and canonical discriminant function.

Table 12 Pooled Within-Groups Correlations

Variables	Canonical Correlation	Rank
Foreign Direct Investment	.966	1
Payment For intellectual property rights	.646	2
Industrial Gross Domestic Product	.186	3

Estimations based on the data from World Bank Report, 2013

Foreign direct investment was ranked first in the standardized discriminant canonical discriminant function. It was the first important variable discriminating the countries into high forest endowed countries and low forest endowed countries. The payment for intellectual property right was ranked as the second important factor in discriminating the countries into high and low forest endowed countries. Contribution of the variables in discriminating the forest endowment of the countries was calculated and shown in Table 13.

Table 13 Relative Contribution of Selected Variables

Variables	Relative contribution	Rank
Foreign Direct Investment	0.0000009	1
Payment for intellectual property rights	99.99999803	2
Industrial Gross Domestic Product	0.0000001	3

Estimations based on the data from World Bank Report, 2013

The payment for intellectual property right was the dominant factor in discriminating the countries into high and low forest endowed countries. It alone contributed 90 percentage of variations in classifying the countries into high and low forest endowed countries. The next important variable was foreign direct investment. The share of industrial gross domestic product in the total gross domestic product was the least important factor in classifying the countries into high and low forest endowed countries.

Conclusion

To conclude, the foreign direct investment and the transfer of technology had increased the gross domestic product of the world economy. The transfer of technology had caused the carbon emissions. Higher amount of payment on intellectual property rights and foreign direct investment were observed in the high carbon emitting countries. Similarly the same was higher in less forest endowment countries. Hence, among the trade related factors, the transfer of technology and the foreign direct investment were the dominant factors in causing the environmental degradation. It is essential to fix a boundary for the transfer of technology not to cross environmental limit.

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