Income, Inequality and Forest Cover Density in India

A Reassessment of the Environmental Kuznets Curve

Group Number 4

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Background

The Kuznets Curve- by Simon Kuznets

The idea of ‘Environmental kuznet Curve’: The relationship between per capita income and environmental degradation is similar to an inverted U shape

A reduced form relationship including different effects

Introduction

- It becomes necessary to throw light on the factors that have a role to play in changing forest cover.

- This change may arise from the lifestyle changes, which in turn changes from the income levels.

- Another paper in the literature suggests that democracy, which has high public participation, transparent systems and equal voter rights reduces environmental degradation (Li & Reuveny, 2006).

- Our study tries to find out how the distribution of income and the variability in the political aspects affect the forest cover density of different state.

Variable Description

Data for 2003-2017 of 28 States and 2 UTs

Variable(Unit)	Description	Acronym	Source
Density of Forest Cover (per sq. km) -Dependent variable	This variable includes state-wise areas under forest / geographical area of state	vdf, mdf, of	State of Forest Report by Ministry of Environment, Forest and Climate Change
Gini Index	To measure state wise inequality, higher gini index indicates more unequal income distribution in a state $\in [0,1]$	gini	National Sample Survey Organization (NSSO)
SDP per capita (INR)	To measure the average per capita consumption of a person in a year in different states	sdp	Ministry of Statistics and Programme Implementation (MoSPI)

Variable Description

Variable(Unit)	Description	Acronym	Source
Literacy Rate (%)	Includes literacy rate for each state. Level of education relates to better income and more awareness about environment	literacy	Census of India
Number of effective parties	Number of effective parties contesting elections for each state in a particular year N=1/summation(pi**2) pi : proportion of seats won by party i in a state level election (Laakso & Taagepera ,1979)	effective_parties	Election Commision of India (State-wise election report)
Participation Score	Measuring participation of different sections of society in state elections ∈ [0,3]	participation_score	Election Commision of India (State-wise election report)

Variable Description

Variable(Unit)	Description	Acronym	Source
Poverty Rate (%)	Percentage of people below poverty line in a state. High poverty links to lower income and is therefore a measure of income inequality	poverty_rate	NSSO, NITI Aayog
Departments	Number of ministries/departments in each state helps identify number of focus areas in a state. More focus areas require better governance and therefore point towards the governance situations in a state.	num_departments	State govt websites
Win Margin	Includes the difference of number of seats won by the winning party and the second winning party in each state election	win_margin	Election Commission of India (State-wise election report)

Variable Description

Variable(Unit)	Description	Acronym	Source
Growth Rate (%)	Includes yearly achieved economic growth rate of each state as per 5 year plan targets. Higher growth rate indicates more growth in primary, secondary or tertiary section which might come at the expense of land	growth_rate	Economic and Statistical Organization, Government of Punjab
Protected Area Funds as % of state GDP (%)	Includes protected area funds of each state released under the CAMPA Act as a percentage of the state's GDP	campa_paf	E-Green Watch

Data Summary

Variable Acronym	N	Mean	Median	SD	Minimum	Maximum
mdf *	240	0.15	0.11	0.13	0.01	0.5
of *	240	0.15	0.10	0.14	0	0.62
vdf *	240	0.03	0.02	0.05	0	0.25
Campa_paf	240	0.06	0.01	0.20	0	2.67
gini	160	0.37	0.34	0.09	0.20	0.58
growth_rate	240	8.39	7.87	5.75	-11.94	73.61
literacy	240	72.71	72.55	10.28	47	94

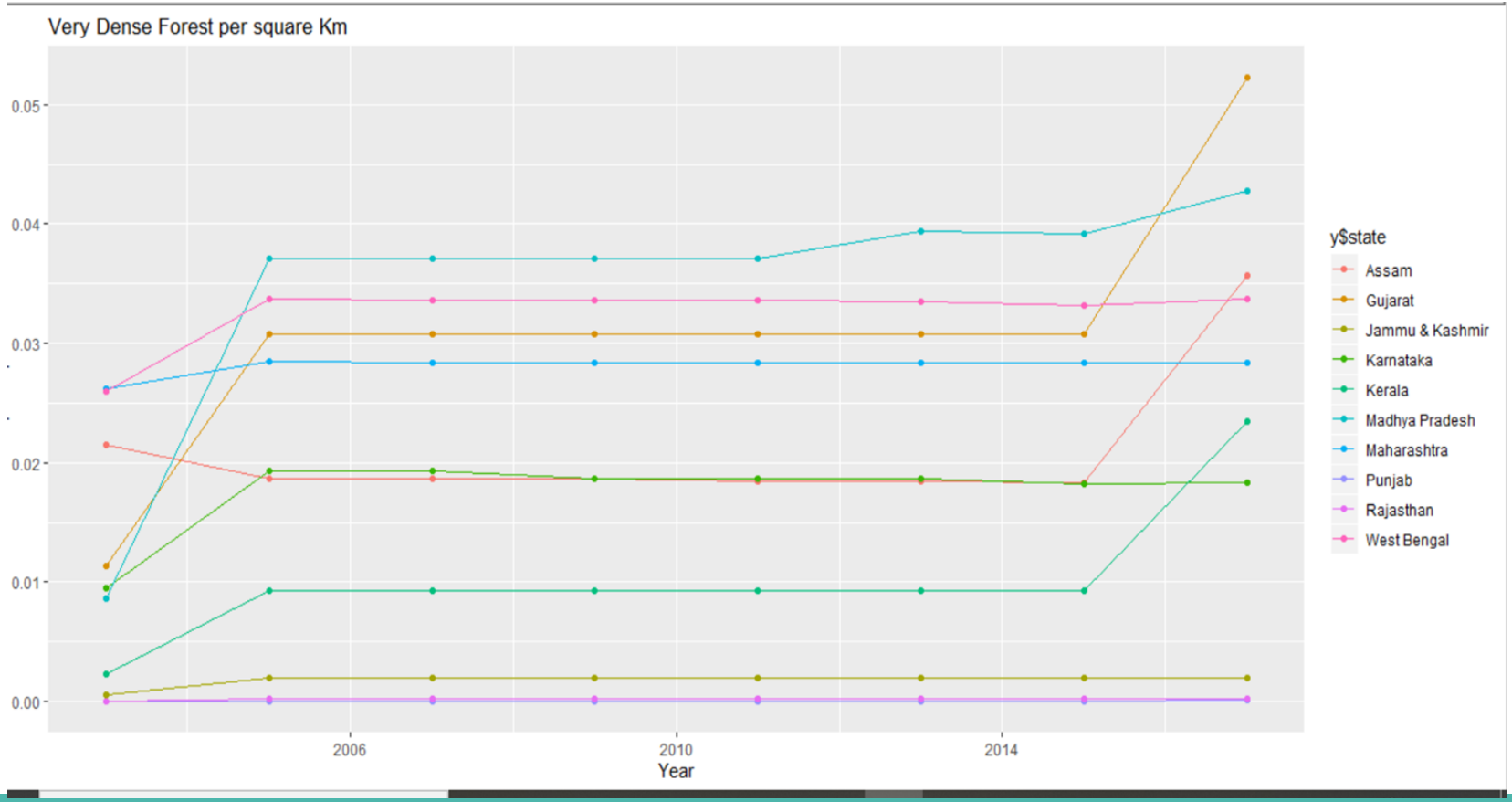
* : Dependent variable

Data Summary

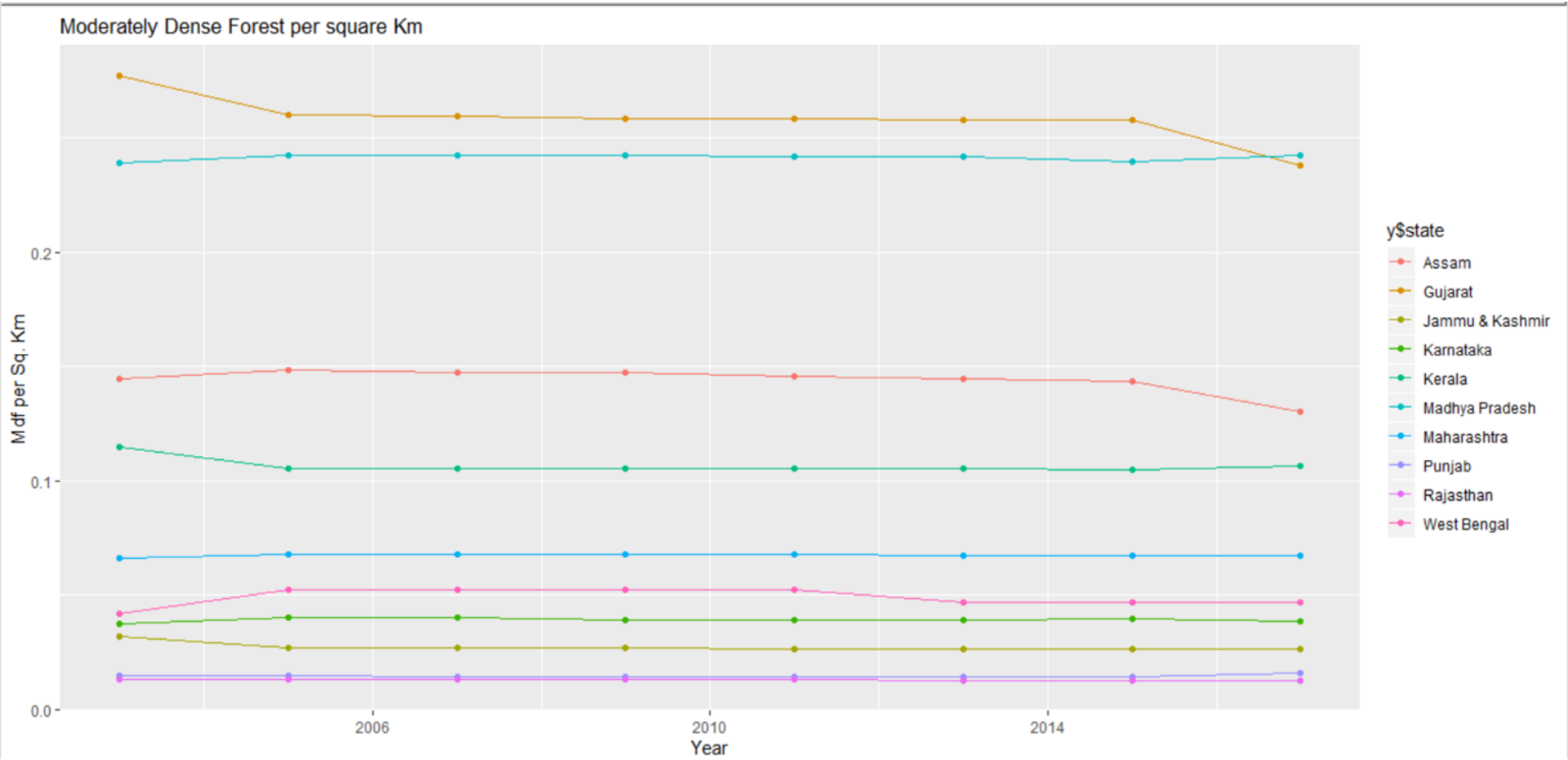
Variable Acronym	N	Mean	Median	SD	Minimum	Maximum
num_departments	240	46.37	46	12.88	23	81
num_parties	240	2.62	2.39	1.01	1.0	6.09
participation_score	240	1.24	1.26	0.44	0.48	2.02
poverty_rate	240	22.66	19.98	12.55	1.2	57.2
sdp	240	68906	50985	58484.73	6852	375550
win_margin	239	40.62	27	41.89	1	265

Trend Graph

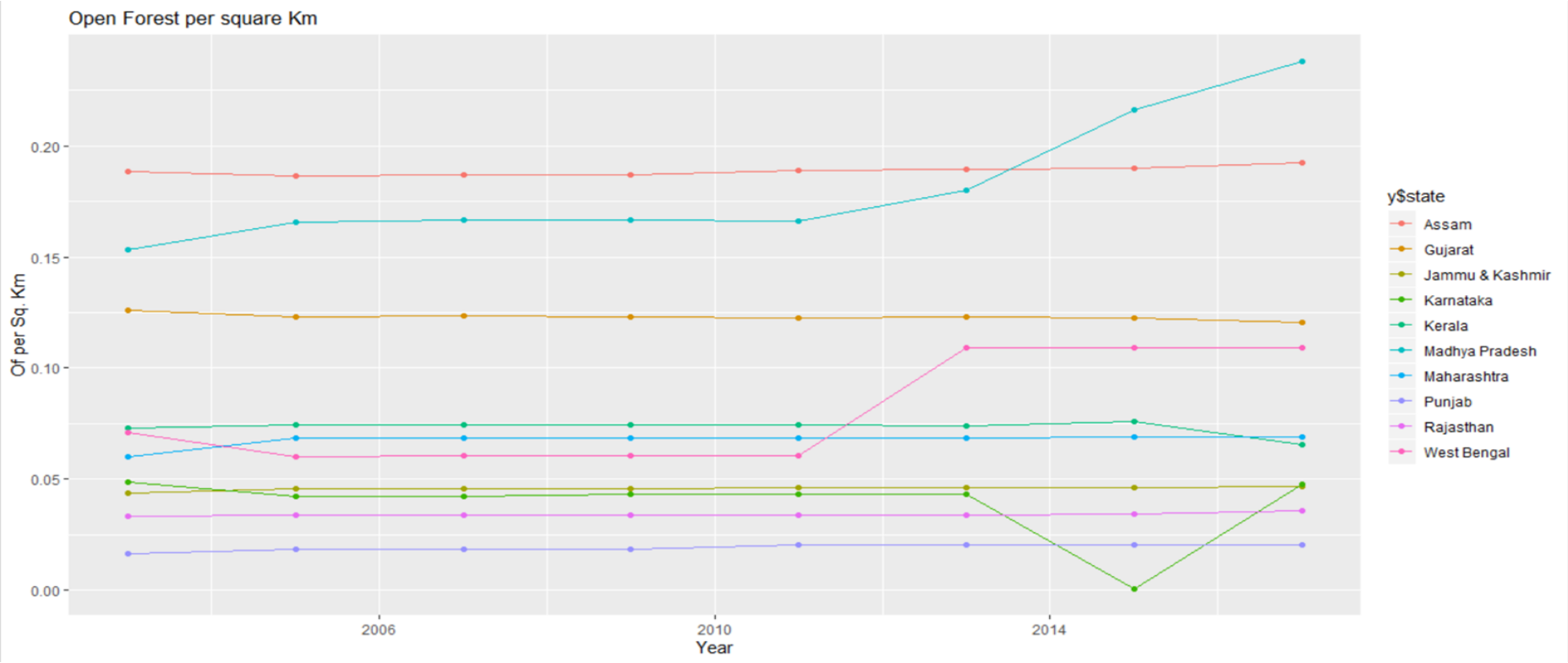
(Randomly selected 2 states each from north, south, east , west and central India)



Trend Graph


Moderately Dense Forest per square Km
Mdf per Sq. Km
0.0
0.1
0.2
2006
2010
2014
Year
y$state
Assam
Gujarat
Jammu & Kashmir
Karnataka
Kerala
Madhya Pradesh
Maharashtra
Punjab
Rajasthan
West Bengal

Trend Graph



Clearly, trends are mostly constant across years and so excluding the trend variable in the regression model will not affect the regression results

Model and Relevant Hypothesis

- Main aim of the model is to study the possibility of a causal relationship between changes in income and power distribution and the density of forest cover.

- Therefore, we represent forest cover, F as:

  F = *f* (SDP, SDP^2, SDP^3, Z)

  where Z denotes variables representing income and power distribution

Model and Relevant Hypothesis

The three equations of linear regression are:

$$vdf_{i,t} = \beta_0 + \beta_1 campa\_paf_{i,t} + \beta_2 gini_{i,t} + \beta_3 growth\_rate_{i,t} + \beta_4 literacy_{i,t} + \beta_5 num\_department_{i,t} + \beta_6 num\_parties_{i,t} + \beta_7 participation\_score_{i,t} + \beta_8 poverty\_rate_{i,t} + \beta_9 sdp_{i,t} + \beta_{10} sdp\_square_{i,t} + \beta_{11} sdp\_cube_{i,t} + \beta_{12}\, win\_margin_{i,t} + \beta_{13} t + u_{i,t}$$

$$mdf_{i,t} = \beta_0 + \beta_1 campa\_paf_{i,t} + \beta_2 gini_{i,t} + \beta_3 growth\_rate_{i,t} + \beta_4 literacy_{i,t} + \beta_5 num\_department_{i,t} + \beta_6 num\_parties_{i,t} + \beta_7 participation\_score_{i,t} + \beta_8 poverty\_rate_{i,t} + \beta_9 sdp_{i,t} + \beta_{10} sdp\_square_{i,t} + \beta_{11} sdp\_cube_{i,t} + \beta_{12}\, win\_margin_{i,t} + \beta_{13} t + u_{i,t}$$

$$of_{i,t} = \beta_0 + \beta_1 campa\_paf_{i,t} + \beta_2 gini_{i,t} + \beta_3 growth\_rate_{i,t} + \beta_4 literacy_{i,t} + \beta_5 num\_department_{i,t} + \beta_6 num\_parties_{i,t} + \beta_7 participation\_score_{i,t} + \beta_8 poverty\_rate_{i,t} + \beta_9 sdp_{i,t} + \beta_{10} sdp\_square_{i,t} + \beta_{11} sdp\_cube_{i,t} + \beta_{12}\, win\_margin_{i,t} + \beta_{13} t + u_{i,t}$$

where t=1 for 2003, t=2 for 2005 and so on and i is index for State/UT i

Model and Relevant Hypothesis

- Ho: There is no statistically significant relationship between income and power inequality and forest cover density

  $\beta_0 = \beta_2 = \beta_3 = \beta_4 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0$ i.e. no effect of income distribution on forest cover

  $\beta_0 = \beta_1 = \beta_5 = \beta_6 = \beta_7 = \beta_{12} = 0$ i.e. no effect of power distribution on forest cover

- Ha: There is some statistically significant relationship between income and power inequality and forest cover density

  At least one $\beta_i != 0$ for i=1,2.....,12

- For EKC: $\beta_9 > 0$, $\beta_{10} < 0$ and $\beta_{11} <= 0$

Regression Results

Independent/Dependent Variable	vdf Estimate (SE)	mdf Estimate (SE)	of Estimate (SE)
Intercept	-0.095*** (0.012)	-0.32*** (0.045)	-2.38e-01*** (3.76e-02)
campa_paf	0.115*** (0.025)	0.476*** (0.089)	1.85e-01* (7.96e-02)
gini	-0.036* (0.017)	-0.0961 (0.060)	-0.096 . (0.053)
growth_rate	-1.44E-04 (3.13E-04)	5.30e-04 (1.11e-03)	2.33e-04 (9.80e-04)

Significance : 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Regression Results

Independent/Dependent Variable	vdf Estimate (SE)	mdf Estimate (SE)	of Estimate (SE)
literacy	1.12e-03*** (1.50e-04)	6.49e-03*** (5.33e-04)	4.17e-03 *** (4.71e-04)
num_department	8.46e-05 (7.33e-05)	-5.03e-04 . (2.59e-04)	-3.69e-05 (2.29e-04)
num_parties	5.07e-03*** (1.13e-03)	0.012** (3.99e-03)	8.72e-03* (3.54e-03)
participation_score	7.05e-03* (3.36e-03)	0.032** (0.0119)	6.58e-03 (0.011)

Significance 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Regression Results

Independent/Dependent Variable	vdf Estimate (SE)	mdf Estimate (SE)	of Estimate (SE)
poverty_rate	4.11e-04*** (9.99e-05)	1.99e-03*** (3.54e-04)	1.67e-03*** (3.13e-04)
sdp	-2.24e-08 (1.99e-07)	-2.67e-06*** (7.08e-07)	-1.55e-06* (6.26e-07)
sdp_square	-2.92e-13 (1.48e-12)	1.55e-11** (5.23e-12)	8.44e-12 . (4.62e-12)
sdp_cube	6.78e-19 (3.23e-18)	-2.77e-17* (1.14e-17)	-1.33e-17 (1.01e-17)

Significance : 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Regression Results

Independent/Dependent Variable	**vdf** **Estimate (SE)**	**mdf** **Estimate (SE)**	**of** **Estimate (SE)**
win_margin	6.193e-05* (2.532e-05)	2.086e-05 (8.978e-05)	1.306e-04 (7.940e-05)
t	1.979e-03* (8.492e-04)	8.064e-03 ** (3.011e-03)	7.375e-03** (2.663e-03)
	N=240 **R squared**=0.47	**N**=240 **R squared**=0.63	**N**=240 **R squared**=0.43

Significance : 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Inference and Conclusion

- p-value of the F-statistic : < 2.2e-16, for vdf and mdf which is highly significant. p-value of the F-statistic : 6.068e-14 for of
- Protected area funds under CAMPA have very significant impact on density of forest cover
- Literacy is positively related to forest cover i.e. an increase in rate of literacy will positively impact forest cover
- Poverty rate follows the same pattern which indirectly indicates the importance of income levels in determining forest cover. This also points towards the relationship between income and environmental degradation.
- Since poverty is a very significant variable, regression could also be run without including SDP per capita and considering poverty as the only indicator of income.
- Number of effective parties also play a significant role in determining forest cover

Inference and Conclusion

- $\beta_9 < 0$, $\beta_{10} > 0$ and $\beta_{11} < 0$ in case of mdf and of which indicates an inverted-N-shaped relationship between income distribution and forest cover. Similar results were also found in another research which was based on the study of EKC on Turkey's income distribution (Yurttagüler & Kutlu, 2017)

- Since the data does not support EKC curve, it suggests that income levels alone cannot solve the problem of environmental degradation

- Policy actions and government interventions are important in environmental protection too.

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