Evaluating Factors Influencing Carbon Dioxide Sinks from Land Use, Land-Use Change and Forestry in U.S.

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What are greenhouse gases?

Intergovernmental Panel on Climate Change (IPCC) (p.82) defined greenhouse gases as "gases in the atmosphere both natural and anthropogenic that absorb and emit radiation at specific wave length within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This process is the fundamental cause of the greenhouse effect."

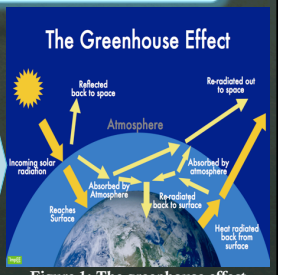


Figure 1: The greenhouse effect

www.wildculture.com

History of Greenhouse Effect

- 1824: Joseph Fourier noted the existence of the greenhouse effect
- 1827 and 1838: Claude Pouillet provided more support for the greenhouse effect
- 1859: John Tyndall - experimental observations for greenhouse effect
- 1896: More research on greenhouse effect by Svante Arrhennius

Issac and Soden (2000); Tyndall (1873)

What are the main global greenhouse gases?

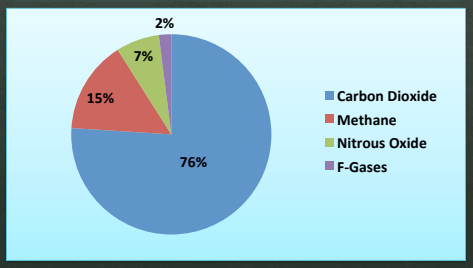


Figure 2: Global Greenhouse Gas Emission by Gas

Ecofys (2010)

Greenhouse Gas Emissions in U.S.

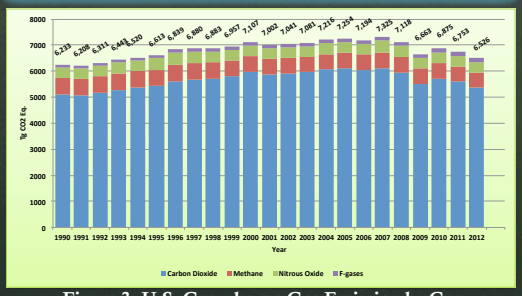


Figure 3: U.S. Greenhouse Gas Emission by Gas

EPA 1999: 2007: 2009: 2014

Where do greenhouse gases originate?

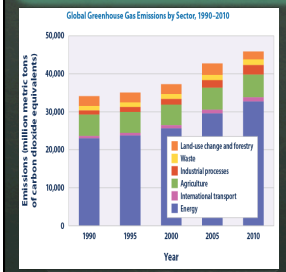


Figure 4: Global GHG Emissions by Sector from 1990 to 2010

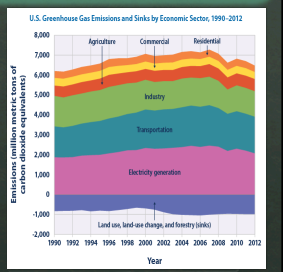


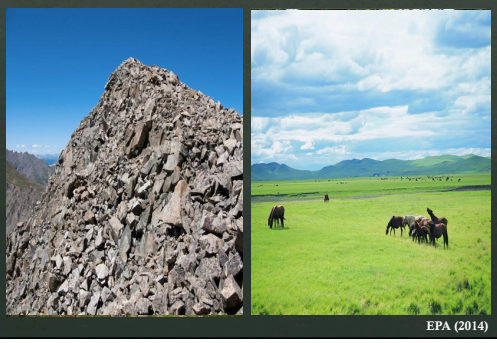
Figure 5: U.S. GHG Emissions by Sector from 1990 to 2012

EPA (2014); WRI (2014);FAO (2014)

What is LULUCF?

Source:
- https://www.youtube.com/watch?v=9GgbBnkcdLw
- www.palmoiltv.org

Types of Land-Use



EPA (2014)

Trends of Global Land-Use

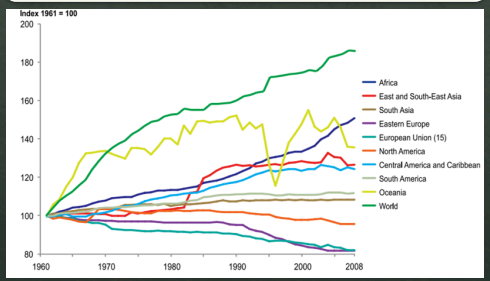
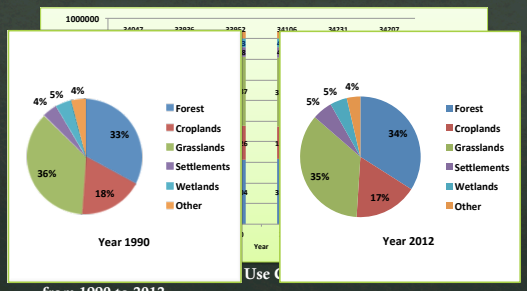


Figure 6: Changes in arable and permanent crop land use, 1961 - 2008 (in percent)

Bindraban et al. (2009); UNEP (2014)

Trends of U.S. Land-Use



from 1990 to 2012

EPA (2014)

U.S. CO_2 Sinks from Land Use, Land-Use Change, and Forestry

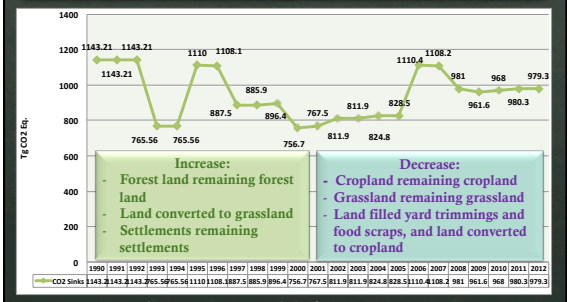


Figure 8: U.S. CO_2 Sinks from 1990 to 2012

EPA (2014)

Research Objectives

1. Identify the factors influencing carbon dioxide (CO_2) sinks from land use, land-use change, and forestry in U.S.

2. Summarize the major causes of sinks and assess methods to mitigate carbon dioxide (CO_2) emissions from land use, land-use change, and forestry

Methods and Procedures

- Data
- Tobit Method
- Empirical Model
- Multicollinearity Diagnostics
- Heteroskedasticity

Methods and Procedures

- Data
  - All data were obtained from U.S. Environmental Protection Agency (EPA), The World Bank, National Oceanic & Atmospheric Administration (NOAA), Food and Agriculture Organization of the United Nations (FAOSTAT) between 1990 and 2011.
  - This research uses the amount of carbon dioxide (CO_2) sinks from land use, land-use change, and forestry (Unit: Tg CO_2 Eq.) as the dependent variable and factors influencing CO_2 sinks as independent variables.

Methods and Procedures

- Tobit Method
  - A Tobit model is used to specify for the amount of CO_2 sinks from 1990 to 2011 as follow (Greene 2012):

$$CARBON_i^* = \beta_k' x_i + \varepsilon_i, \varepsilon_i \sim \mathrm{N}(0, \sigma^2)$$

where β_k' is a vector of unknown parameters, x_i is a vector of factors that affect $CARBON_i^*$, ε_i is an error vector, and the distribution of $CARBON_i^*$, given x_i, is $CARBON_i^* | x_i \sim \mathrm{N}(\beta x_i, \sigma^2)$.

Methods and Procedures

- Tobit Method
  - The marginal effect with censoring at zero on the expected value of $CARBON_i^*$ is (Greene 2012):

$$\partial E[CARBON_i^* | x_i, CARBON_i > 0] / \partial x_i = \beta_k \Phi\left(\frac{\beta' x_i}{\sigma}\right),$$

where β_k are $k = 0, \ldots$, m parameters to be estimated using maximum likelihood and Φ is the standard normal distribution function.

Methods and Procedures

- Tobit Method
  - Maximum-likelihood method is used to estimate the vector of β that maximize the log-likelihood function for carbon sinks (Greene 2012):

$$\ln L = \sum_{\{i|CARBON_i>0\}} \ln\left[\sigma_i^{-1}\phi\left(\frac{CARBON_i^* - x_i'\beta_k}{\sigma_i}\right)\right] + \sum_{\{i|CARBON_i=0\}} \ln\left[1 - \Phi\left(\frac{CARBON_i^* - x_i'\beta_k}{\sigma_i}\right)\right].$$

Methods and Procedures

- Empirical Model
  - The following model was specified to determine the factors influencing carbon sinks between 1990 and 2011:

$$CARBON_i = \beta_0 + \beta_1 CROPIND_i + \beta_2 EMPLOY_i + \beta_3 EDUCAT_i + \beta_4 INFLAT_i + \beta_5 LEND_i + \beta_6 GDPG_i + \beta_7 POPGR_i + \beta_8 PRODUCT_i + \beta_9 TEMPE_i + \beta_{10} RAIN_i + \varepsilon_i.$$

where the variable definitions and hypotheses are given in Table 1.

Methods and Procedures

Table 1. Definitions and Hypothesized Signs for Dependent and Independent Variables Used in Tobit Regression.

Variable[1]	Definition	Sign
Dependent Variables		
CARBON	Amount of carbon sinked from land use, land-use change, and forestry (Tg CO_2 Eq.)	N/A
Explanatory Variables		
CROPIND	Crop production index shows agricultural production for each year relative to the base period 2004-2006 including all crops except fodder crops	–
EMPLOY	Employees are people who work for a public or private employer and receive remuneration in wages, salary, commission, tips, piece rates, or pay in kind including hunting, forestry, and fishing (% of total employment).	–
EDUCAT	School enrollment, tertiary (% gross)	+
INFLAT	The annual percentage change in the cost to the average consumer of acquiring a basket of goods and services	–

Methods and Procedures

Table 1. (cont.)

Variable[1]	Definition	Sign
LEND	The bank rate that usually meets the short and medium-term financing needs of the private sector	–
GDPG	Annual percentage growth rate of GDP at market prices based on constant local currency	–
POPGR	Population growth (annual percentage) is the exponential rate of growth of midyear population from year t-1 to t	–
PRODUCT	All forest products (tonnes)	–
TEMPE	Average annual temperature in all states ()	–
RAIN	Average precipitation (millimeters, mm)	–

[1]All data were collected from 1990 to 2011.
Source: The World Bank, National Oceanic & Atmospheric Administration (NOAA), United States Environmental Protection Agency (EPA) and United Nations Food and Agriculture Organization (FAOSTAT).

Methods and Procedures

- Multicollinearity Diagnostic
  - Variance inflation factors (VIF) are applied to diagnose collinearity among independent variables. The variance inflation factors are calculated by the equation below (Afifi and Clark 1984; Fox 1984):

$$\text{VIF} = \frac{1}{1-R^2},$$

where R^2 is the coefficient of determination of a regression of an independent variable on all the other independent variables (Nagelkerke 1991). If VIF value is greater than 10 indicates that multicollinearity may exist among independent variables (Neter, Wasserman, and Kutner 1985).

Methods and Procedures

❖Heteroskedasticity

The existence of heteroskedasticity occurs the maximum likelihood estimators will be inconsistent (Maddala and Nelson 1975). Peterson and Waldman (1981) recommended to check the heteroskedatic tobit model. A Lagrange multiplier (LM) test is used to test for heteroskedasticity as follow:

$$\mathrm{LM} = \mathrm{n}R^2.$$

The null hypothesis of homoscedasticity is $\alpha = 0$. If the LM value of the model is exceeded the critical value of LM, so the null hypothesis is rejected (Greene 2012).

Benefits of this Research

- ❖Policy Making
- ❖Research
- ❖Management

Literature References

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Figure & Video References

- **Figure 1:**
  - http://www.wildculture.com/article/what-do-home-reduce-greenhouse-gas-emissions/1375 (ppt 2).
- **Figure 2:**
  - Ecofys. 2010. World GHG Emissions Flow Chart 2010. http://www.ecofys.com/files/files/asn-ecofys-2013-world-ghg-emissions-flow-chart-2010.pdf
- **Figure 3:**
  - U.S. Environmental Protection Agency (EPA). 1999. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–1999*. EPA, Washington, D. C.
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- **Figure 4:**
  - WRI (World Resources Institute). 2014. Climate Analysis Indicators Tool (CAIT) 2.0: WRI's climate data explorer. Accessed May 2014. http://cait.wri.org.
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Figure & Video References

- **Figure 5:**
  - U.S. EPA (U.S. Environmental Protection Agency). 2014. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2012. EPA 430-R-003.
- **Figure 6:**
  - Bindraban, P., E. Bulte, S. Conijn, B. Eickhout, M. Hoogwijk, M. Londo (2009). Can biofuels be sustainable by 2020? An assessment for an obligatory blending target of 10% in the Netherlands. Netherlands Research Programme on Scientific Assessment and Policy Analysis for Climate Change.
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- **Figure 7:**
  - U.S. EPA (U.S. Environmental Protection Agency). 2014. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2012. EPA 430-R-003.
- **Figure 8:**
  - U.S. Environmental Protection Agency (EPA). 2014. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014*. EPA, Washington, D. C.

Figure & Video References

- **Pictures (Title Slide):**
  - (Left)http://consilium.europa.eu/homepage/showfocus?focusName=assessing-the-climate-impact-of-land-use-and-forestry&lang=es;
  - (Middle) http://www.ecologic.eu/10829;
  - (Right) http://www.foe-scotland.org.uk/biomass-facts
- **Pictures (Slide#8):**
  - http://oregonsunshine.net/gallery2/d/386-3/Starker2.jpg;
  - http://files.campus.edublogs.org/blogs.cornell.edu/dist/c/2110/files/2012/06/Rows-of-Greens-28zhsmk.jpg;
  - http://www.freegreatpicture.com/files/28/23029-pasture-scenery-of-vast-grassland.jpg;
  - http://www.burnsmcd.com/Resource_/Article/5228/Image1/BM-NeedToKnowWetlandBanking-GAL.jpg;
  - http://mathieuhelie.files.wordpress.com/2008/11/palios_pn_anteleeimonas.jpg;
  - http://2.bp.blogspot.com/_rbR9hPqruWQ/TDiiRO-3RnI/AAAAAAAACUg/mfmAaqA9F3g/s400/IMG_4521-10.jpg;
- **Pictures (Slide#29):**
  - http://repaircafe.nl/deventer/files/2012/10/ZevenRs.jpg
- **Video (Slide#28):**
  - https://www.youtube.com/watch?v=9GgbBnkcdLw;
  - http://www.palmoiltv.org

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Question?

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