Examining the Carbon Emission Technical Efficiency : A Stochastic Frontier Approach

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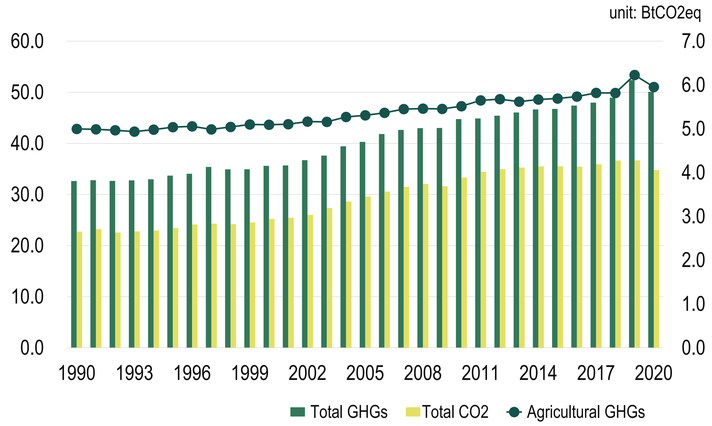
Introduction

- Global carbon emissions increased by 52.6% from 22.8 BtCO2eq in 1990 to 34.8 BtCO2eq in 2020. The agricultural sector is expected to contribute to global carbon emissions significantly. According to OECD (2015), agricultural activities resulted in about 17% of GHG emissions and 7~14% of land-use change.
- This study aims to estimate the GHG emission technical efficiency (GETE) and GHG mitigation potential (GMP) in the global agricultural sector.



Method and Data

- This study employs the stochastic frontier analysis (SFA) combined with the directional distance function considering input and output.
- The framework assumes that GHG is an undesirable output (Färe et al., 2005) and the efficiency term follows a time-decay pattern (Battese and Coelli, 1992).
- The data in this research are obtained from the FAO and Climate Watch database for 128 countries from 1995 to 2018.

Variable	Unit	Mean	Std. dev.	Min	Max
GHG emission	MtCO2eq	36.9	98.5	0.0	718.7
Value-added	Millions $	24,667	94,790	36	1,240,670
Fixed capital	Millions $	2,950	9,891	1	145,113
Labor	1000 persons	6,776	33,242	1	364,491
Energy	TJ	61,281	175,742	17	1,929,170

Result of SFA

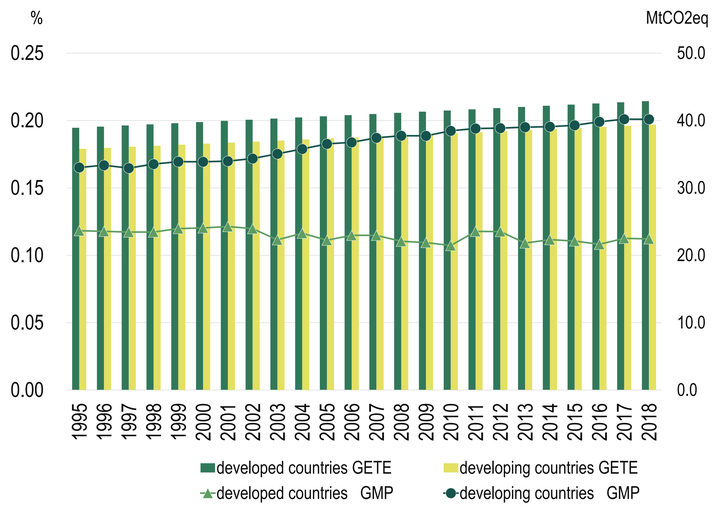
- Using the Cobb–Douglas production function, the stochastic frontier model is specified as follows.

$$-lnc_{it} = \beta_0 + \beta_k lnk_{it} + \beta_l lnl_{it} + \beta_e lne_{it} + \beta_y(lny_{it} + lnc_{it}) + \beta_{kl} lnk_{it} lnl_{it} + \beta_{ke} lnk_{it} lne_{it} + \beta_{ky} lnk_{it}(lny_{it} + lnc_{it}) + \beta_{le} lnl_{it} lne_{it} + \beta_{ly} lnl_{it}(lny_{it} + lne_{it}) + \beta_{ey} lne_{it}(lny_{it} + lnc_{it}) + v_{it} - u_{it}$$

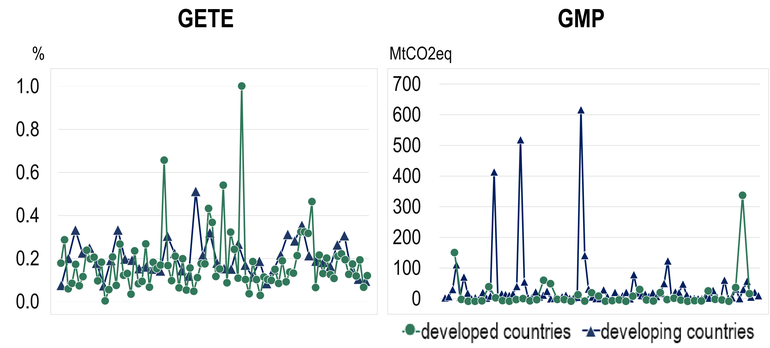
Variable	Coef. Value	Std. err.	Variable	Coef. value	Std. err.
lnK	0.000	0.018	lnLlnE	0.009***	0.003
lnL	-0.068***	0.025	lnKlnYC	0.006***	0.002
lnE	-0.059***	0.015	lnLlnYC	0.006***	0.002
lnYC	-0.551***	0.017	lnElnYC	0.000	0.002
lnKlnL	-0.014***	0.003	Cons	5.339***	0.134
lnKlnE	0.004**	0.002			
$\ln\sigma 2$	-1.259***	0.128	μ	1.733***	0.101
ilgt γ	3.843***	0.134	η	0.003***	0.000
Obs.	3,072		Groups	128	

Notes: *** , ** and * denote the level of significance at 1%, 5% and 10% respectively

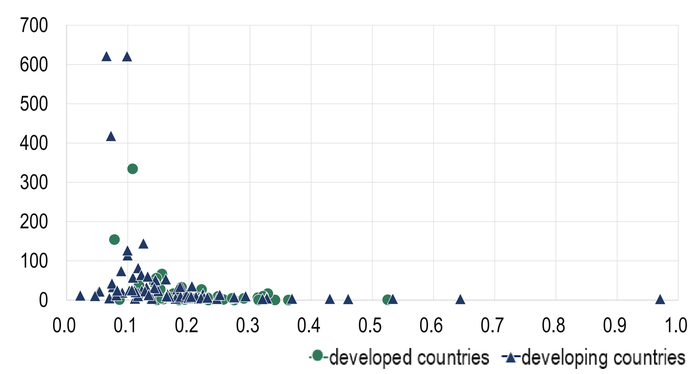
Trend of GETE and GMP



GETE and GMP by country



Relationship between GETE and GMP



Conclusion

- The agricultural sectors in most countries have low GETE (19.6%), while the average GETE has improved by 10.1% from 0.18% in 1995 to 0.20% in 2018.
- The average GMP is 32.6 MtCO2eq, which is also increased by 14.1% from 30.5 MtCO2eq in 1995 to 34.8 MtCO2eq in 2018.
- The GMP in developed countries decreased, whereas that in developing countries increased; India, China, Brazil, and the United States dramatically were deteriorated.

References

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