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THE IMPACT OF THE AGRICULTURAL SECTOR IN DEVELOPING COUNTRIES THAT PRODUCE NATURAL GAS ON GREENHOUSE GAS EMISSIONS

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Abstract

The agricultural sector is one of the most important sectors in the economies of developing countries. In addition, due to environmental concerns, global demand for energy has moved toward fuels with less carbon content such as natural gas. This study examines the impact of six factors of the agricultural sector on CO2 emissions for a group of countries that are among the list of 94 natural gas producers. Using the Tobit Panel model for the 2006-2015 period, the results show that the agricultural export variable has the greatest positive effect on CO2 emissions. Furthermore, cultivating area, agricultural production, agricultural imports, value-added agriculture, and fertilizer use have an impact on CO2 emissions. A policy recommendation of this research is that the government can help protect the environment by adapting a clean technology strategy to reduce GHG emissions.

Keywords: *Carbon Dioxide, Developing Countries, Natural Gas, Tobit Panel*.
JEL Classification: *C21, F30, F43, G10*

1. Introduction

Today's world faces a series of environmental challenges. One of the most dangerous environmental crises that seriously threaten human life is the emissions of pollutants and greenhouse gases. Many of these emissions are due to a lack of appropriate environmental policies (Fell et al., 2018). These emissions are pervasive and they have caused serious damage to the environment so that preventing their expansion in many cases is very costly or even impossible.

According to the U.S. Energy Information Administration (EIA, 2018), carbon dioxide (CO2) emissions due to energy by developing countries will grow faster than in developed countries. They will outpace emissions from the Organization for Economic Co-operation and Development (OECD) countries over the next three decades due to their generally stronger rate of economic growth and continued use of fossil fuels. Figure 1 shows the share of global CO2 emission for the largest emitters. Among the developing countries, India, Iran and Saudi Arabia have the largest share in CO2 emissions.

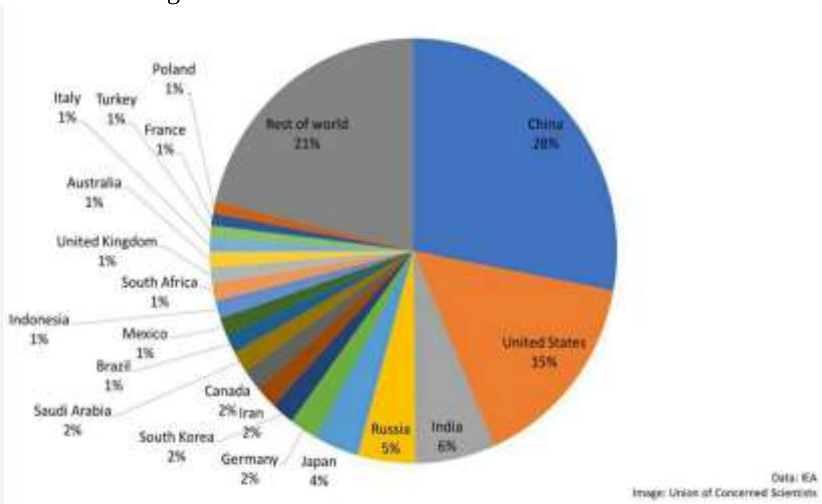

Figure 1. Share of Global Carbon Dioxide Emission In 2017

One important source of greenhouse gas (GHG) emissions and CO2 is the agricultural sector. The use of resources to produce crops leads to GHG emissions, so the agricultural sector harms the environment by producing CO2 emissions from increased production and value added. This is particularly true as forests lands are destroyed to increase area under cultivation (Calvin et al., 2016).

Yet the agricultural sector in developing countries is a major driver of economic growth and development, where it is a precursor for faster development. While trying to expand agricultural production, developing countries could bring harm to the environment. However, it is possible to manage agricultural production in a way that decreases the amount and costs of pollutant emissions (Golub et al., 2013; Lubowski and Rose, 2013). Reducing CO2 emissions in the agricultural sector requires proper use of chemical fertilizers to diminish their environmental consequences (Gilhespy et al., 2014; Smith et al., 2013). The use of organic fertilizers could lessen GHG emissions (Li et al., 2018), but many farmers use chemical fertilizers to increase their production to save money.

Environmental preservation and the pursuit of sustainable agriculture are major concerns for developing countries moving their agriculture away from traditional methods towards more productive practices. The world must preserve natural resources and guard against large environmental degradation (Daly, 1973). Sustainable agriculture involves practices that balance biological, economic and social concerns in ways that lead to better long-run use of natural resources and ecosystems (De pinto et al., 2016).

Sustainable development is the optimal utilization of resources without harming natural resources with the help of modern technologies. However, most developing countries do not have access to these technologies. Developing countries are the fastest growing agricultural export markets, but they struggle with environmental damage and unpredictable energy and commodity prices. Successful GHG mitigation approaches, however, need to support developing countries' economic and social development needs and institutional, financial and technical capacity. These countries cannot take on the same climate commitments as developed countries because they often lack institutional, financial, and technical capacity, which influences their ability to implement and comply with climate commitments. Given the importance of the environment and the shortcomings of environmental policy in developing countries, this study focuses on the relationship between agricultural economic activities and their environmental impacts.

One way that developing countries might find to ease their transit towards a more climate-friendly agriculture is to move to cleaner fossil fuels such as natural gas. The share of natural gas as a fuel has been rising in recent years because it is a relatively clean, abundant and inexpensive energy source that is currently being exploited on a large scale (Kayani, 2013). Energy, in particular natural gas, is a key ingredient to generate increases in agricultural production and exports because of its use in transportation and production of nitrogen fertilizers (Konyar, 2001). The increased availability of natural gas, a cleaner source of energy than coal or oil, has opened up the possibility of meeting the energy demands while causing less harm to the environment.

As the world faces increased environmental concerns and the global effort to decrease GHG emissions and CO2 is heightened, the use of natural gas becomes more appealing. This trend towards natural gas is likely to continue in the future. Developing countries with large reserves of natural gas could play a prominent role in increasing food production, while preserving the environment. This study examines the role of the agriculture sector in CO2 emissions. Due to the lack of appropriate environmental policies in developing countries and the important impact of natural gas on air pollution emissions, this study focuses on the developing countries that produce natural gas with the idea that they can use their abundant natural gas supplies to increase agricultural production.

In addition to the advantages of natural gas as a clean energy in increasing agricultural production and exports, the use of natural gas in the production of chemical fertilizers causes an adverse effect on the environment (Konyar, 2001). Most natural gas used in agriculture today is through farm inputs (Bomford et al, 2011). The main component of chemical fertilizers is natural gas, and the use of fertilizers is an important factor in agriculture in most countries, especially in countries producing natural gas (Minear, 2015). Figure 2 shows the impact of fertilizers on crop production.

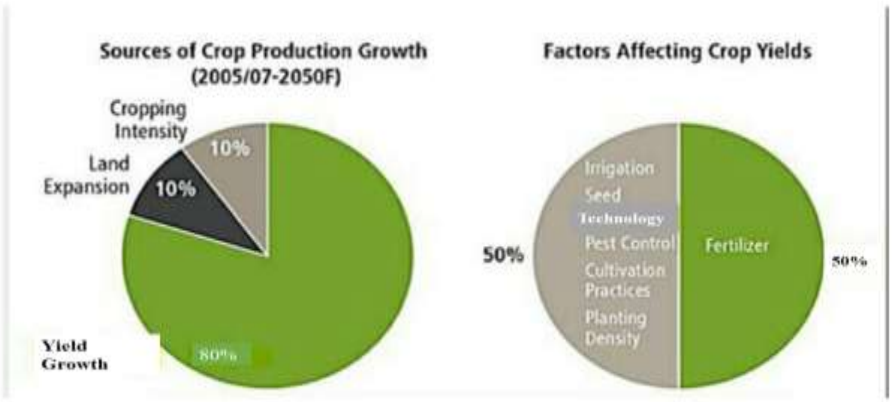

Figure 2. Impact of Fertilizer on Crop Production (IPNI, Agronomy Journal, FAO)

Of the three primary nutrients (Nitrogen, Phosphate, Potash), nitrogen production is the most geographically diverse because of the widespread availability of natural gas. Since the development of the Haber-Bosch process to convert gaseous nitrogen into a biologically usable form in the early 1900s, farmers have been able to use each acre of land more efficiently for crop production (Follett et al, 2010). This relatively inexpensive fertilizer has allowed producers to be less dependent on leguminous plants and manure. Natural gas costs make up 72 to 84 percent of the cost for chemical fertilizers (Huang 2007). Ammonia (NH3) is a concentrated form of nitrogen that is the basic feedstock for all upgraded nitrogen products. It can also be applied directly as a fertilizer or used to make industrial products.

Figure 3 shows the top five natural gas producers in the world. The US leads in natural gas production, estimated at over 687 billion m^3 annually and accounting for 20.4% of world gas production. Unlike other gas producing countries, the US consumes most of its natural gas production, consuming over 95% of its domestic production. The world's second largest natural gas producer, Russia, is more active in the international market, exporting approximately 20% of its production annually. Russia produces over 627 m^3 of natural gas and country ranks as the #1 exporter (Daily Records, natural gas, 2018).

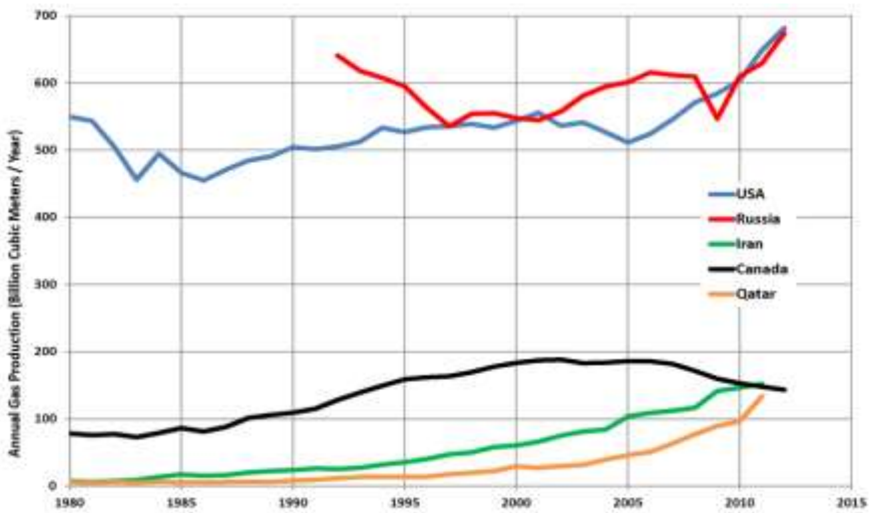

Figure 3. The Top Five Countries with the Largest Natural Gas Production in 2017 (Data from U.S. Energy Information).

Iran is the third largest natural gas producer in the world and ranks first among developing countries in natural gas production. It exports about 5% of its production. Estimates indicate the country has the capacity to produce over 163 m^3 of natural gas annually. With 17% of the world's gas reserves, Iran produces only a small share of its potential. With consumption of natural gas increasing rapidly, Iran is expected to increase its production and exports of natural gas (Daily Records, 2018 and Global Energy Statistical Yearbook 2018). Qatar is another leading producer and exporter of natural gas, but it has limited agricultural potential.

While several studies have analyzed the effects of agricultural factors on CO2 emissions (De pinto et al., 2016; Gilhespy et al., 2014; Smith et al., 2013), none of the environmental and agricultural studies have focused on developing countries, which are also producers of natural gas but suffer from lack of appropriate environmental policies. Natural gas is a source of clean energy that can play a major role in the mitigation of CO2 emissions, but as a key element in production of chemical fertilizers, it could cause environmental pollution. The present study analyses developing countries that are also producers of natural gas as a sample, and focuses on the impact of different economic components of the agricultural sector on CO2 emissions. The null hypotheses of this study to be tested are:

- As the area under cultivation increases, CO2 emissions will decrease.
- As the amount of fertilizer increases, CO2 emissions will increase.
- As agricultural exports increase, CO2 emissions will increase.
- As agricultural imports increase, CO2 emissions by the importing countries will decrease.
- As agricultural production increases, CO2 emissions will decrease.

2. Literature Review

Since the late 1970s, issues related to the environment have become very prominent, and literature regarding the effects of increased international trade on the environment is vast. Some have argued that expansion of international trade leads to increased competition among countries and an improvement in the efficient use of scarce resources, while some oppose the expansion of global trade because it could lead to the depletion of natural resources, increased pollution, and degradation of environmental quality (Ozturk et al., 2015). During this time, researchers have studied the relationship between trade and environment in many ways, including trade’s impacts on CO2 emissions.

One of the early, key articles providing the framework for the relationship between trade and the environment was by Copeland and Taylor (2004). They investigated the relationship between trade and CO2 emissions and suggested that trade has three types of pollution effects on countries. The first is the environment-friendly technologies effect in which increases in income increase the consumption of environmental goods. Trade induces people’s interest in understanding of environmental issues, and consequently they require effective pollution control and management policies. Thus, the environment-friendly technologies effect through trade is likely to improve the environment.

The second is the scale effect. Increased trade leads to increased output, which deteriorates the environment. The third is the composition effect brought about by changes in the types of goods produced as trade expands. Developing countries tend to attract pollution-intensive industries, and developed countries are likely to avoid such industries. A decrease in pollution depends on the relative size of the technology and composition effects.

Al-Mulali and Sheau-Ting (2014) investigated the bi-directional long-run relationship between exports/imports and CO2 emission for 189 countries from different regions using panel fully-modified ordinary least squares (FMOLS) for the period of 1990–2011. The panel results showed that all the regions, except Eastern Europe, show a long-run positive relationship between the trade variable and CO2 emission. However, the FMOLS test results provided evidence for the presence of a bi-directional long-run negative relationship between trade and CO2 emission for East European countries.

Kasman and Duman (2015) studied the relationship among economic growth, CO2 emissions, and trade openness for new EU member and candidate countries from 1992 -2010, utilizing panel unit root tests, panel cointegration methods and panel causality tests. They found evidence in favor of environmental Kuznets curves (EKCs). The results indicate that there is short-run unidirectional panel causality running from trade openness to carbon emissions. As for the long-run causal relationship, the results indicate that the estimated coefficients of lagged error correction terms in the CO2 emissions, energy consumption, GDP, and trade openness equations are statistically significant, implying that these four variables could play an important role in the adjustment process as the system departs from the long-run equilibrium.

Research on economic growth, trade, and environment continued with the study by Destek et al (2016) which investigated the relationship between real GDP, CO_2 emissions, and trade openness for ten Central and Eastern European Countries (CEECs) from 1991–2011. The results showed that there is a relationship between real GDP and CO_2 emissions, and the FMOLS results revealed that a 1% increase in trade openness leads to a 0.069% decrease in CO_2 emissions.

Due to the important role of the agricultural sector in the economy as well as its impact on environmental pollution, Vermont et al. (2010) examined the costs of reducing CO_2 emissions from agriculture. This study used agricultural emissions and the corresponding costs collected from 21 studies that assessed abatement potentials and costs using various modeling approaches and assumptions. The CO_2 emissions from agriculture account for approximately 13.5% of global GHG emissions. Hence, agriculture plays a significant role in reducing global GHG emissions in a cost-effective manner, and agriculture can play a major role in the design of cost-effective mitigation policies.

Others have also examined the impact of agricultural factors on CO_2 emissions. Chuan et al. (2017) studied the impact of reducing chemical fertilizers and increasing organic amendments for vegetables from 2009–2012. The results showed that the excessive use of agro-chemicals (such as mineral fertilizers) pose risks to soil quality and air pollution, but the substitution of organic amendments for inorganic fertilizer is an environmentally sound approach for reducing GHG emissions.

Since the last decade, there has been increasing research on value added agricultural products. Gallegos et al. (2017) examine an ecosystem-based agricultural economy with the goal of increased value-added products through sustainable development. Their review mainly focuses on various aspects of sustainable technology into value-added products and considers the effects of product value added on the environment. Innovations provide a portfolio of sustainable and eco-efficient products to compete in the market. Their results show that there are ways to increase value-added production and improve the environment through innovative processes.

Ben Jebli and Youssef (2017) examine the relationship between per capita CO_2 emissions and agricultural value added for a panel of five Africa countries from 1980–2011. They use panel cointegration techniques and Granger causality tests to check for the existence of a long - run association and to examine the direction of causalities between variables. The OLS and the panel FMOLS techniques are used to estimate the long-run parameters with per capita CO_2 emission as the dependent variable. The results show that there are short and long-run bidirectional causalities between agricultural value added and CO_2 emissions, implying that agriculture has an impact on emissions. The existence of a short-run unidirectional causality running from agriculture to GDP explains the important role played by the agricultural sector in boosting economic growth.

3. Methodological Approach and Model Development

Greenhouse gas emissions and CO_2 are serious environmental crises that threaten human life. Many studies have attempted to investigate the impact of various factors on CO_2 emissions (Battisti et al., 2015; Larch et al., 2017; Burnett et al., 2013; Benjamin et al., 2018). In practice, it is usually difficult to reduce this emission because there are many sectors that contribute to CO_2 emissions, but one of the most important sources of CO_2 is the agricultural sector. This research focuses on the impact of the agricultural factors on CO_2 emissions for a list of 94 natural gas producing developing countries.

This research uses the Panel Tobit model following Bruno (2004); Busse et al, (2002); and Chang (2008). In a Panel Tobit model, individual-specific and time-invariant effects are modelled as random effects; a fixed effects model is plagued by the incidental parameter problem. However, in data-censoring applications under the maintained assumption that $H\bar{0}: \xi = 0$, adding $\bar{X}_i$ to the random effects Tobit model solves the unobserved heterogeneity problem (Wooldridge, 2002).

$$Y_{it} = \beta X_{it} + C_i + u_{it} \qquad t = 1,2, \ldots, T \tag{1}$$
$$C_i = \psi + \bar{X}_i \bar{\xi} + \alpha_i \tag{2}$$

where C_i is the unobserved effect and Xi contains X_{it} for all t. These equations represent a data-censoring model, and β is of primary interest.

In this paper, we use panel data with a limited dependent variable (LDV). According to the Tobit method, we must define a threshold where the data under that threshold is censored (considered as zero values) and the data above it is visible. In this paper, we consider 40 million m^3 of natural gas production, which is the mean of natural gas production for developing countries, as the threshold. These countries have the most impact on CO2 emissions (EIA, 2018), so the LDV identifies those developing countries that produce more than 40 million m^3 per year of natural gas. The zero values are assigned to other developing countries on the list.

According to the studies reviewed in the literature review section, the most important economic variables in the agriculture sector affecting CO2 emissions are cultivating area (percentage of land area under cultivation), agricultural exports, agricultural imports, agricultural value-added, fertilizer use, and agricultural production. Due to the importance of trade impacts on environmental pollution, the choice of agricultural exports and imports is emphasized in the literature (Kasman et al., 2015; Destek et al., 2016). Furthermore, many indicators have been used for agricultural sustainability, but agricultural production is the most common and most used indicator for agricultural sustainability (Zhen and Routray, 2003; Becker, 1997; Bithas et al., 1997). Hence, in this study, the agricultural production index is considered as the most important indicator of agricultural sustainability.

4. The Panel Tobit Model

One critical issue in the panel data models is the estimation of LDV models characterized by the presence of lagged dependent variables and serially correlated errors. Conventional estimation methods used for linear panel data models are not applicable to panel Tobit models because of the Tobit model structure, our use of lagged dependent variables, and time-dummy variables.

The random effects approach can also be used by specifying the distribution of the error conditional on the regressors and maximizing the corresponding likelihood function. The random effects approach allows time-invariant, time-varying, and time dummy variables. In addition, identification is straightforward under the assumption of normally distributed errors (Olsen, 1978).

The structure of the econometric model of the Panel Tobit is (Bruno, 2004):

$$y_{it}^* = \beta' x_{it} + u_{it} \qquad i = 1,2, \ldots, N \qquad t = 1,2, \ldots, T \tag{3}$$
$$u_{it} = v_i + \varepsilon_{it} \qquad (v_i \sim NID(0, \sigma_v^2)) \qquad (\varepsilon_{it} \sim NID(0, \sigma_\varepsilon^2)) \tag{4}$$

Where the observed variables are:

$$y_{it} = \begin{cases} y_{it}^* & if \quad y_{it}^* > 0 \\ 0 & other\ wise \end{cases} \tag{5}$$

Where y is a dichotomous dependent variable and the x's are independent variables. The common error term, u_{it} in equation (4), is correlated over time. The error component model splits u_{it} into a time-invariant individual random effect (RE), v_i, and a time-varying idiosyncratic random error, ε_{it}.

If the v's and the Ɛ's are independent and d_{it} = 1 for uncensored observations and d_{it} = 0 for censored observations, the likelihood function for each individual, marginalized with respect to the random effect v_i is:

$$l_{it} = \int_{-\infty}^{\infty} \left[\frac{1}{\sigma_\varepsilon} \emptyset \left(\frac{y_{it} - \beta' x_{it} + vi}{\sigma_\varepsilon}\right)\right]^{d_{it}} . \left[\Phi \left(\frac{-\beta' x_{it} + vi}{\sigma_\varepsilon}\right)\right]^{(1-d_{it})} f(vi, \sigma_i) dvi \quad (6)$$

Where: $\emptyset(.)$ is the probability density function and $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution, f(v_i, σ_i) is of normal density with mean v_i and standard deviation σ_i. For T_i observations the likelihood function is:

$$L_{it} = \int_{-\infty}^{\infty} \prod_{t=1}^{t=T_i} . \left[\frac{1}{\sigma_\varepsilon} \emptyset \left(\frac{y_{it} - \beta' x_{it} + vi}{\sigma_\varepsilon}\right)\right]^{d_{it}} . \left[\Phi \left(\frac{-\beta' x_{it} + vi}{\sigma_\varepsilon}\right)\right]^{(1-d_{it})} f(vi, \sigma_i) dvi \quad (7)$$

The dependent variable is CO2 in this research and it is greater than zero for developing countries that produce more than 40 million m^3 of natural gas per year and zero otherwise. The independent variables are: Cultivated Area (L), Agricultural Exports (E), Agricultural Imports (M), Agricultural Value-added (V), Fertilizer Use (F), and Agricultural Production (P). All independent variables are chosen based on the Wald test and the Lm test with a significance level of 5%. Thus, all the included independent variables add significant explanatory power to the model and removing any one substantially reduces the model's fit. The hypothesis of random effects is not rejected by the Breusch-Pagan test, so the empirical model is as follows:

$$Co2_{it} = \begin{cases} Co2_{it}^* & if \quad y_{it}^* > 0 \\ 0 & other\ wise \end{cases} \quad (8)$$

$$y_{it}^* = \beta' L_{it} + \beta' E_{it} + \beta' M_{it} + \beta' V_{it} + \beta' F_{it} + \beta' P_{it} + u_{it} \qquad i = 1,2, \ldots\ldots, N \quad t = 1,2, \ldots\ldots, T \quad (7)$$

$$U_{it} = v_i + \varepsilon_{it} \qquad \left(v_i \sim NID(0, \sigma_v^2)\right) \qquad (\varepsilon_{it} \sim NID(0, \sigma_\varepsilon^2)) \quad (9)$$

$$l_{it} = \int_{-\infty}^{\infty} \left[\frac{1}{\sigma_\varepsilon} \emptyset \left(\frac{y_{it} - \beta' L_{it} - \beta' E_{it} - \beta' M_{it} - \beta' V_{it} - \beta' F_{it} - \beta' P_{it} + vi}{\sigma_\varepsilon}\right)\right]^{d_{it}} \quad (10)$$

$$. \left[\Phi \left(\frac{-\beta' L_{it} - \beta' E_{it} - \beta' M_{it} - \beta' V_{it} - \beta' F_{it} - \beta' P_{it} + vi}{\sigma_\varepsilon}\right)\right]^{(1-d_{it})} f(vi, \sigma_i) dvi$$

The sample likelihood function is the product of the L_i over the N individuals

$$L = \sum_{i=1}^{N} \ln(l_i) \quad (11)$$

Equation (11) does not collapse into a sum because it is an integral of a product. Interpendence among the observations prevents parceling out the likelihood contribution of the *Ti* periods for the *i* individual when serial correlation is present. Classical estimation methods are infeasible in a T-dimensional integral when the number of time periods is more than three or four.

In this paper, the feasible maximum likelihood estimation for limited dependent variable panel data is available for a particularly simple structure of the random disturbance and we use STATA for the panel Tobit models. The random effects model estimation assumes that ε_{it} is serially uncorrelated, the v_i are uncorrelated across individuals, and $v_i \mid x_i \sim$ NID (0, σ^2).

5. Data Description and Analyses

This study covers annual data for 2006 - 2015 for a group of developing countries that are natural gas producers. Panel data is a collection of data by a large number of cross-sectional variables (N) over a period of time (T). The Panel data properties are: it shows heteroscedasticity, it provides more degrees of freedom and more variation in data and less correlation among variables, and therefore, generates a more efficient estimator (Gujarati, 2007). Panel data allows one to have the strength of both cross sectional and time series analysis. One can see not only how cross sectional units change over time, but also see the differences among cross sectional units. In addition, all available data are used and thus, the observation errors are reduced (Salami 2017). The descriptive statistics of the variables are shown in Table 1.

Table 1. The Descriptive Statistics of Model Variables

Variable	Maximum	Minimum	Standard Deviation	Mean
Land area (% Cultivating area)	133.10	2.70	31.15	39.32
Agricultural Exports (% of merchandise exports)	7.52	5.32	1.68	1.79
Agricultural Imports (% of merchandise imports)	4.19	0.22	0.97	1.57
Value-added agriculture	108.84	0.49	20.23	10.99
Fertilizer	869.00	0.26	119.85	99.98
Agricultural production	166.67	1.25	39.12	93.02

First, stationary tests are performed with the Fisher's generalized unit root test (Zra'nzhad and Anwari, 2005). In the Fisher test for panel data, the null hypothesis of a unit root is rejected at the 5% level of significance (Table 2).

The cross-section correlation test is performed with the Freeze test (Table 2). The null hypothesis of no correlation is rejected at the 5% level of significance. We also use the Hausman test to investigate fixed versus random effects. The null hypothesis of no fixed effects is accepted (Table 3) so the random effects model is used.

Table 2. The Fisher Unit Root Test Results and Freeze Test

Method	Value	P value
Chi-Square and Fisher Dickey Fuller	163.49	0.00
Freeze Cross-Section Correlation	158.02	0.02

Table 3. Hausman Test Results

Test Hausman	P value
Hausman panel ols1	0.00
Panel, RE	0.97

Notes: Breusch Pagan test probability distribution p = 0/00

6. Estimation Results

In this study, the effects of agricultural factors on CO2 emissions are estimated with the Tobit Panel model and the results are presented in Table 4. Cultivating area has a negative relationship with CO2 emissions, which is surprising. Farmers in some developed countries turn forest land into agricultural land by cutting down trees. This has a negative effect on air purification (Calvin et al., 2016). But in this research, there is a negative relationship between cultivating area and CO2 emissions because developing countries lack equipment and possess cheap labor to encourage the use of human labor for most agricultural processes. This prevents increased pollution from machinery and energy use (Konyar, 2001). In the Tobit panel method, the coefficients must be transformed in order to determine the elasticities. The total elasticity is the effect of one percentage change in x on y. The elasticity of the area under cultivation in the agricultural sector is -0.18. This means that if the amount of the variable increase by one percent, the CO2 emissions will decrease by 0.18 percent.

Table 4. The Results of Tobit Panel

Variables	Coefficient Estimates	Z statistics	Standard Deviation Estimates	P value
Cultivating area	-0.25***	-2.65	0.09	0.00
Agricultural Exports	4.18***	3.08	1.36	0.00
Agricultural Imports	-0.89	-1.10	0.81	0.27
Value-added agriculture	-0.16**	-1.95	0.08	0.05
Fertilizer	0.08**	2.12	0.04	0.03
Agricultural production	-0.11***	-3.81	0.03	0.00
Sigma u	8.26***	5.03	1.64	0.00
Sigma e	3.05***	12.50	0.24	0.00
Rho	0.87		0.04	

Notes: *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Increasing agricultural exports increase CO2 emissions (Table 4). Tunc et al. (2006) also found that exports increase CO2 levels. The elasticity of agricultural export is 3.04 with a positive sign; it has the largest elasticity for CO2 emissions found in this study. This elasticity shows if agricultural exports increase one percent, CO2 emissions increase by 3.04 percent, assuming all other factors are stable. Increasing exports stimulates manufacturing and packaging, use of food preservatives, artificial dyes, and plastic containers. All of these consume energy and fossil fuel resources in a number of ways, increasing CO2 emissions. Of course, agricultural exports need fuel for transportation so they increase energy consumption and CO2 emissions (Konyar, 2001).

The results show that increasing imports for a developing country reduces the country's CO2 emissions, but the coefficient is not significantly different from zero at the 5% level. This is similar to the findings of Faizi et al. (2016). This result is unexpected, though, because when a country imports the natural assumption is that it produces less and therefore produces less CO2. However, the finding here suggests that imports are not substituting for domestic production, but instead allowing consumption in the developing country to increase.

Increasing the value-added in agriculture reduces CO2 emissions, which is similar to the finding of Bhowmick et al. (2016), everything else equal, increasing agricultural value-added reduces the intermediary service use of machinery, packaging and transportation industries which are big emitters of CO2. If those activities are performed by the agricultural sector there is less CO2 entering the atmosphere. The elasticity of the value-added in the agricultural sector is -0.11. This means that if the amount of the variable increase by one percent, the CO2 emissions decreases by 0.11 percent.

The chemical fertilizer variable has a positive relationship with CO2 emissions and the elasticity of this variable is 0.06. This result is the same as Li et al. (2018). These fertilizers are often produced with natural gas and there is CO2 emitted from that process.

Since agricultural production is the most important indicator of agricultural sustainability (Becker, 1997; Bithas et al., 1997; Zhen & Routray, 2003), sustainability implies preserving natural resources, therefore, it is more efficient in resource utilization and more balanced with respect to the environment. It is expected that improved agricultural sustainability reduces environmental pollution and CO2 gas emissions, and that is exactly what this study finds. The elasticity of the agricultural production shows that if the amount of these variables increase by one percent, CO2 emissions decrease by 0.08 percent. Agricultural production, as the most prominent indicator of agricultural sustainability, has a coefficient that is negative and highly significant, indicating that it is a very important indicator of environmental protection (Sotude, 2010). This finding is similar to Ozturk et al. (2017).

The rho is 0.87. It is known as the intraclass correlation and it shows that 87% of the variance is due to differences across panels.

Sigma u = sd of residuals within groups u_i
Sigma e = sd of residuals (overall error term) e_i

$$\text{Rho} = \frac{(sigma\ u)^2}{(sigma\ u)^2 + (sigma\ e)^2}$$

Table 5. Elasticity Frequency of Independent Variable

Variable	Total Elasticity	Z statistics	Standard Deviation Estimates
Cultivating area	-0.18***	-2.58	0.07
Agricultural Exports	3.04***	2.70	1.13
Agricultural Imports	-0.64	-1.12	0.58
Value-added agriculture	-0.11*	-1.86	0.06
Fertilizer	0.06**	2.06	0.03
Agricultural production	-0.08***	-3.55	0.02

Notes: *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5 shows the elasticities for all variables. As shown in Table 5, these elasticities are small relative to the elasticities for agricultural exports. It is clear that the developing countries in the sample are exporting crops that release a great deal of CO2. This is similar to the findings for the developing countries (Mohammadi et al, 2016); by increasing the exports of agricultural raw materials, the environment suffers more from pollution by increased CO2 emissions.

7. Conclusions

The agricultural sector can play a significant role in the growth of exports for developing countries, and the growth of their economies depend on the development and stability of non-oil exports. In addition, due to environmental concerns, global demand for energy has been moving towards renewable fuels or fuels with less carbon content, such as natural gas. The studies on the environment have mostly ignored the important role of natural gas in the developing countries' economies, especially for those countries that are producers of natural gas, but suffer from lack of appropriate environmental policies. In this research, we investigate the impact of six factors of the agricultural sector on CO_2 emissions for a group of countries that are among the list of 94 natural gas producers. The results show that agricultural exports and the use of fertilizers have positive effects on CO_2 emissions, with the agricultural export variable having the greatest impact. The estimated elasticity shows if agricultural exports increase one percent, the CO_2 emissions increase by 3.04 percent, assuming all other factors are stable. Furthermore, cultivating area, agricultural production, agricultural imports, and value-added agriculture have negative effects on CO_2 emissions.

The results show that controlling the excessive use of chemical fertilizers and other inputs that increase environmental pollution, should be considered as a major goal for developing countries to mitigate CO_2 emissions. Sustainable agricultural policy has led practitioners to use living organisms available in the soil to provide the nutrient requirements of the plants. Hence, the use of organic fertilizers are better in order to avoid polluting the ecosystem.

Considering the conditions of developing countries and their dependence on the agricultural sector for economic growth, the production of agricultural and horticultural products using clean technologies could address their domestic needs as well as exports with less pollution. According to the World Trade Organization negotiations on environmental goods and services, the use of clean technology options can help reduce GHG emissions by developing countries (Frankel, 2008). Access to climate-friendly, clean energy technologies is especially important for the fast growing developing economies. In this regard, the task of the policy makers and agribusiness owners is to determine the appropriate technology needs in each region that can be offered to farmers in order to achieve the long-term goals of the agricultural sector, economic growth, and creation of a healthier environment.

The removal of tariff and nontariff barriers can increase the diffusion of clean technologies. Within the context of current global trade regime, a removal of tariffs and non-trade barriers for basic clean energy technologies (including clean coal) in 18 of the high GHG-emitting developing countries will result in trade gains of up to 13 percent. If translated into emissions reductions, these gains suggest that—even within a small subset of clean energy technologies and for a select group of countries—the impact of trade liberalization could be substantial (International Trade and Climate Change, 2008).

Streamlining of intellectual property rights, investment rules, and other domestic policies will aid in widespread dissemination of clean technologies in developing countries. Firms sometimes avoid tariffs by undertaking foreign direct investment (FDI) either through a foreign establishment or through projects involving joint ventures with local partners. While FDI is the most important means of transferring technology, weak (or perceived weak) intellectual property rights (IPRs) in developing countries often inhibit diffusion of specific technologies beyond the project level. Developed country firms, which are domestically subject to much stronger IPRs, often transfer little knowledge along with the product, thus impeding widespread dissemination of much-needed technologies. Furthermore, FDI is also subject to a host of local country investment regulations and restrictions. Most of the developing countries also have low environmental standards, low pollution charges, and weak environmental regulatory policies, which also hinder the acquisition of sophisticated clean energy technologies (World Bank, 2008).

The huge potential for trade between developing and developed countries to promote clean energy technology needs to be explored more. Traditionally, developing countries have been importers of clean technologies, while developed countries have been exporters of clean technologies. However, as a result of their improving investment climate and huge consumer base, developing countries are increasingly becoming major players in the manufacture of clean technologies (Environmental Permitting, 2012). Developing countries should emerge as manufacturers of renewable energy technologies, which will augur well for technology transfer in the future (World Bank, 2008).

There is definitely a need for further research in this area. The oil and natural gas revenues are not stable in developing countries, and the importance of the agricultural sector as a major source of revenue is highlighted for these countries. They must find solutions for improving agriculture with less pollution, and the development of appropriate environmental policies must be adopted along with agricultural development.

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Appendix 1 - List of Natural Gas Producer Countries In 2017

Rank	Country	Continent	Annual natural gas production (m^3)	Date of information
—	*World*	—	4,359,000,000,000	2010 est.
1	United States	North America	728,200,000,000	2014 est.
2	Russia	Eurasia	578,700,000,000	2014 est.
—	European Union	—	132,300,000,000	2014 est.
3	Iran	Asia	255,500,000,000	2015 est.
4	Canada	North America	143,100,000,000	2012 est.
5	Qatar	Asia	133,200,000,000	2011 est.
6	Norway	Europe	114,700,000,000	2012 est.
7	China	Asia	107,200,000,000	2012 est.
8	Saudi Arabia	Asia	103,200,000,000	2012 est.
9	Algeria	Africa	82,760,000,000	2011 est.
10	Netherlands	Europe	80,780,000,000	2012 est.
11	Indonesia	Asia	76,250,000,000	2011 est.
12	Turkmenistan	Asia	64,400,000,000	2012 est.
13	Uzbekistan	Asia	62,900,000,000	2012 est.
14	Malaysia	Asia	61,730,000,000	2011 est.
15	Egypt	Africa	61,260,000,000	2011 est.
16	Mexico	North America	53,960,000,000	2012 est.
17	United Arab Emirates	Asia	52,310,000,000	2011 est.
18	Bolivia	South America	48,970,000,000	2012 est.
19	Australia	Oceania	48,240,000,000	2012 est.
20	United Kingdom	Europe	40,990,000,000	2012 est.
21	Trinidad and Tobago	Caribbean	40,600,000,000	2011 est.
22	India	Asia	40,380,000,000	2012 est.
23	Pakistan	Asia	39,150,000,000	2011 est.
24	Argentina	South America	38,770,000,000	2011 est.
25	Thailand	Asia	36,990,000,000	2011 est.
26	Oman	Asia	35,940,000,000	2012 est.
27	Peru	South America	32,400,000,000	2012 est.
28	Nigeria	Africa	31,360,000,000	2011 est.
29	Venezuela	South America	25,280,000,000	2012 est.
30	Kazakhstan	Asia	20,200,000,000	2011 est.
31	Bangladesh	Asia	20,110,000,000	2011 est.
32	Ukraine	Europe	19,800,000,000	2011 est.
33	Azerbaijan	Asia	16,700,000,000	2013 [7]
34	Brazil	South America	17,030,000,000	2012 est.

35	Kuwait	Asia	13,530,000,000	2011 est.
36	Bahrain	Asia	12,620,000,000	2011 est.
37	Brunei	Asia	12,440,000,000	2011 est.
38	Myanmar	Asia	11,910,000,000	2011 est.
39	Colombia	South America	10,950,000,000	2011 est.
40	Romania	Europe	10,610,000,000	2011 est.
41	Yemen	Asia	9,620,000,000	2011 est.
42	Vietnam	Asia	9,300,000,000	2012 est.
43	Germany	Europe	9,000,000,000	2012 est.
44	Syria	Asia	7,870,000,000	2011 est.
45	Libya	Africa	7,855,000,000	2011 est.
46	Italy	Europe	7,800,000,000	2012 est.
47	Equatorial Guinea	Africa	6,880,000,000	2011 est.
48	Israel	Asia	6,860,000,000	2013 est.
49	Denmark	Europe	6,412,000,000	2012 est.
50	Poland	Europe	6,193,000,000	2012 est.
51	Portugal	Europe	4,904,000,000	2012 est.
52	New Zealand	Oceania	4,590,000,000	2012 est.
53	Philippines	Asia	3,910,000,000	2012 est.
54	Mozambique	Africa	3,820,000,000	2011 est.
55	Japan	Asia	3,273,000,000	2012 est.
56	Hungary	Europe	2,462,000,000	2012 est.
57	Tunisia	Africa	1,930,000,000	2011 est.
58	Austria	Europe	1,906,000,000	2012 est.
59	Croatia	Europe	1,863,000,000	2013 est.
60	Cote d'Ivoire	Africa	1,500,000,000	2011 est.
61	South Africa	Africa	1,280,000,000	2011 est.
62	Chile	South America	1,144,000,000	2012 est.
63	Cuba	Caribbean	1,030,000,000	2012 est.
64	Congo, Republic of the	Africa	946,000,000	2012 est.
65	Iraq	Asia	880,000,000	2011 est.
66	Tanzania	Africa	860,000,000	2011 est.
67	Angola	Africa	752,000,000	2011 est.
68	Turkey	Asia	632,000,000	2012 est.
69	France	Europe	508,000,000	2012 est.
70	Serbia	Europe	484,700,000	2013 est.
71	South Korea	Asia	424,900,000	2012 est.
72	Bulgaria	Europe	410,000,000	2011 est.
73	Ireland	Europe	373,000,000	2012 est.
74	Taiwan	Asia	330,200,000	2011 est.
75	Ecuador	South America	240,000,000	2011 est.
76	Jordan	Asia	230,000,000	2011 est.
77	Belarus	Europe	220,000,000	2011 est.
78	Czech Republic	Europe	200,000,000	2012 est.
79	Cameroon	Africa	150,000,000	2011 est.
80	Afghanistan	Asia	140,000,000	2011 est.
81	Slovakia	Europe	105,000,000	2012 est.