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Analysis

Climate change mitigation and agricultural development models: Primary commodity exports or local consumption production?

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A B S T R A C T

The increasing demand for agricultural products partly due to the high population growth requires agriculture to struggle for productivity improvement. However, productivity search is constrained by environmental preoccupations, raising the question of agricultural development models to be adopted to increase productivity while limiting environmental consequences. This paper examines the role of market orientation by assessing the effect of agricultural commodity export on greenhouse gas emissions relatively to local market oriented agricultural production model. Using panel data from 1986 to 2010 for 136 countries around the world, and accurate instrumental variables technique, the findings suggest that the proportion of primary commodity export in agricultural production increases greenhouse gas emissions. These results are robust to different sources of agricultural export and environmental data, and to the inclusion of additional control variables.

1. Introduction

During the first decade of the 21st century, African countries performed significant improvement in terms of economic growth relatively to the two previous decades. The average economic growth rate of the continent was 5.6% between 2002 and 2008 before an abrupt fall to 2.2% in 2009 due to the world financial and food crisis. The African economy then grew at about 5% in 2012 (UNECA, 2013). However, this economy is largely characterized by the export of agricultural primary commodities, a production with low value addition. Agricultural sector employs about 65% of Africa's labor force and accounts for 32% of gross domestic product. According to the World Bank, since 2000 agricultural performance has improved. The growth rate of agricultural Gross Domestic Product (GDP) in sub Saharan Africa was 2.3% per year in the 1980s and reached 3.8% per year from 2000 to 2005. This growth has been mostly the result of area expansion, instead of land and agricultural productivity gain. Policy makers generally propose agricultural productivity improvement, facilitation of agricultural markets access and trade, and the reduction of rural vulnerability and insecurity as challenges facing agricultural sector.

Agricultural productivity improvement should be done with caution since it can be possible in the short term at the cost of long term production and increasing vulnerability. Indeed, agriculture could be source of environmental degradation (air, water, and soil pollution) and climate change through greenhouse gas emission (carbon dioxide, methane, nitrous oxide). Global warming, in part likely due to climate change, affects negatively agriculture in longer term, and increases farmer's vulnerability. The improvement of the productivity with limited impact on environment led researchers to propose solutions and agricultural practices known as sustainable agriculture such as conservative agriculture or organic farming. The debate on agricultural development models to be implemented is still opened: small-scale versus large-scale farming, local consumption food production versus agricultural commodity export. This paper contributes to this debate by assessing the effect of agricultural commodity export on greenhouse gas emissions relatively to local market oriented agricultural production. The pressure of external primary commodity demand may lead to excessive use of

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agricultural inputs (land, forest, fertilizer, pesticide), and this in turn may lead to environmental damage including increase greenhouse gas emissions (carbon dioxide, methane, nitrous oxide).

The environmental impacts of agricultural intensification have been largely documented in the literature. These effects include many aspects of environment such as soil, water and air pollution (Jayet and Petel, 2015; Mozumder and Berrens, 2007), habitat degradation and the loss of biodiversity (Emmerson et al., 2016; Chamberlain et al., 2000; Donald et al., 2006; Mineau and Whiteside, 2013; Flohre et al., 2011; Geiger et al., 2010; Storkey et al., 2012). Van der Sluijs et al. (2015) provide a review of the literature covering 800 peer-reviewed journal articles published over the past two decades. It is generally found that agricultural intensification is detrimental for the environment, but the empirical literature remains more focused on flora and fauna, and the causal effect of agricultural intensification on air pollution is not largely investigated. Regarding the geographical interest of the authors, even though the majority of these studies focus on Europe, a small number of them covers other geographical areas such as Africa Söderström et al. (2003), America (Brennan and Kuvlesky, 2005; Mineau and Whiteside, 2013) and Asia (Semwal et al., 2004). However, empirical works on the issue using cross-country analyses are scarce and generally focus on European countries (Donald et al., 2006; Flohre et al., 2011; Geiger et al., 2010; Storkey et al., 2012). An exception is Mozumder and Berrens (2007) that analyzed the empirical association between the intensity of inorganic fertilizer use and biodiversity risk using cross-country biodiversity risk indices from developed and developing countries. It is found that the amount of inorganic fertilizer use per hectare of arable land is significantly related to increasing biodiversity risk.

We explore this relationship between agricultural trade and greenhouse gas emissions using simple econometric models with instrumental variable methods and panel data structure covering the 1986–2010s period and 136 developed and developing countries. The robustness of the results is checked with alternative data sources and different subsamples. The paper improves the existing literature on the relationship between agricultural intensification and environmental degradation by focusing on greenhouse gas emissions, by using cross-country and panel data structure taking into account the geographical diversity of countries, and by analyzing causal effect through instrumental variables method.

The rest of the paper is organized in five sections. Section 2 reviews the literature on the association between exporting agricultural commodity production and environmental degradation. In Section 3, we empirically investigate the effects of the relative production of primary agricultural commodity exports on environmental degradation. Section 4 presents empirical results and discussions, and the robustness checks of our results are shown in Section 5. The discussion of the results is presented in Section 6. Finally, conclusion and recommendations are at the core of the last section.

2. Agricultural trade and the environment

2.1. Agriculture and environment

In fact, the growing demand for agricultural products, the increasing domestic food production by fewer individuals because of rural exodus, and the need of non-traditional export products as a means of increasing income, and earning valuable foreign currency for the country lead farmers to look for alternative agricultural methods in order to raise their productivity and production.

This productivity targeting in agricultural sector largely contributes to climate change through greenhouse gas emissions. Indeed, agriculture accounts for about 20% of total world greenhouse gas emissions. These emissions are mainly caused by direct production, fossil fuel emissions along the agricultural supply chain, and emissions from agricultural deforestation (Smith et al., 2005). According to Dickie et al. (2014), 40% of agricultural greenhouse gas emissions come from direct production, 40% from deforestation, and about 20% from the supply chain and on-farm machinery. Agricultural emissions are projected to grow at about 0.8 to 1.3% annually in the coming years: about 30% between 2010 and 2030 in Sub-Saharan Africa, 20 to 25 in South America excluding Brazil, the U.S., and Southeast Asia, and 3% in European Union.

Directly, agricultural production affects climate change through a large amount of methane emission (second most important greenhouse gas) and nitrous oxide emission (third most important greenhouse gas). Potentially, nitrous oxide could warm the earth more than 296 times relatively to carbon dioxide (CO_2) and methane 23 times relatively to carbon dioxide (CO_2) according to Dickie et al. (2014) and Solomon et al. (2007). These emissions are mainly caused by crops and livestock. According to the Gerber et al. (2013), the entire lifecycle of livestock causes 14.5% of all human-induced greenhouse gas emissions. Ruminants through direct emissions of methane as a byproduct of digestion, manure deposited on grazing lands and croplands nitrous oxide and methane emissions, synthetic fertilizers (N_2O) emissions from large amounts of nitrogen fertilizer, methane emissions from anaerobic decomposition on flooded fields are the main sources of agricultural greenhouse gas emissions. For Dickie et al. (2014), Asian agriculture emits 45% of global agricultural greenhouse gas emissions, and China, United States, India, and Brazil together produce more than 40% of direct agricultural emissions. The emissions from crop and livestock production experienced a growth rate of 14% between 2001 and 2011 going from 4.7 billion tons of carbon dioxide equivalents in 2001 to over 5.3 billion tons in 2011 (United Nations Food and Agriculture Organization (FAO), 2014). This increase, due to an expansion of total agricultural production, mainly occurred in developing countries.

The agricultural supply chain is responsible for the fossil fuel emissions from transportation, energy used for irrigation and cold chain, and fertilizer production. It accounts for about 3.5 Giga tons CO_2 equivalent per year.

Agriculture also increases greenhouse gas emission through changes in land use, namely deforestation, peatlands conversion to agricultural lands, agricultural waste, grassland and savanna burning. As greenhouse gas, land use changes account for about 7.8 Gt CO_2 equivalent per year according to Dickie et al. (2014). Agriculture is responsible for about 80% of forestry and land use change (Kissinger et al., 2012). South America and south Asia are experiencing the largest forest destructions. The Congo Basin is projected to be the future deforestation target. Agricultural sources of deforestation and land use changes include cattle ranching, small-scale agriculture, commercial crops such as palm oil, cocoa, coffee, soybeans, sugar cane, rubber, and pulp and paper. Fire from agriculture also accounts for agricultural greenhouse gas emissions with about 400 to 800 MT CO_2 equivalent per year according to FAO as methane and nitrous oxide emissions in addition to the black carbon, ozone and aerosols emissions. The greenhouse gas emissions from to land use change and deforestation decreased at about 10% from 2001 to 2010, about 3 billion tons of carbon dioxide equivalents per year mainly due to reduced levels of deforestation and increases in the amount of atmospheric carbon being sequestered in many countries (FAO, 2014). Over the 2001–2010 decade, greenhouse gas emissions from agricultural sector was broken down in billion tons of carbon dioxide equivalents per year as: 5 from crop and livestock production, 4 from net forest conversion to other lands, 1 from degraded peatlands, 0.2 from biomass fires (FAO, 2014).

2.2. Agricultural export and environment

In many developing countries, economic growth is largely dependent on agricultural production, and the export of agricultural raw products represents a major source of foreign currency. This increasing demand makes a pressure on production, and therefore degrades physical environment, and including greenhouse gas emissions. To assess whether the international trade of primary agricultural commodity is detrimental to environment or not, some important issues have to be addressed: (i) investigation of whether commodities exported are substitutes of local consumption goods in terms of production and then, are replacing them or are additional production, and (ii) comparison of the