How Agricultural Trade Can Help to Mitigate Climate Change Risks to Food Availability

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Selected paper prepared for presentation at the 2019 Summer Symposium: Trading for Good – Agricultural Trade in the Context of Climate Change Adaptation and Mitigation: Synergies, Obstacles and Possible Solutions, co-organized by the International Agricultural Trade Research Consortium (IATRC) and the European Commission Joint Research Center (EU-JRC), June 23-25, 2019 in Seville, Spain.

2019 IATRC Symposium - "Trading for good - Agricultural trade in the context of climate change adaptation and mitigation: synergies, obstacles and possible solutions"

Title: **How agricultural trade can help to mitigate climate change risks to food availability**

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Introduction

Although trade per se cannot revert or prevent climate change, it can be a very useful vehicle for mitigation of intermittent low food availability in some regions. Thus, this paper add to the bundle of literature (Baldos & Hertel, 2015 among others) that examines a role of trade on mitigation of climate change impacts referred to food security.

The influence of climate change on agriculture can synthetically be divided into two aspects. First, one refers to extreme weather events such as floods, droughts, hurricanes, tornado and heat waves that eventually could eliminate almost all crops at the affected geographic areas. The adaptation to this aspect is very difficult and the only reliable source of mitigation is openness to trade that can deliver agricultural goods from other geographic areas not affected by this extreme events. Second aspect of climate change refers to long terms effects of CO_2 and other greenhouse gases accumulation in the earth atmosphere and is reflected in increase in average temperatures and changes in precipitation patterns over years. In this case investments in research and development of new varieties of seeds for agricultural crops is indispensable and on their way already. Thus, through development of new better-adapted varieties it is possible to mitigate almost 98%-100% of this aspect of climate change according to IPCC (2013, 2014). However, as some other works suggest, the effects are not homogeneously distributed over the world, which outstands the importance of free movement of agricultural products from regions benefitted by climate changes to the regions with deficient agricultural production due to climate change.

Under the mentioned background, the main purpose of the current paper is to evaluate the usefulness of trade as an instrument for mitigation of low food availability through several scenarios executed in Computable General Equilibrium model.

Methodology

A GTAP (Global Trade Analysis Project) Computable General Equilibrium (CGE) model has been used to answer the purpose of the study. A GTAP model first realise was in 1992, initially to allow a quantitative evaluation of impacts on individual countries of Uruguay Round negotiations, which took place under the General Agreement on Tariffs and Trade (GATT) (Hertel 1997). Over time, a number of improvements and amendments have been introduced in the way that GTAP can address environmental issues (GTAP-E, Burniaux and Truong, 2002) as well as a version of the model that allows monopolistic competition in custom-defined sectors (Swaminathan & Hertel, 1997), imperfect competition (Francois, 1998), immigration issues (GTAP-MIG), global policy impacts on poverty (GTAP-POV), the evaluation of costs of the EU Common Agricultural Policy (Philippidis & Hubbard, 2001) and recently a CGEBox utility of GTAP in GAMS was developed (Britz 2019). The modelling language of the GTAP model is GEMPACK, although a version in GAMS is also currently available.

The following scenarios were elaborated in GTAP to achieve the purpose of the study:

Scenraio 1: Baseline scenario is "business as usual".

Scenario 2: Benchmark scenario that includes decline in the grain crops output by 15% in three important agricultural producing and importing countries: Egypt, China & India.

Scenario 3: On top of the benchmark scenario in the affected countries, we make tariffs for all traded commodities as endogenous by fixing the level of imports as in baseline in all sectors.

Scenario 4: On top of the benchmark scenario, trade limitation are introduced in the mentioned countries in a way that countries cannot use imported Grain crops. The trade is limited through zero set in Armington elasticity of substitution between imported and domestically produced grain crops.

Scenarios 3 & 4 represent two different ways of modelling impact of trade on mitigation of decreased food availability. The difference between them consist in the fact that scenario 3 is using different closure making tariffs endogenous and making import exogenous. At the same time, modelling of scenario 4 consists in declining to zero Armington elasticity, which stops substitution of domestically produced grain cops by imported that eventually blocks trade.

Data aggregation in GTAP Data base.

GTAP 9 Data base have been used at the study. The GTAP 9 Data Base comprises 140 regions, 57 sectors and 8 factors of production. However, for the objective of the study 140 regions was aggregated into nine:

- Egypt
- China
- India
- USA
- EU-28
- Russian Federation
- Argentina
- Ukraine
- RoW

The 57 sectors were aggregated into ten: Grains crops, Meat and others, Extraction, Processed food, Textile and related, Light manufacturing, Heavy manufacturing, Construction and related, Transport & communication, Other services.

The eight factors of production were aggregated into five groups: Land, Unskilled workers, Skilled workers, Capital, and Natural resources. The main part subject of aggregation in this category were several types of workers aggregated in only two categories: Unskilled and Skilled.

Results

The evaluation of trade importance is done in Scenarios 3 and Scenario 4. Due to the experimental design of the scenario 3 (see description given in the methodology section) import tariffs are calculated endogenously and represent a first glance to the importance of trade (Table 1)

Table 1. Percentage changes in import tariffs in Egypt, China & India due to decline in production and blocked trade. Scenario 3.

Sectors	Egypt	China	India
1 GrainsCrops	18.1	26.2	26.3
2 MeatLstk	7.1	7.1	7.1
3 Extraction	-0.2	-0.4	-0.6
4 ProcFood	2.0	7.7	8.1
5 TextWapp	-2.4	0.1	-0.5
6 LightMnfc	-2.1	-0.8	-2.2
7 HeavyMnfc	-1.3	-0.8	-1.3
8 Util_Cons	-1.8	-1.8	-2.5
9 TransComm	-2.7	-1.0	-3.4
10 OthServices	-1.9	-1.9	-4.2

Source: own elaboration.

As it can be seen from the table 1 a decline of 15% in production of grain crops is equivalent to 18.1% import tariffs in Egypt, 26.2% in China and 26.3% in India. The higher value for tariffs is the more dependent on imports is a country in question. Meat and livestock sector is the second most affected by the decline in production and blocked trade, which is logical due to the necessities of livestock in vegetable food. The results are only presented for three mentioned countries since the scenario only affect these countries.

Table 2. Sensitivity analysis of changes in import tariffs. Standard deviation of results of Scenario 3 through the possibility of variation of Armington elasticity for all traded commodities by 20%.

Sectors	Egypt	China	India
1 GrainsCrops	0.03	0.08	0.02
2 MeatLstk	0.03	0.03	0.07
3 Extraction	0.05	0.10	0.11
4 ProcFood	0.33	0.11	0.23
5 TextWapp	0.12	0.04	0.13
6 LightMnfc	0.20	0.06	0.13
7 HeavyMnfc	0.10	0.05	0.11
8 Util_Cons	0.12	0.10	0.13
9 TransComm	0.18	0.07	0.26
10 OthServices	0.15	0.07	0.20

Source: own elaboration.

As it can be seen from the table 2, the results presented in the table 1 can be considered as robust since greatest standard deviation is for transport and communication sector and is 0.26.

Table 3. Percentage changes in market prices due to blocked trade. Scenario 3.

Sectors	USA	EU_28	Russia	Ukraine	Argentina	Egipt	China	India	RestofWorld
1 Land	-9.6	-2.1	-3.0	-3.0	-7.9	20.5	17.9	4.4	-4.1
2 UnSkLab	0.0	0.0	-0.1	-0.4	-0.7	2.9	-0.1	0.4	0.0
3 SkLab	-0.1	0.0	0.0	-0.2	-0.6	0.8	-0.5	-0.2	0.0
4 Capital	-0.1	0.0	0.0	-0.3	-0.6	0.9	-0.5	0.0	0.0
5 NatRes	0.2	-0.2	0.0	1.0	2.3	-2.6	-1.9	-1.6	0.0
6 GrainsCrops	-1.7	-0.2	-0.8	-0.7	-2.2	3.9	4.7	1.8	-0.8
7 MeatLstk	-0.6	-0.1	-0.2	-0.6	-1.4	3.1	3.4	1.6	-0.3
8 Extraction	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.3	0.0
9 ProcFood	-0.3	0.0	-0.1	-0.3	-1.1	4.7	3.2	1.2	-0.2
10 TextWapp	0.0	0.1	0.1	0.0	-0.4	0.9	1.3	0.2	0.1
11 LightMnfc	0.0	0.0	0.0	-0.1	-0.5	0.2	0.0	-0.3	0.0
12 HeavyMnfc	0.0	0.0	0.0	-0.1	-0.4	0.0	-0.2	-0.4	0.0
13 Util_Cons	-0.1	0.0	0.0	-0.2	-0.5	0.3	-0.2	-0.2	0.0
14 TransComm	-0.1	0.0	0.0	-0.2	-0.6	0.6	0.1	0.0	0.0
15 OthServices	-0.1	0.0	0.0	-0.2	-0.6	1.0	-0.2	-0.2	0.0

Source: own elaboration.

The most outstanding from the table 3 is an increase in price of land in all three countries subject of experiment. Egypt would suffer the highest increase in land price of 20.5%, following by China with increase by 17.9%. India is a country with a lowest expected increase in price of land (4.4%). This increase in price of land is a result of the increased demand for grain crops that needed to be produced. This also can be a value of trade as an instrument for food shortage mitigation. The land prices in other countries is falling due to decline in demand for different commodities traded with the three countries in question.

Table 4. Sensitivity analysis of changes in market prices. Standard deviation of results of Scenario 3 through the possibility of variation of Armington elasticity for all traded commodities by 20%.

pm	USA	EU_28	Russia	Ukraine	Argentina	Egypt	China	India	RestofWorld
1 Land	0.28	0.29	0.14	0.25	0.26	1.48	0.87	0.89	0.20
2 UnSkLab	0.02	0.00	0.02	0.08	0.08	0.05	0.02	0.03	0.01
3 SkLab	0.02	0.00	0.01	0.11	0.08	0.09	0.04	0.14	0.00
4 Capital	0.02	0.00	0.02	0.10	0.09	0.06	0.04	0.10	0.00
5 NatRes	0.00	0.06	0.07	0.23	0.12	0.03	0.43	0.22	0.04
6 GrainsCrops	0.03	0.03	0.05	0.01	0.00	0.13	0.20	0.29	0.04
7 MeatLstk	0.00	0.01	0.02	0.03	0.04	0.04	0.10	0.18	0.02
8 Extraction	0.01	0.01	0.01	0.02	0.03	0.03	0.10	0.11	0.01
9 ProcFood	0.01	0.00	0.02	0.04	0.04	0.07	0.05	0.07	0.01
10 TextWapp	0.01	0.00	0.01	0.04	0.05	0.06	0.00	0.04	0.00
11 LightMnfc	0.01	0.00	0.01	0.04	0.05	0.09	0.03	0.09	0.00
12 HeavyMnfc	0.01	0.00	0.01	0.03	0.05	0.07	0.04	0.10	0.00

13 Util_Cons	0.01	0.00	0.01	0.06	0.06	0.07	0.04	0.09	0.00
14 TransComm	0.02	0.00	0.01	0.07	0.08	0.08	0.03	0.08	0.00
15 OthServices	0.02	0.00	0.01	0.08	0.08	0.07	0.03	0.11	0.00
16 CGDS	0.01	0.00	0.01	0.03	0.05	0.07	0.04	0.09	0.00

Source: own elaboration.

From the table 4 can be observed that greatest standard deviation is for land in Egypt (1.48). In general, this results are robust because Egypt is a country with a highest spike in land price after the trade blockage, so highest standard deviation in this variable is coherent with the expectations.

Table 5. Percentage changes in market prices due to blocked trade. Scenario 4.

Sectors	USA	EU_28	Russia	Ukraine	Argentina	Egypt	China	India	RestofWorld
1 Land	-9.0	-2.0	-4.0	-2.3	-7.5	27.8	18.5	4.3	-4.9
2 UnSkLab	0.0	0.0	-0.1	-0.2	-0.6	4.2	0.1	0.4	-0.1
3 SkLab	-0.1	0.0	0.0	-0.1	-0.5	1.4	-0.3	0.1	0.0
4 Capital	-0.1	0.0	0.0	-0.1	-0.5	1.6	-0.3	0.1	0.0
5 NatRes	0.1	-0.2	-0.1	0.3	1.8	-4.4	-1.4	-1.1	-0.1
6 GrainsCrops	-1.6	-0.2	-1.0	-0.5	-2.0	4.9	4.9	1.8	-1.0
7 MeatLstk	-0.6	-0.1	-0.3	-0.4	-1.2	3.7	2.9	1.4	-0.4
8 Extraction	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	0.0
9 ProcFood	-0.3	0.0	-0.2	-0.2	-1.0	1.6	2.1	1.0	-0.2
10 TextWapp	0.0	0.0	0.0	0.0	-0.4	1.6	0.7	0.5	0.0
11 LightMnfc	-0.1	0.0	0.0	-0.1	-0.4	0.9	0.2	0.2	0.0
12 HeavyMnfc	-0.1	0.0	0.0	-0.1	-0.3	0.7	0.0	0.1	0.0
13 Util_Cons	-0.1	0.0	0.0	-0.1	-0.4	1.1	0.0	0.2	-0.1
14 TransComm	-0.1	0.0	0.0	-0.1	-0.5	1.4	0.2	0.2	-0.1
15 OthServices	-0.1	0.0	0.0	-0.1	-0.5	1.5	-0.1	0.1	0.0

Source: own elaboration.

The scenarios 3 and 4 are representing the same situation of trade blockage, but using different modelling tools available in GTAP. Thus, it is coherent that results showed in table 3 and 5 are similar. For instance in the table 5 price of land in Egypt, China and India grows by 27.8%, 18.5% and 4.3% consequently. Price of land in other countries is going down. The grain crops price is going up in Egypt, China and India by 4.9%, 4.9% and 1.8% consequently and declining in other countries. The same trend can be observed for Meat and livestock.

Conclusions

According to the results obtained in current research, the usefulness of trade for mitigation of climate change risks to food availability was proved. Three important agricultural producing and importing countries were chosen for these purposes: Egypt, China and India. Taking into account underlying assumption of scenario 3 the value of trade is estimated in terms of import tariffs, which oscillate between 18.1% and 26.3% depending on the country of analysis. Trade value is also expressed in terms of land prices changes that in Scenario 3 are increasing by 20.5% in Egypt, by 17.9% in China and by 4.4% in India. The changes in land prices but in Scenario 4 are similar to Scenario 3: increase by 27.8% in Egypt, by 18.5% in China and by 4.3% in India.

The sensitivity analysis performed for scenario 3 shows robustness of the results. In the case of tariffs, standard deviation for grain crops is between 0.02 and 0.08. In the case of land price changes standard deviation is 1.48 for Egypt, 0.87 for China, and 0.89 for India.

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