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Trade effects of climate change: An application to MENA countries

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Abstract

This paper tests the relationship between climate and trade of agricultural products in MENA countries, using bilateral data disaggregated at product level. The model includes gravity control variables and addresses the selection bias with disaggregated production variables in a Heckman two-step procedure. Results show that a rise in temperature and a decrease in precipitation significantly reduce exports and increase imports in MENA countries. This raises the question of food security in these countries.

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1. Introduction

Climate change, especially global warming, has recently become a major issue for the world population and policy makers. In this regard, the Intergovernmental Panel on Climate Change (IPCC, 2007) predicted global warming to range between 1.0°C and 4.5°C by the end of the 21rst century. Using a slightly different method, the last IPCC report updates this range between +2.6°C and +4.8°C while predicting significant changes in rainfall (IPCC, 2013). In this regard, a significant rise in precipitation is observed and predicted in America, Northern Europe and Central Asia. Conversely, Mediterranean countries but also Southern Asia and Southern Africa are affected by a strong decrease in rainfall (IPCC, 2013).

Given these alarmist figures, economists have recently attempted to quantify the economic impact of climate (or climate change) on the real economy. For example, Dell e al. (2009) show that the rise in temperature by 1°C leads to a reduction in income and growth by 8.5% and 1% respectively. Using a different method and country sample, Nordhaus (2006) shows that global warming is expected to reduce income by about to 4%.

At industry and product levels, climate change can be expected to be impacting productivity, production and thus trade. However, the relationship between climate and trade has been explored only recently in the literature. As a result, there are very few studies available. The most interesting one is probably Jones and Olken (2010) which show that a 1°C increase of the temperature gives rise to an export reduction from developing countries to the USA which ranges from 2.0% to 5.7% depending on the industry considered. Agricultural products are particularly concerned with an export reduction induced by climate shock due to direct impacts on crop yields. Country-specific studies are still scarce. Felkner et al. (2009) show that trade effects can be significant for rice producers in Thailand and that that poor farmers are able to adapt to climate change for very small shocks only. Guiteran (2009) find similar results for India while forecasting a 25% decrease in agriculture yield by the end of the century.

To our knowledge, no quantitative study is devoted to Middle East and North African (MENA) countries. These countries are particularly interesting first because they are very much trade dependent especially in agricultural products. On the export side for example, Morocco and Tunisia export fruit and vegetables which account for a significant share of total exports. In the same way, imports of cereals or dairy products also account for a notable share of total imports. In addition, these countries are very sensitive to climate change because their geographic location (close to deserts) makes them particularly concerned with temperature elevation and rainfall decline. In other words, since these countries are strongly sensitive to climate and agricultural trade, climate change is likely to have significant effects on their trade patterns in agricultural products.

This article fills this lack of literature with the following additional contributions. First, the trade model includes both reporter and partner countries' climate variables, such as temperature and precipitation. Secondly, the model is estimated at disaggregated product level. Finally, it accounts for country and time heterogeneity as well as zero observations through the Poisson pseudo-maximum likelihood (PPML). It is organized as follows. Section 2 provides key features about agriculture and climate in MENA countries. Section 3 develops the model and data whereas section 4 discusses the results.

2. Key features about agriculture and climate sensitivity in MENA countries

Agriculture plays a major role in the economies of MENA countries. Table 1 shows that agricultural products account for about 10% of total exports in many countries over the period considered (1962-2008). Some countries heavily depend on the exports of key products such as fruit and vegetables (citrus fruit and tomatoes in Morocco and Israel to a lesser extent; nuts, walnuts and grapes in Turkey; dates in Tunisia and Algeria) and olive oil (Tunisia, Turkey). Agricultural products also generally account for more than 10% of total imports, especially in Egypt, Algeria, Jordan as well as Syria and Libya. The main import products are cereals (especially wheat), but also dairy products (Algeria, Lebanon, Jordan) and sunflower oil (Libya, Algeria, Egypt).

Table 1: Share of agricultural products in MENA countries' total trade (% from yearly average 1962-2008)

EXPORTS	agriculture	fruit and vegetables	cereals	dairy products	vegetable oil	main exported products
Algeria	0.24	0.2	0.01	0.01	0.01	dates, prepared nuts, potatoes, oranges, olive oil virgin
Egypt	8.00	4.27	2.44	0.19	0.11	potatoes, oranges, grapes, tomatoes, olive oil virgin
Israel	4.3	3.87	0.15	0.07	0.04	oranges, potatoes, tomatoes, grapes, dates
Jordan	7.48	6.22	0.47	0.18	0.36	tomatoes, potatoes, olive oil virgin, dates, oranges
Lebanon	11.07	6.91	1.08	0.33	1.01	potatoes, olive oil virgin, grapes, oranges, prepared nuts
Libya	0.03	0.02	0.00	0.00	0,00	oranges, potatoes, olive oil virgin
Morocco	13.47	12.04	0.27	0.16	0.51	oranges, tomatoes, clementines, potatoes, olive oil virgin
Syria	6.89	3.17	1.74	0.45	0.74	olive oil virgin, prepared nuts, potatoes, tomatoes, hazelnuts shelled
Tunisia	8.12	2,00	0.53	0.13	5.14	olive oil virgin, dates, oranges, chillies and peppers green, prepared nut
Turkey	9.46	7.43	0.81	0.03	0.53	prepared nuts, hazelnuts shelled, olive oil virgin, tomatoes, clementines
IMPORTS	**agriculture**	**fruit and vegetables**	**cereals**	**dairy products**	**vegetable oil**	**main imported products**
Algeria	17.62	1.50	9.53	3.74	1.27	wheat, milk, corn, sunflower oil, barley
Egypt	16.82	1.66	12.14	1.54	0.85	wheat, corn, soya, milk, sunflower oil
Israel	4.65	0.82	2.22	0.12	0.13	wheat, soya, corn, barley, coffee green
Jordan	13.24	2.77	6.63	1.78	0.65	wheat, barley, corn, milk, soya oil
Lebanon	8.94	2.17	2.74	2.39	0.44	wheat, milk, corn, soya oil, barley
Libya	12.33	1.74	5.26	1.79	2.3	barley, wheat, milk, corn, sunflower oil
Morocco	9.76	0.56	6.08	0.80	1.15	wheat, tea, soya oil, corn, barley
Syria	11.17	1.63	5.58	1.40	0.6	corn, barley, wheat, soya, milk
Tunisia	6.56	0.43	3.70	0.50	1.09	wheat, soya oil, corn, barley, milk
Turkey	1.78	0.18	0.89	0.08	0.41	wheat, corn, soya oil, soya, sunflower oil

Source: own calculations from Comtrade database. Data exclude animal products.

Given that water resources are scarce and that irrigation is not sufficiently developed, MENA countries are very sensitive to weather conditions, especially rainfall. Periods of drought generally lead to a rise in grain imports (due to domestic production cuts) as well as a decrease in exports (due to yield decrease in the production of fruit and vegetables).

Looking at temperature and precipitation data (Table 2), it is striking to observe that temperature has significantly increased over the past 50 years, especially in North Africa (+1°C in Tunisia and Libya, +0.8°C in Egypt, +0.6°C in Algeria). In addition, precipitation has decreased by more than 10% in Israel, Jordan, Lebanon and Syria. The reduction in rainfall is even more dramatic if we consider a longer period, i.e. from 1900-1929 to 1990-2008. In this case, precipitation has declined in all countries, down to 50% in Mashrek countries. These changes in climate patterns are likely to have a significant impact on both exports and imports for the most sensitive agricultural products.

Table 2: Recent changes in yearly average temperature and precipitation in MENA countries

	Temperature (°C)			Precipitations (mm)		
	1960-1989	1990-2008	change °C	1960-1989	1990-2008	% change
World	13.8	14.6	+0.8	900.1	971.5	7.9%
Algeria	23.1	23.7	+0.6	86.7	87.0	0.3%
Egypt	21.9	22.7	+0.8	17.7	18.0	1.7%
Israel	19.8	20.0	+0.2	164.5	145.9	-11.3%
Jordan	19.2	19.5	+0.3	124.9	108.3	-13.3%
Lebanon	17.2	17.6	+0.4	654.1	568.0	-13.2%
Libya	22.3	23.3	+1.0	39.0	43.3	-11.0%
Morocco	19.0	19.4	+0.4	180.9	181.0	0.1%
Syria	18.0	18.5	+0.5	332.9	272.0	-18.3%
Tunisia	19.9	20.9	+1.0	236.7	240.8	1.4%
Turkey	12.2	12.4	+0.2	590.9	570.9	-3.4%

Source: own calculations from the *Terrestrial Air and precipitation: 1900-2009*, version 2.01 (Matsuura and Willmott 2009).

3. The model and data

The relationship between climate and trade is tested through the estimation of the new gravity equation developed by Anderson and van Wincoop (2003). These authors develop a consistent general theoretical framework with special emphasis on trade costs from which the gravity equation can be derived. In this framework, exports from country i to country j depend not only on the traditional gravity variables, i.e. GDP and bilateral distance, but also on bilateral and multilateral trade costs. In a cross-section framework, the multilateral resistance is generally taken into account by introducing country-specific effects. The advantage of this specification is that it reduces the bias due to omitted variables through the specific inclusion of multilateral trade resistance (Baldwin and Taglioni (2006)).

In a panel data framework, this analysis can be extended the use of bilateral and specific country-time effects. In this case however, only the parameters corresponding to bilateral time-varying variables can be estimated, e.g. regional integration dummies.

The model proposed in the present paper is the following:

$$\begin{aligned}\log(trade_{ijt}) = {} & a_0 + a_1 \log(TEMP_{it}) + +a_2 \log(TEMP_{jt}) + a_3 \log(PRECIP_{it}) \\ & + a_4 \log(PRECIP_{jt}) + a_5 \log(GDP_{it}) + a_6 \log(GDP_{jt}) + a_7 \log(REG_{ijt}) \\ & + \alpha_i + \alpha_j + \alpha_t + \alpha_{ij} + \varepsilon_{ijt}\end{aligned}$$

In fact, this trade equation includes two separate equations: exports and alternatively imports from country i to country j at year t for each major traded agricultural product (source: Comtrade)[1]. The sample country includes the 10 MENA countries described above as reporters. Partner countries include EU and MENA countries as well as the USA, Canada, Russia, China and Japan (42 countries). These countries account for more than 90% of total trade of MENA countries. The time period considered is 1962-2008.

TEMP and *PRECIP* reflect temperature and precipitation in country i and j (source: the *Terrestrial Air and precipitation: 1900-2009*, version 2.01, Matsuura and Willmott 2009). A rise in temperature and a decrease in rainfall in any country is expected to lead to a decrease in their exports and an increase in their imports.

GDP_{it} and GDP_{jt} are traditional gravity variables that stand for for country size. The higher this size, the higher exports and imports with between i and j (source: World Bank). *REGijt* accounts for regional integration (source: Cepii), measured by a dummy variable.

Finally, the gravity equation includes country-specific effects (α_j and α_j) which reflect multilateral resistance, a time specific effect α_t which considers the role of business cycles and any other time-specific omitted variables as well as a bilateral effect (α_{ij}) which replaces the time-invariant variables such as distance, language and colonies, as recommended by Baier and Bergstrand (2007). Ideally, country and time specific effects should be replaced by country-time effects (α_{it} and α_{jt}). In this case however, it would not be possible to estimate the key parameters related to GDP, temperature and precipitation. The solution put forward here is recommended by Egger and Pfaffermayr (2003) so as to properly account for both multilateral resistance and bilateral effects in a panel data model with key country and time varying variables.

Given the significant number of zero observations due to the high disaggregation level at country and product levels, two possible estimators can be implemented. The first is the Heckman two-step procedure which enables us to explain the probability to export related to the selection bias. However, given the problems and the potential biases related to the choice of an appropriate selection variable, an alternative estimator is implemented[2]. This is Poisson pseudo-maximum likelihood (PPML) estimator, which can also be used in case of zero observations. It has been proposed by Santos Silva and Tenreyro (2006).

Compared with the models existing in the literature, the equation tested here is more accurate, mainly because it includes reporter and partner countries' climate variables and provides

[1] Since Comtrade data are not always fully reliable especially going as back as 1962 for developing countries, alternative solutions have been implemented, i.e. i) the use of FAO-Stat specific data and ii) the estimation of the model with Comtrade starting from 1995. However, these alternative solutions lead to a significant reduction in the number of observations, either because of data unavailability at disaggregated level (FAO-stat) or because of the restricted period of time (Comtrade 1995-2008). Consequently, it seems preferable to present the results for the whole period 1962-2008.

[2] Preliminary tests have been implemented by using as selection variables the production of the agricultural product considered in country i ($PROD_{it}$) in the export equation and in country j ($PROD_{jt}$) in the import equation. Indeed, it is expected that the probability to export a given agricultural product primarily depends on the capacity of country i to produce this product and thus of its comparative advantage. Identically, the probability to import an agricultural product primarily depends on the capacity of the importing country to produce this good. One limitation is that although the selection variable is a good predictor of the likelihood of exporting (importing), it is also a good predictor of the volume of exports (imports). As a result, the selection variables do not only explain the probability to export (import). Still, preliminary estimations with the Heckman procedure provide the same qualitative results as the PPML estimator, but not the same size results.

estimations at disaggregated product levels for both exports and imports. It covers the main products traded by MENA countries, i.e. exports of fruit and vegetables (clementines, oranges, tomatoes, potatoes, grapes, nuts, walnuts, olive oil, dates and pepper) as well as imports of cereals (wheat, corn, barley, soya), sunflowers and dairy products.

4. Results

Table 3 displays regression results for both exports and imports. Most variables are significant and show the expected sign. An increase in the reporter and partner's GDP leads to a rise in exports and imports, as expected by gravity models. It is also striking to observe that regional agreements do not always increase MENA countries' exports. This can be attributed to the restricting conditions of the EU Common Agricultural Policy (CAP) with regard to sensitive products, especially tomatoes and olive oil. In the same way, regional agreements do not necessarily lead to an increase in imports, because of the existence of separate bilateral agreements for sensitive cereals (corn, wheat) which cause trade diversion.

Table 3: Estimation results

EXPORTS						
	Total agriculture	**Total fruit and veg.**	**tomatoes**	**oranges**	**clementine**	**potatoes**
Temperature reporter	-0.462***	-0.753***	-1.168***	0.924**	1.189***	-0.074**
Precipitation reporter	0.185***	0.901***	0.248**	0.537***	0.516***	0.319***
Temperature partner	0.681***	0.849***	0.984***	-0.647***	-2.185***	0.186***
Precipitation partner	-0.251***	-1.224***	-0.584***	-0.314***	-0.156**	-0.624***
GDP reporter	0.345***	0.725***	0.318***	0.427***	0.249***	0.217***
GDP partner	0.438***	0.694***	0.467***	0.285***	0.349***	0.0179***
Regional agreement	0.249***	0.826***	-0.591**	0.851*	0.097	0.395***
Intercept	-12.184***	-5.164***	-3.047***	2.187***	3.981***	-4.249***
number of observations	14246	7188	2175	1972	1261	1761
EXPORTS (cont'd)						
	pepper	**grapes**	**dates**	**nuts**	**walnuts**	**olive oil**
Temperature reporter	0.047***	-1.698***	5.186***	-4.891***	0.561**	-0.549***
Precipitation reporter	0.198*	0.00651**	0.816***	0.0168	0.247*	0.008*
Temperature partner	-0.146***	0.864***	-3.156***	2.489***	0.166*	1.846***
Precipitation partner	0.173*	-0.0105**	-1.165***	-1.006*	-0.816*	0.01*
GDP reporter	0.507***	0.718***	0.112***	0.358***	0.687***	0.204***
GDP partner	0.098**	0.215***	0.118***	0.374***	0.917***	0.249***
Regional agreement	0.318***	-0.241**	0.178**	0.164***	0.461**	-0.467***
Intercept	-14.196**	-25.286***	-15.891***	3.247**	-20.186***	9.179***
number of observations	1224	1317	1742	1478	773	1437

IMPORTS					
	Total agriculture	**Total cereal**	**wheat**	**corn**	**soya**
Temperature reporter	1.059***	1.104***	2.148***	0.219**	0.409***
Precipitation reporter	-0.429***	-0.003***	-0.078**	-0.197***	-1.168***
Temperature partner	-2.186***	-1.199***	-1.948***	-0.284***	-1.069***
Precipitation partner	0.661***	0.089***	0.244***	0.486***	1.867***
GDP reporter	0.058***	0.426***	0.116***	0.174***	0.679***
GDP partner	0.069***	0.301***	0.169***	0.115***	0.247***
Regional agreement	-0.488***	-0.189***	-0.671***	-1.189***	0.547
Intercept	-3.161***	-1.891***	1.416**	4.168***	-6.156***
number of observations	12493	5605	1888	1336	325
IMPORTS (cont'd)					
	barley	**fruit and veg.**	**veg. oil total**	**sunflow. oil**	**dairy prod.**
Temperature reporter	0.519***	0.519***	0.284*	0.248**	2.189***
Precipitation reporter	-0.003*	-0.058*	-0.167***	-0.365**	-0.086**
Temperature partner	-0.945***	-0.347***	-1.347**	-0.264***	-3.954***
Precipitation partner	0.008**	0.114**	0.146**	0.394**	0.094**
GDP reporter	0.001	0.324***	0.176***	0.189	0.246***
GDP partner	0.102*	0.167***	0.01*	0.008	0.002*
Regional agreement	-0.218***	-0.045	0.145	-1.716**	1.817***
Intercept	7.161	-1.917***	8.924***	6.006***	2.587**
number of observations	1111	6322	3719	1055	4972

***: significant at 1%, ** 5% and * 10%

Turning to climate variables, it is worthwhile to note that a rise in temperature and a decline in precipitation in MENA countries significantly reduce their exports and increase their imports for most products. The export products which are the most sensitive to temperature elevation are nuts, tomatoes and grapes whereas those which are the most sensitive to rainfall decline are dates, potatoes and citrus fruit. In the same way, the most sensitive import products to temperature are wheat and dairy products whereas sunflower oil, soya, wheat and corn are very sensitive to rainfall decline.

Interestingly, MENA countries' trade depends also on climate change in their partners. As a matter of fact, a rise in temperature and a decrease in precipitation in the partner generally give rise to an export increase and an import decrease in MENA countries.

Overall, these findings clearly show that climate change in MENA countries leads to i) an increasing dependence of these countries vis-à-vis cereal and milk imports and ii) a decrease in their export capacity for most fruit and vegetables. As a result, climate change is likely to strongly affect their current account balance for agricultural products. Of course there are a few exceptions in our results. For instance, a temperature elevation leads to an increase in citrus fruit and dates' exports since these fruit like warm temperatures. However, these fruit also need rain and they are thus negatively impacted by a decline in rainfall. In the same way, tomatoes are not sensitive to rainfall because of irrigation but very sensitive to temperature elevation. So overall, the negative effects of climate change appear quite clearly for these countries. Unless they are able to adapt to climate change through the development of irrigation or by selecting more robust varieties, they will hardly be in a position to develop their export capacity in the long run and reduce their import dependence from Northern products. This raises the problem of food security for these countries in the coming years.

This problem is reinforced by the fact that MENA countries also depend on climate change in their trading partners. Should these partners face a rise in temperature or a decrease in precipitation, MENA countries would be compelled to import less from these countries. This means that trade (especially imports) cannot be viewed as a fully relevant solution for preserving food security in these countries.

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