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The impact of foreign land acquisitions on Africa virtual water exports

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ABSTRACT

Do Foreign Land Acquisitions (FLA) in Africa increase the use of water? This paper provides empirical evidence about the impact of FLA on the water content of goods exported from African countries. A dynamic panel gravity-like equation is estimated to explain the pattern of African agri-food exports, of total Virtual Water exports, and of the green and blue Virtual Water components. Results suggest that FLA in African countries increase exports and that, by changing the composition of traded products, they imply an increase in overall water consumption both green and blue. However, a differentiated pattern emerges depending upon the origin of the investing firm. While investments coming from North and South America tend not to affect the water content of African exports, this is not the case for FLA from other parts of the world.

1. Introduction

Since 2007, large-scale land acquisitions by foreign firms have been rapidly increasing in developing countries, fuelled by the 2007 crisis in agricultural prices and the worldwide increase in the demand for food and bioenergy. A number of studies emphasized the distinguishing features of this new “land rush”: first, the emergence of new investors from developing countries; second, the concentration of foreign investments in least developed countries; third, the destination of a considerable amount of the land acquired to a new industry, the production of biofuels; fourth, the need to access natural resources – and in particular land and water - as the main driver; finally, the direct involvement of the governments of hosting countries in the allocation of the land to foreign firms (e.g. Von Braun and Meinzen-Dick, 2009; UNCTAD, 2009; Cotula et al., 2009; World Bank, 2011; Anseeuw et al., 2012; Messerli et al., 2014; Arezki et al., 2015; Lay and Nolte, 2017; Raimondi and Scoppola, 2018; Arezki et al., 2018).

The nature and implications of this new “land rush” have become among the most hotly debated development issues (Schoneveld, 2014), with two main views (Borras Jr., 2010). On one hand, it has been argued that the lack of transparency regarding land allocations and the expansion of large-scale export-oriented agricultural production associated with these land deals increase the risk of a new “land grab”. The concern raised by NGOs and civil society is that they may displace local communities from land, with potentially negative implications in terms of worsening food security and poverty in developing countries. On the other hand, international organizations point out that FLA could be an opportunity to substantially increase investments in developing countries agriculture and could create the pre-conditions for sustained development (World Bank, 2011; FAO, 2013). Several scholars have emphasized that not all Foreign Land Acquisitions (FLA) can be considered as “land grabs”, yet not all FLA imply agricultural investments fostering growth and development in the developing countries (e.g. Cotula et al., 2009; Borras et al., 2011; Wolford et al., 2013). In fact, the implications of FLA largely depend upon a number of factors; among others, the actual investments made by foreign investors; the development of infrastructure; the creation of new employment; knowledge and technological spillovers or other externalities associated with the FLA; the involvement and consultation with the local community (Cotula et al., 2009; Cotula, 2011; FAO, 2013; Messerli et al., 2014; Kleemann and Thiele, 2015; Nolte and Voget-Kleschin, 2014).

Among the potential negative externalities associated to FLA, the risk of a decrease in the local population's access to water has raised concerns (Mehta et al., 2012). Because FLA imply a rapid industrialization of agriculture, they may considerably increase the pressure on natural resources (UNEP, 2011) and, in particular, on water. FLA are generally associated with intensive monoculture, which is highly water demanding. Since FLA are typically associated with situations of power imbalance in the allocation of water resources, often in disregard of local users, they may imply a “water grabbing”; in other words, they entail a consumptive use of water that may exclude other (local) actors.

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A strand of literature investigated the potential implications of FLA in terms of water use by computing the FLA-related consumptive use of water. To this end, information about the amount of the land acquired has been combined with data about water consumption at the crop level (e.g. Bossio et al., 2012; Rulli and D'Odorico, 2013; Breu et al., 2016; Dell'Angelo et al., 2018). Moreover, previous studies emphasized the importance of distinguishing between the different types of consumptive water use that is, green and blue. Green water (moisture stored in soils and plants) is strictly tied to the land; hence, when the land acquired by foreign firms is used to produce crops relying solely on green water (i.e. rainfed agriculture) the local population is not excluded from the use of the same water. On the contrary, blue water (water stored in aquifers and surface water reserves) can be transported, and hence FLA heavily reliant on blue water (i.e. irrigated agriculture) may exclude neighbouring farmers from this resource. FLA have been found to mostly use green water and the estimated consumption of green water turns out to be quantitatively important especially in a number of African countries (e.g. Rulli and D'Odorico, 2013; Breu et al., 2016; Dell'Angelo et al. (2018).

This paper aims at contributing to the literature by using a different approach, that is, by checking whether there is ex-post econometric evidence that FLA has a positive impact on the intensification in water use. The basic idea is that, because FLA are mostly export-oriented, by assessing the impact of FLA on the water content of exports, we capture a large part of the effect of FLA on the use of water. For this purpose, we use data about Virtual Water Trade (VWT).

Our analysis focuses on African countries, first, because they account for more than 50% of the land acquired by foreign firms and, second, because they are considered as the most exposed to the risk of a water grab (e.g. Dell'Angelo et al., 2018; Breu et al., 2016). Our first aim is to check whether the water content of African exports and its two main components, green and blue, are positively affected by FLA in Africa. To this end, we first check the more general effect of FLA on the African agri-food exports.

Building on the VWT literature (Tamea et al., 2014; Fracasso, 2014; Fracasso et al., 2016; Duarte et al., 2019), a dynamic panel gravity-like equation is estimated by means of the System-GMM estimator (Blundell and Bond, 1998), to take into account of the persistency of exports and to deal with the likely endogeneity bias of FLA. Indeed, FLA can be determined by the amount of trade between countries, as the investors may be more attracted by locations where trade relationships already exist. We use an unbalanced panel of bilateral land acquisitions data including 14 years (2000–2013), 45 African countries, and 158 importers.

This paper is related to three strands of literature. First, we contribute to the literature on foreign land acquisitions, by providing empirical evidence about the impact of FLA on (African) exports. While most of the empirical literature on FLA has investigated the determinants of FLA (e.g. Arezki et al., 2015; Arezki et al., 2018; Lay and Nolte, 2017; Raimondi and Scoppola, 2018) there is a substantial lack of cross-country econometric evidence about the effects of FLA. To the best of our knowledge, this is the first empirical analysis of the relationship between FLA and the exports of target countries. Second, we contribute to the "water grabbing" literature, by providing econometric evidence of the impact of FLA on the water extraction in target countries, whereas previous studies provide ex-ante assessments (e.g. Rulli and D'Odorico, 2013; Breu et al., 2016; Dell'Angelo et al., 2018). Third, the paper contributes to the VWT literature by a) using a dynamic model and b) exploring one additional possible determinant of VWT, that is foreign investment. None of the previous studies using gravity models to explain VWT have used dynamic specification or included foreign investment in the RHS of the gravity equation (e.g. Duarte et al., 2019; Fracasso, 2014; Fracasso et al., 2016).

Our results provide interesting insights into the issues addressed herein. First, our findings confirm that a dynamic specification is an appropriate way to investigate the drivers of VWT. Second, evidence supports our hypothesis that FLA in Africa are overall export-enhancing and that they increase the water content of exports. Third, we find a differentiated regional pattern depending upon the origin of the investing firm; in particular, while investments coming from North and South America tend not to affect the blue content of African exports, this is not the case for FLA from other regions.

The paper is organised as follows. In the next section, we illustrate the background to our empirical assessment. The third section illustrates the empirical strategy, while the fourth the data used. Then, in the fifth section, we discuss our results and finally provide, in the last section, some concluding remarks.

2. Virtual water trade and foreign land acquisitions in Africa

VWT is the amount of water embodied in the international trade of products. Through the international trade in goods, water is virtually moved from the production country to the consumption country. Agricultural trade is the major vehicle of water trade; according to Mekonnen and Hoekstra (2011), over the period 1996–2005, 88% of world VWT was related to agricultural products. Since the 1980s, the rate of growth of world VWT has been around 3.3% per year, driven by the marked growth in agricultural trade (Duarte et al., 2019). The growth in VWT has raised concerns over its potential impact on the availability of water.[1] Indeed, on one hand, through imports, countries that are relatively scarce in water can provide their population with agricultural and food products whose production would require an excessive amount of water domestically (Antonelli and Tamea, 2015). On the other hand, an increase in the VW exports, due for example to the intensification of export-oriented crops, is perceived as potentially worsening the situation in countries with limited water endowment. (Dell'Angelo et al., 2018).

Water scarcity is also considered as the main driver of VWT. Starting from the seminal paper by Allan (1994), a growing body of literature has analysed VWT from a water scarcity perspective, that is, by considering the absolute water endowment of countries as the driver of VWT. From this perspective, water scarce (rich) countries are expected to be net importers (exporter) of VW. Debaere (2014) first challenged this view, by pointing out that traded goods do not only contain water, but a number of other factors of production; in order to explain VWT, comparative and not absolute advantages should thus be considered. He empirically investigated the role of water in determining the comparative advantages of countries in agriculture and found that countries with more water per capita tend to export more water-intensive goods.

The issue of the impact of FLA on the use of water has been addressed from a somewhat different perspective by another strand of the literature investigating the extent to which FLA determine water dispossession in host countries, the so called "water grabbing"[2] (e.g. Mehta et al., 2012; Bossio et al., 2012; Williams et al., 2012; Rulli and D'Odorico, 2013; Breu et al., 2016; Dell'Angelo et al., 2018). This literature points out that foreign investors do not seek lands that do not have water for production in the first place; hence, because land and water are inextricably connected, FLA have important implications not only on food security, economic development, land tenure or human rights, but also in terms of water availability in host countries. Breu et al. (2016) measure the water consumption linked to FLA by means of an

[1] A review of the literature on the impact of VWT on water scarcity can be found in Wichelns (2015). The concept of water scarcity includes both a natural and an anthropic dimension; while the former is related to those physical factors limiting water availability, the latter refers to the many constraints that local people may face accessing water due to the failure of institutions to ensure a regular supply or due to a lack of adequate infrastructure (https://www.unwater.org/water-facts/scarcity/).

[2] A discussion of the definition of water grabbing can be found in Dell'Angelo et al. (2018).

index and found that FLA imply an average increase of 1.8% in water consumption; this data is much higher for a number of African countries, especially in Sub Sahara. They also showed that the amount of water consumption through FLA depends upon the origin of the investor: rather surprisingly, countries often suspected of using FLA to relieve pressure on their domestic water resources (such as China, India, and Gulf States except Saudi Arabia) invest in less water-intensive crops; on the contrary, large investors such as the United States, Saudi Arabia, Singapore, and Japan are found to externalize crop water consumption through FLA.

Furthermore, this literature highlights the importance of distinguishing between two components of the water associated with the production of a certain good, the so-called water footprint of a product. The blue water footprint is the fraction due to the consumption of water for irrigation (water withdrawn from both surface and aquifers). The green water footprint is the fraction contributed by precipitation (D'Odorico et al., 2019). The basic idea is that while the use of green water - which is strictly tied to the acquired land - cannot displace other local users, the use of blue water (irrigation) may exclude neighbouring farmers from future use, thereby leading to dispossession. Recently, Dell'Angelo et al. (2018) have developed a methodology to assess the likelihood that water appropriations due to FLA jeopardize future agricultural development based on three indicators: the amount of green and blue water used, a biophysical measure of water scarcity and an indicator of food insecurity. This likelihood is higher when a country is affected by undernourishment and with high level of (blue) water scarcity. They provide a worldwide map of the likelihood of blue water appropriation associated with FLA. Their results show that for a number of African countries the likelihood of water grabbing is high, while this is not the case for Eastern Europe, Latin America and most important Asian target countries.

Drawing on this literature, we focus on African exports and investigate the impact of FLA on the green and blue components of VWT. Two main reasons lie behind our focus on Africa. First, as aforementioned, the likelihood of water grabbing in several African countries is considered higher than on average (Dell'Angelo et al., 2018). Moreover, even in African countries relatively abundant in “unused” water, the intensification of water use for export-oriented crops is considered to have important implications in terms of water scarcity at the local level (Mehta et al., 2012; Breu et al., 2016). Second, Africa accounts for an important share of world FLA. Over the period 2000–2015, about 50% of the total land acquired by foreign firms and about the 40% of total deals concerned Africa (Raimondi and Scoppola, 2018).

To investigate the impact of FLA on VWT, we first need to address the more general issue of the effect of FLA on exports. Empirical evidence on the nexus FLA-trade, to the best of our knowledge, is still lacking. The literature on Foreign Direct Investment (FDI) suggests that the relationship between FDI and trade depends upon the type of foreign investment (Antràs and Yeaple, 2014).[3] Traditionally, the literature distinguishes between horizontal and vertical FDI. With horizontal FDI, the affiliate of the multinational firm replicates abroad the same production as at home and sells the product on the local (foreign) market. The main drivers of horizontal are the need to reduce trade costs and the proximity to the final consumer. Thus, horizontal FDI do not increase the exports of the target country. On the contrary, with vertical FDI, the affiliate produces abroad commodities or intermediate goods, which are then processed (sold) in the investor's country. Firms invest abroad to reduce production costs and/or to access resources (labour, land, water etc.) that are not available at home. Vertical FDI, thus, involves exporting commodities or intermediates back home. More recently, a more complex type of FDI has come to dominate, the so-called export-platform FDI. In this case, commodities or intermediates produced abroad are processed (sold) in other (third) countries. Therefore, export-platform FDI involves the exports of commodities or intermediates from the target country to countries other than the investor's country.

What type of foreign investment is prevalent in the case of FLA in Africa? Available FLA data do not provide us with information about the trade of firms investing in land abroad. Nevertheless, there are good reasons to believe that foreign investors producing agricultural products in African countries then import the harvested crops to the home country. Empirical studies seem to support this hypothesis, albeit indirectly. They have shown that the main driver of FLA is the difference in natural resources endowment (e.g. Arezki et al., 2015; Raimondi and Scoppola, 2018). A large part of FLA originates from developed countries where land and/or water is relatively scarce, and it is directed toward developing countries abundant in natural resources. Natural resources-oriented investments are aimed, by and large, at making raw materials available in the country of origin. Hence, our first hypothesis is that foreign firms acquire land and water abroad to produce agricultural products, which are then sold on their domestic market. Case studies have reported many examples of this vertical-type FLA in African countries, where foreign firms typically produce export crops (FAO, 2013). However, the global organization of multinational firms is becoming increasingly complex, as underlined in the literature on global value chains (e.g. World Bank, 2020). Production processes are often globally fragmented with different stages of production located in different countries. If this is the case, agricultural raw materials produced in African countries could, in theory, be exported to third countries where they are processed, before being shipped back home. Thus, we cannot exclude a priori the presence of export-platform FDI in the agrifood global value chains as well.

Summing up, the first hypothesis to be tested is whether FLA do actually increase the exports of African countries, either in the direction of the investor's country (vertical FDI) or to third countries (export-platform FDI). Second, we will check whether FLA increase VW exports – the green and blue components - of African countries; finally, we check if these impacts depend upon the investor's country of origin.

3. Empirical model and econometric issues

To investigate these issues, we use the gravity model which has been widely employed to explain international trade flows. Just as the gravitational attraction is proportional to the product of the masses and diminishes with the distance, trade between two countries is proportional to their economic size and decreases with distance or, more generally, with the degree of accessibility of a foreign market to producers from a certain country; besides geographical distance, market accessibility depends also from trade policies and cultural affinity due, for instance, to a common language or to past colonial relationships. The standard gravity equation commonly estimated is:

$$X_{ij} = \delta_0 (Y_i)^{\delta_1} (Y_j)^{\delta_2} (Z_{ij})^{\delta_3} (T_{ij})^{\delta_4} \varepsilon_{ij} \quad (1)$$

where X_{ij} is the trade flow to country i from country j; Y_i (Y_j) is the economic size generally measured by the nominal gross domestic product and by population size; Z_{ij} is the degree of accessibility of market j by producers from i, T_{ij} are the trade policies and ε_{ij} is the error term.

A number of studies used the gravity model to empirically explain VWT (Fracasso, 2014; Tamea et al., 2014; Fracasso et al., 2016; Duarte et al., 2019); they included, besides the common gravity and policy variables, measurements of relative water and land endowments and found, by and large, that they exert a positive and significant impact on

[3] Following the relevant literature (Lay and Nolte, 2017; Raimondi and Scoppola, 2018; Arezki et al., 2015) we here consider FLA as a type of FDI. Indeed, it is widely held that because of the long-term duration of the lease and the frequent commitments of foreign firms making investments, this type of arrangement is equivalent to FDI.

VWT.[4] None of these studies consider as a possible driver of VWT foreign investments in agriculture, which is instead our main variable of interest.

Rewriting eq. (1) in logarithmic form, introducing the time dimension, as well as the specific determinants of VWT, the basic empirical model can be expressed as:

$$\ln X_{ij,t} = \delta_0 + \delta_1 lnY_{i,t} + \delta_2 \ln Y_{j,t} + \delta_3 Z_{ij} + \delta_4 \ln T_{ij,t} + \delta_5 FLA_{ij,t-1} + \delta_6 \ln W_{i,t} + \delta_7 \ln W_{j,t} + \upsilon_{ij} \quad (2)$$

where $FLA_{ij,\ t-1}$ is a measure of FLA in country i by firms originating from country j in the year (*t-1)*; indeed, as the potential impact of land acquisitions on countries exports requires at least one production season, we lag the FLA variable by one year. $W_{i,t}$ ($W_{j,t}$) is country's i (j) endowment in land and water.

The economic size of countries ($Y_{i,t}/Y_{j,t}$) is expected to positively influence trade. Among factors influencing market accessibility (Z_{ij}), geographical distance is expected to negatively influence trade while the opposite holds for cultural affinity, which has been found to positively influence trade. As for trade policies ($T_{ij,t}$), tariffs are expected to negatively influence trade, while Regional Trade Agreements exert a positive effect. Finally, we expect that land and water endowment of countries positively influence their agricultural exports, and negatively their agricultural imports.

3.1. The dynamic gravity equation

Previous studies using a gravity model to explain VWT have used cross-section (e.g. Fracasso, 2014) or panel data (Tamea et al., 2014; Duarte et al., 2019) and a static specification. Here we shall use a dynamic panel gravity model. The main reason is that a dynamic model takes into account the likely persistency of the dependent variable (exports). Indeed, the literature has shown that the stock of capital that firms have invested in the form of marketing and distribution networks, brand-name loyalty and so forth, to sell their product abroad, live on for many years thereafter. As a consequence, trading partner countries tend to be somewhat resistant to change, possibly due to sunk costs, and the current realizations of the dependent variable may be influenced by previous ones (Roodman, 2009).[5]

The introduction of dynamics raises econometric problems when the time span of the panel is short, as is the case with our application. Indeed, the correlation between the lagged dependent variable and the transformed error term renders the OLS with fixed effect estimator biased and inconsistent in panels with large cross-sections and short time series. To avoid this inconsistency, Arellano and Bond (1991) proposed a Generalized Method of Moments (GMM) estimator as an alternative to OLS. They suggested transforming the model into a two-step procedure based on first difference to eliminate the fixed effects, as a first step. In the second step, the lagged dependent variable is instrumented using the two-period lagged differences (or two-period lagged level) of the dependent variable.[6]

Further, a GMM dynamic panel specification appears better equipped to deal with the likely endogeneity bias of our estimations. Unlike previous studies, we include FLA as an independent variable and this increases the risk of endogeneity bias, mostly because of simultaneity. We cannot exclude the possibility that FLA are partly determined by the amount of trade between countries, as investors may be more attracted by a certain location, because of already existing (trade) relationships. Well-established relations between countries may reduce, among other aspects, the fixed costs of investing abroad. If this is the case, the explanatory variable, FLA, is correlated with the error term and estimates may be biased and inconsistent. Further, we cannot exclude selection bias due to omitted variables or measurement errors.

The System Generalized Method of Moment (SYS-GMM) estimator proposed by Blundell and Bond (1998) addresses the issue of endogeneity in panel data and provides consistent results in the presence of different sources of endogeneity.[7] The SYS-GMM supplements the equations in first differences with equation in levels. In particular, the SYS-GMM estimator utilizes instruments in level for the first-differenced equation and first-differenced instruments for the equation in levels. Following the Blundell and Bond system equations, our benchmark equations are:

$$\begin{aligned} d\ \ln\ X_{ij,t} &= \beta_0 + \beta_1 d\ \ln X_{ij,t-1} + \beta_2 d\ FLA_{ji,t-1} \\ &\quad + \beta_3 d\ \ln\ Y_{j,t} + \beta_4 d\ \ln\ Y_{i,t} \\ &\quad + \beta_5 d\ \ln\ W_{j,t} + \beta_6 d\ \ln\ W_{i,t} \\ &\quad + \beta_7 d\ \ln\ t_{ji,t} + \beta_8 d\ RTA_{ij,t} + \alpha_t + \varepsilon_{ij,t} \\ \ln\ X_{ij,t} &= \beta_0 + \beta_1 \ln X_{ij,t-1} + \beta_2 FLA_{ji,t-1} + \beta_3\ \ln\ Y_{j,t} \\ &\quad + \beta_4\ \ln\ Y_{i,t} + \beta_5 \ln\ W_{j,t} + \beta_6 \ln\ W_{i,t} \\ &\quad + \beta_7 \ln\ t_{ji,t} + \beta_8 RTA_{ij,t} + \beta_9 Z_{ij} + \alpha_t + \varepsilon_{ij,t} \end{aligned} \quad (3)$$

where d denotes the first differences, $X_{ij,\ t}$ are the exports of the African country i to country j at time t, $FLA_{ji,\ t-1}$ is the number of contracts signed by firms originating from country j in the African country i at time *t-1*[8]; $Y_{j,\ t}$ ($Y_{i,\ t}$) and $W_{j,\ t}$ ($W_{i,\ t}$) are matrixes of time-varying country variables and include measures of the countries' economic size and factor endowments, respectively. More specifically, we include GDP and population as economic size and, following previous literature (e.g. Duarte et al., 2019; Fracasso, 2014), measurements of water and land endowments; $t_{ji,\ t}$ is the tariff applied by country j to the export of the agri-food products from the African country i in year t; $RTA_{ij,\ t}$ is a dummy equal to 1 if there is a Regional Trade Agreement between i and j in year t, and zero otherwise; Z_{ij} is a vector of gravity covariates including the geographical distance between countries, and two dummies equal to one if countries share a common language, or have previous colonial relationships, and zero otherwise Finally, α_t are year dummies accounting for any shock that affects trade flows in a particular year.

Following Martınez-Zarzoso et al. (2009), we consider that, by including lagged bilateral exports in the right-hand side of the equation, we are able to control for the time-varying components of the multilateral resistance term. Consequently, neither time-varying exporter dummies nor other explicit fixed effect dummies are included in the GMM regressions.

A positive and significant β_2 suggests that bilateral FLA (from j to i) increases bilateral exports (from i to j). This is consistent with the existence of “pure” vertical-FDI.

However, as mentioned in Section 2, we cannot exclude a different kind of foreign investment, that is the export-platform type. In that

[4] A comprehensive review of the literature modelling the drivers of VWT is included in D'Odorico et al. (2019).

[5] Because VWT is computed by multiplying exports volume by crop and country-specific water content coefficients (see section 4), persistency of exports implies persistency also of the VWT variable. While many papers have used dynamic gravity models of trade, to the best of our knowledge, this is the first paper to use a dynamic gravity framework to explain VWT.

[6] It is worth noting that System GMM is preferred to difference GMM when the dependent variable is persistent and when the series are stationary. To check for stationarity of our dependent variables, we use Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) unit root tests for panel data. The results, not reported but available upon request, confirm that the null hypothesis is rejected for all series and that each time series (or fraction of series) is stationary.

[7] Blundell and Bond (1998) have shown that, with highly persistent data and short panel (along the time dimension), as in the case of bilateral exports flows and of our dataset specifically, the GMM estimator proposed by Arellano and Bond (1991) may suffer marked small sample bias due to weak instruments.

[8] Due to the high number of zeros in bilateral FLA, we are forced to include the variable in level, as the log of zero is undetermined and the use of log (1 + FLA) could bias the results. Consequently, the estimated coefficient for the FLA is interpreted as a semi-elasticity.

case, a bilateral flow of FLA from *j* to *i* does not necessarily increase bilateral exports from *i* to *j*, in that products are exported mainly toward countries other than *j*. In order to capture the impact of FLA even with export-platform FLA, we estimate a second equation where FLA are aggregated by target country. A positive and significant FLA coefficient suggests that an increase in (total) FLA received by (target) countries ($FLA_{i,\ t-1}$) causes an increase in its bilateral exports; this may well reflect the fact that target countries serve as export-platform.

Hence, our second equations system is the following:

$$\begin{aligned} d\ \ln X_{ij,t} &= \gamma_0 + \gamma_1 d\ \ln X_{ij,t-1} + \gamma_2 d\ FLA_{i,t-1} \\ &\quad + \gamma_3 d\ \ln Y_{j,t} + \gamma_4 d\ \ln Y_{i,t} \\ &\quad + \gamma_5 d\ \ln W_{j,t} + \gamma_6 d\ \ln W_{i,t} \\ &\quad + \gamma_7 d\ \ln t_{ji,t} + \gamma_8 d\ RTA_{ij,t} + \alpha_t + \varepsilon_{ij,t} \\ \ln X_{ij,t} &= \gamma_0 + \gamma_1 \ln X_{ij,t-1} + \gamma_2 FLA_{i,t-1} + \gamma_3 \ln Y_{j,t} \\ &\quad + \gamma_4 \ln Y_{i,t} + \gamma_5 \ln W_{j,t} + \gamma_6 \ln W_{i,t} \\ &\quad + \gamma_7 \ln t_{ji,t} + \gamma_8 RTA_{ij,t} + \gamma_9 Z_{ji,t} + \alpha_t + \varepsilon_{ij,t} \end{aligned} \tag{4}$$

We estimate equations systems (3) and (4) by first considering the volume of exports as the dependent variable. Then, to estimate the impact of FLA on the VWT and on its components, we use as dependent variable the total VWT (virtual water trade), and its blue and green components. In the latter estimations, a positive β_2 (γ_2 in model 4) suggests that FLA increases the African countries export of water intensive products.

Finally, to check whether the impact of FLA depends upon the characteristics of the investor area of origin, we estimate systems (3) and (4) by distinguishing six world regions, as defined by the World Bank.[9] Specifically, we estimate system (3) by interacting the number of contracts originating from country *j,* in the African country *i* at time *t-1,* with a (geographic) regional dummy equal to one when the investor country *j* belongs to that region, and zero otherwise. We estimate system (4) using the FLA aggregated by target country but distinguishing investor countries by region.

4. Data

Our panel dataset includes 14 years (2000–2013), 45 African countries, and 158 importers.

Bilateral trade data on agri-food products at the HS 6-digit level are drawn from BACI database (Base pour l'Analyse du Commerce International) of CEPII (Centre d'Etudes Prospectives et d'Informations Internationales). These data allow us to correct, with a rigorous procedure, the potential discrepancies between import values, expressed as CIF, and export values, expressed as FOB (Gaulier and Zignago, 2010). Although this problem is not serious when trade between developed countries is considered, it becomes so when using bilateral trade data of African countries.

To measure the total VWT and its green and blue components, we multiply the 'water footprint' (WFP) or "virtual water content" of crops (and derived products) provided by Mekonnen and Hoekstra (2011) by the respective volume of bilateral export, from BACI.[10] The WFP, expressed in water volume per unit of product (usually m3/ton), is the sum of the water footprint of the various production stages of each product. The indicator of direct and indirect appropriation of "freshwater resources" includes consumptive water use (the green and blue WFP) (Mekonnen and Hoekstra, 2011). The WFP database is product and country-specific and reports the global average over the period 1996–2005 for 146 primary crops, more than two hundred derived products, and 191 countries.

Commodities with relatively large WFP are coffee, tea, cocoa, tobacco, spices, nuts, rubber and fibres (Mekonnen and Hoekstra, 2011). Specifically, among the 267 HS 6-digit products exported by African countries during the analysed period, ten products account for half of the total volume exported in the period 2009–2013, and seven of these top ten products show values of green WFP well above the median/average.[11] Two of these products, Cocoa Beans and Cashew Nuts, are particularly significant in terms of (green) virtual water exported by African countries, with green WFP more than ten times higher than the median value of the 267 products used, and, jointly, represent more than 10% of the exported volumes. In term of blue virtual water trade, among the 242 exported products having blue WFP above zero, raw and refined sugar (sugarcane) and rice (broken, semi-milled or wholly milled) show blue WFP above the median (particularly rice) and account by 17% and 10%, respectively, of the total blue VW exported by African countries during the period 2009–2013.

Some studies assume product WFP to be constant over time (i.e. Shi et al., 2014). However, time-constant WFP do not capture the likely impact of yield trends (as well as of climate changes) on the WFP of agricultural trade (Tuninetti et al., 2017). There is no consensus on the methodological approach to calculate time-varying WFP. A number of studies consider the changes in the variables influencing the WFP of crops over the period; thus, improvements in irrigation techniques, variations in the crop mix, the growing use of fertilizers and pesticides, or changes in yields over time are used to calculate a long-term WFP (Duarte et al., 2016).

Here we follow the simple approach that ascribes the time variability of WFP only to yield trends (Konar et al., 2012; Dalin et al., 2012).[12] In line with this approach, crop WFP of a country in year *t* is driven by crop yield variations, while keeping evapotranspiration constant with the average value of our reference period (1996–2005).[13] Thus, the time-averaged crop $\overline{WFP}$ is scaled with yield variations:

$$WFP_{ik,t} = \overline{WFP}_{ik,T} * \frac{\overline{Yield}_{ik,T}}{Yield_{ik,t}} \tag{5}$$

where the subscripts *i*, *k*, *T*, and *t* correspond to the country of production (and export), the crop, the average period, and year, respectively.[14]

The correspondence between WFP and exported products is worked at the HS 6-digit level. Then, we aggregated the bilateral-product-time data of exports and VWT at the exporter-importer-time level.[15]

GDPs and population data come from the World Bank's Development Indicators (WDI), as well as Land Endowment, computed as the share of agricultural land (WDI-Agricultural land in sq. km) over total land (WDI-Land area in sq. km). For Water Endowment we use annual

[9] See Table A2 in Appendix.

[10] Other studies quantify the water consumption in agriculture (i.e. Schmitz et al., 2013); nevertheless, we chose to use the Mekonnen and Hoekstra (2011) dataset given the large sample of agricultural products and countries covered.

[11] In detail, these ten HS 6-digit products, listed in order of export volume, are: Cocoa Beans, Oil Seeds and Oleaginous fruits, Oranges, Maize, Raw Sugarcane, Refined Sugar, Cashew Nuts, Palm oil, Sesame Seeds, Bananas. Among these, the seven products with green WFP above the median are: Cocoa Beans, Oil Seeds and Oleaginous Fruits, Maize, Cashew Nuts, Palm Oil, Sesame Seeds, Bananas; the three products with blue WFP above the median are: Oil Seeds and Oleaginous Fruits, Refined Sugar, Sesame Seeds.

[12] Tuninetti et al. (2017) have shown that the WFP changes over time are mainly driven by yield trends, while evapotranspiration plays a minor role. This confirms the suitability of the followed approach, called 'Fast Track', enabling a simple, yet appropriate, evaluation of time-varying crop WFP.

[13] Crop yield time-series data are available at the FAOSTAT database.

[14] For a number of processed products there is no yield data and the WFP is kept constant at 1995–2006 average values.

[15] It is worth noting that the detailed WFP data here used refer to the (average) period 1996–2005 and (till now) no more recent estimates exist (Mekonnen and Leenes, 2020). Thus, because the WFPs are estimated around the year 2000 and may change significantly over time, using these WFP data to measure virtual water trade of the period 2000-appears to limit potential biases in measurement.

data on renewable water resources per inhabitant from the Aquastat FAO database. Computed on a yearly basis, it reports both surface water and groundwater generated through the hydrological cycle, divided by population.

Bilateral time invariant country variables (distances) and dummies (common language and colonial relationship) are from CEPII database. RTA, obtained from the transcription of the list of regional trade agreements available on the WTO, is also from CEPII database. Tariffs are from TRAINS. The HS 6-digit tariff data are then averaged to a simple mean of agri-food bilateral tariffs.

Data on FLA are sourced from Land Matrix. More specifically, we draw our analysis on the version of Land Matrix used by Raimondi and Scoppola (2018) which has the advantage of reporting data whose source has been verified; this reduces the shortcomings of using unofficial and unverified data.[16] By using the investor-country origin and the target-country destination information reported by the Land Matrix dataset, the number of contracts has been aggregated at the country level and cumulated over the analysed period. The final (bilateral) country level dataset includes the stock of African FLA, from one investor country to one target country. Specifically, 28 out of the 45 African countries host FLA, originating from 38 out of the 158 importing countries included in our dataset.[17]

A preliminary glance at our data reveals that the amount of land deals in Africa has started to grow in the early 2000, but it is only after 2007 that the rate of growth rapidly increased up to 2013–2014; during these six years, the number of contracts increased threefold (Fig. 1), while in the most recent years the rate of growth has importantly reduced.

Four countries, Ethiopia, Mozambique, Ghana and Tanzania, in 2013 accounted for more than 50% of contracts and for about 30% of the hectares acquired; further, in the period 2011–2013, these countries accounted for the 27% of total volume of agri-food exports, and for the 34% of the total VW exported by Africa.

Fig. 2 reports the share of African exports and FLA by importing/investing regions. More than 40% of contracts involve foreign firms from Europe and Central Asia, a region that also accounts for more than 45% of agri-food imports and of green VW African exports. Although the blue component of VWT represents a small share of the water used by African export-crops (6%), the figure highlights that almost half of blue water is imported from the two driest regions, that is, MENA and Sub-Saharan Africa. This may also depend on the fact that about half of the VW imports of these two regions come from one African country, Egypt, whose agriculture is highly dependent upon irrigation.

Finally, Fig. 3 shows the pattern of total agri-food exports, VW exports and the number of contracts during the period 2003–2013. In line with our expectations Fig. 3 reveals a positive correlation between FLA and African exports that seems to hold also for the Virtual Water content of exports. These simple correlations, therefore, confirm the importance of empirically checking the role played by FLAs in determining the trade and VWT of African countries.

5. Results and discussion

Results of our estimations of models (3) and (4) are reported in Tables 1 and 2, respectively.

We note, first, that the lagged dependent variable turns out to be significant at the 1% level across all our estimations. Further, the size of the estimated coefficient of the lagged dependent variable is, by and large, high: a 1% increase in the volume of previous exports increases exports in short-run by an amount ranging from 41% to 77%. Overall, this confirms the importance of previous exports in determining current trade, and the overall appropriateness of using a dynamic specification.

Second, the impact of gravity variables is in most cases the expected one. Distance exerts a significant negative effect across all estimations, while the coefficients of the variables "common language" and "colonial relationship" positively influence trade even if, in a number of estimations, the coefficients are not significant.

Third, as for the other control variables, the coefficient of the GDP and population variables, mostly significant across our estimations, shows the expected positive sign. As for the trade policy variables, membership of an RTA, as expected, positively affects exports in all but one of our estimations. Conversely, the coefficient of average tariffs, albeit of expected size, is not significant in a number of estimations. This is probably due to the low level of tariffs faced by African countries when they export toward developed countries, which account for a large part of their exports.

The water endowment variable is significant and with the expected sign across most of our estimations. Indeed, per capita water endowment of African countries positively affects their total and VW exports; conversely, per capita water endowment of the investing country negatively affects their imports from Africa. These results confirm previous studies on VWT on the role of water endowment in determining VW flows: water rich countries exports (import) more (less) agricultural products and virtual water. One apparently counterintuitive result is the (significant) negative sign of the coefficient of water endowment of African countries, when the dependent variable is virtual blue water (Column 4, Tables 1 and 2). Indeed, this - rather robust - result suggests that the higher the water endowment, the lower are blue water exports. This puzzling result may be driven by the fact that two countries, Egypt and South Africa, account for more than 50% of blue VW exports and their water endowment is well below the median of African countries.

Turning to the land endowment of African countries, this significantly and positively influences their total and VW exports, while land endowment of investing countries does not exert any influence on their imports from African countries. We note again that the coefficient of the land endowment variable of African countries tends to be significant and negative when the dependent variable is blue water exports, in both models. Again, the role played by a small number of countries may explain this result, which would lead to the counterintuitive conclusion that the more African countries are abundant in natural resources, the less they export blue water intensive products.

Fourth, our checks of autocorrelation of the residuals and of the validity of the instrumental variables are reported in the bottom of all Tables. The number of instruments never exceeds the number of groups, as suggested by Roodman (2009). The Arellano–Bond test (AR) for autocorrelation shows that we cannot reject serial correlation up to the third order.[18] Finally, the Hansen test and the difference-in-Hansen test confirm that in all cases our set of instruments is valid, and that the use of lagged levels of the dependent variable as instruments for the first-differenced model is correct.[19]

Turning to the main variable of interest, that is FLA, Tables 1 and 2 show that exports from African countries are significantly and positively affected by FLA. Indeed, this impact is marked when bilateral FLA is used (model 3, Table 1): one more contract increases the volume of exports toward the investor country by 9% on average in the short

[16] The Land Matrix Global Observatory is a database compiled by NGOs and research institutes coordinated by the International Land Coalition (Anseeuw et al., 2012). Raimondi and Scoppola (2018) have verified the source for each deal downloaded from Land Matrix in October 2015; hence, these data cover the period 2000–2013.

[17] The list of investor and target countries included in the dataset is reported in Appendix (Tables A1 and A2). The total number of FLAs in African countries at the end of year 2013 amounts to 316 deals.

[18] Thus, we use deeper lags and report the AR(3) p-value in tables.

[19] Indeed, as the Arellano-Bond AR(2) test does not reject the null hypothesis of no second-order serial correlation of the first-differenced errors, then the difference-in-Hansen test for the level instruments is informative because it helps to evaluate whether the Blundell-Bond mean stationarity assumption might be violated.

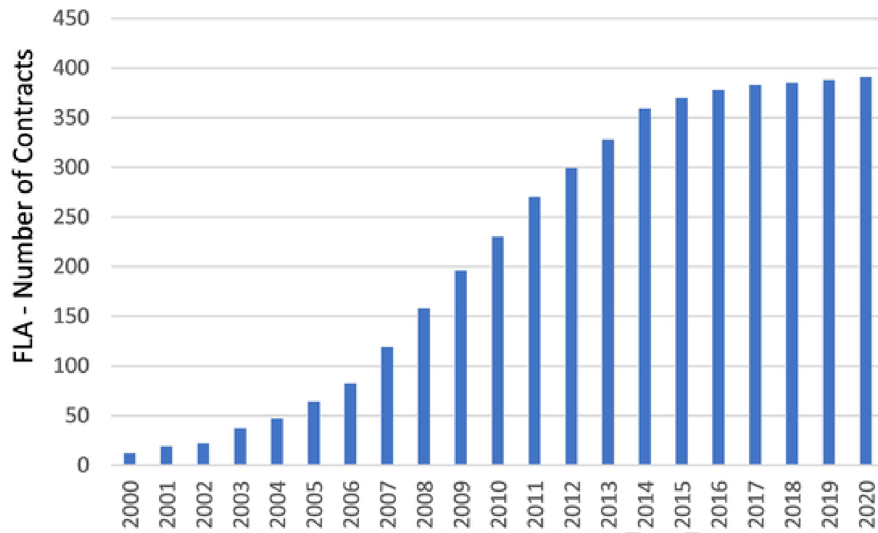

Fig. 1. FLAs in African Countries.
(Source: Authors' analysis based on Land Matrix data (see text).)

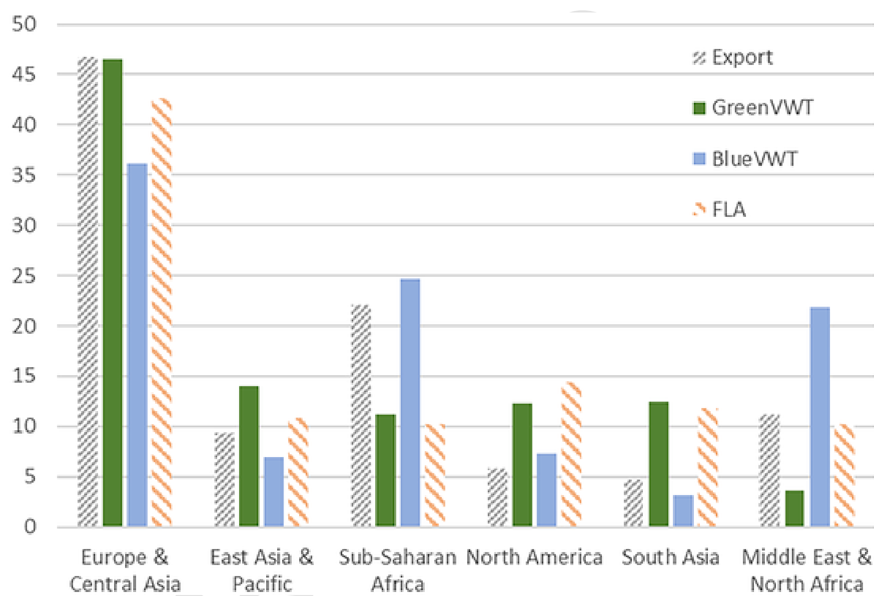

Fig. 2. – Share of African exports, VWT and FLA by importing/investor regions.
(Source: Authors' analysis based on data described in the text.)Notes: Exports and virtual water trade (VWT) refers to average volume exported during the period 2009–2013; foreign land acquisition (FLA) refers to the total number of contracts in year 2013.

run, and by more than 39% in the long run.[20] Conversely, one more contract increases the volume of exports by about 0.6% (about 2.6% in the long run), when we estimate model 4 (Table 2). Our estimations are, in theory, consistent with both the existence of "pure" vertical and export-platform FLA, as the coefficients of the FLA variable are positive and significant in both estimations. However, the size of the coefficient is definitely higher when we use bilateral FLA. Model (3) captures the effect of bilateral FLA on bilateral exports which, on the contrary, is ignored in model (4). Hence, our results seem to confirm that new FLA generates more exports from African countries to the investor country, thereby confirming the prevalence of pure vertical-FDI.

Columns 2 to 4 of the Tables report results when the dependent variable is the VWT and its two components (green and blue). The number of contracts positively and significantly influences VWT. The findings confirm that the increase of one contract increases the overall water content of exports by 14% in model (3) and by 1% in model (4) (see Column 2, Tables 1 and 2). Again, when we use bilateral FLA, we obtain high and significant coefficients across all estimations for the two VWT components. The findings suggest that, in the short run, one more contract increases the green virtual water exports by 19.8% and the blue by 25% (see Columns 3 and 4, Table 1). Hence, new African land acquisitions, by changing the product composition of exports, may well lead to a significant increase in the water- both green and blue- content of exports. Our ex-post estimates are hardly directly comparable with the ex-ante assessments by previous studies, providing the different approach

[20] The long run effect of FLA is measured as: β_2 / (1- β_1), where β_2 and β_1 are the FLA and the lagged dependent variable estimated coefficient (0.09/(1–0.76)) = 0.39 (see column 1, Table 1).

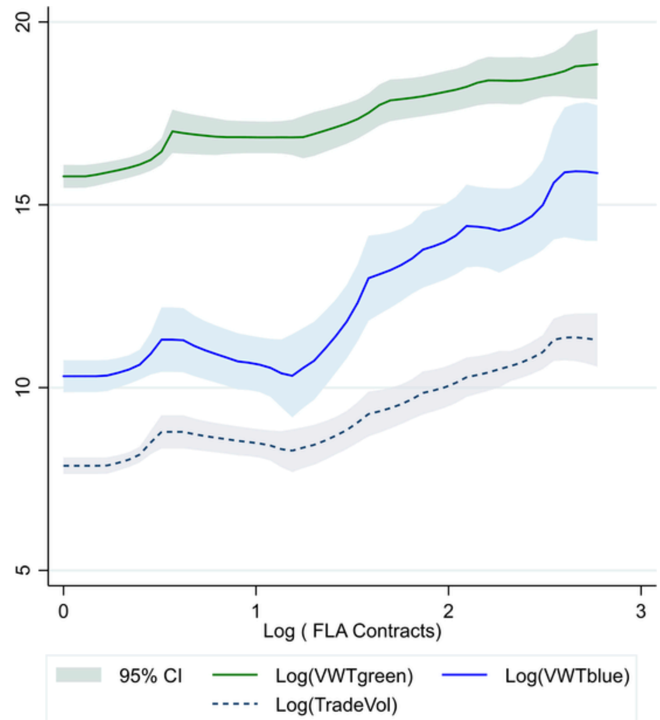

Fig. 3. African agri-food exports, VW exports and FLA.
(Source: Authors' analysis based on data described in the text.)Notes: The figure shows the relation between the (smoothed) average exports (Volume/ Green VWT/ Blue VWT) and FLA and their 95% confidence interval (computed using Stata's command for local polynomial smooth plots with CIs lpolyci).

and data here used[21]; nevertheless, two issues deserve attention. The first is that our results confirm one of the key messages from previous studies, that is, the "sizable" impact of FLA on the water use in Africa. The second is that the impact on the green and blue water components may be rather different. In our results, this impact turns out to be higher for blue water; this heavy consumption of blue water is more likely to generate negative effects in the target country, in terms of dispossessing local communities from water resources. Thus, our findings would seem to confirm the concern of potential water grabbing in Africa.

To check for robustness, we run estimations of eq. (3) for total VWT by using different specifications; findings, reported in Table A3 of the Appendix, show that FLA impact on VWT does not change in sign and significance when our explanatory variables are changed.[22] Finally, we also check for potential bias due to GDP endogeneity. Indeed, as emphasized by the gravity model literature, one of the biggest challenges is to obtain reliable estimates of the effects of trade policy, in that the trade policy variables are endogenous. Trade barriers imposed at time (t - 1) might have an impact on trade volumes at time t and these barriers also impact capital accumulation in (t - 1), which changes country size (GDP) (Olivero and Yotov, 2012). To check if this possible endogeneity of GDP could bias the estimated FLA coefficients, we estimated Table 1 equations treating also GDP as endogenous. The results (reported in Table A4 of the Appendix) show that the magnitude and the

Table 1
Impact of bilateral FLA on exports and on virtual water trade of African Countries

FLA - Number of contracts				
Dependent variable	Log(Trade Volume)	Log(VWT)	Log (GreenWT)	Log (BlueWT)
	(1)	(2)	(3)	(4)
FLA (ji, t-1)	0.0940***	0.1388***	0.1976***	0.2546***
	(0.0305)	(0.0422)	(0.0542)	(0.0556)
LogGDP (j, t)	0.0988***	0.1735***	0.2477***	0.2946***
	(0.0282)	(0.0412)	(0.0574)	(0.0628)
LogGDP (i, t)	0.0834***	0.1279***	0.1490***	0.1293***
	(0.0279)	(0.0399)	(0.0438)	(0.0405)
LogPOP (j, t)	0.0943***	0.2049***	0.2949***	0.0769*
	(0.0259)	(0.0425)	(0.0565)	(0.0448)
LogPOP (i, t)	0.1026***	0.2299***	0.4492***	−0.0074
	(0.0291)	(0.0495)	(0.0825)	(0.0408)
LogLand (j, t)	0.0243	−0.0047	0.0498	0.0042
	(0.0196)	(0.0299)	(0.0504)	(0.0407)
LogLand (i, t)	0.0326	0.1763***	0.4884***	−0.1442***
	(0.0218)	(0.0444)	(0.0812)	(0.0369)
LogWater (j, t)	−0.0465***	−0.0676***	−0.1161***	−0.0394**
	(0.0110)	(0.0158)	(0.0251)	(0.0183)
LogWater (i, t)	0.0187	0.1643***	0.4364***	−0.3483***
	(0.0148)	(0.0368)	(0.0705)	(0.0694)
LogDistance (ij)	−0.2390***	−0.3750***	−0.4394***	−0.2116***
	(0.0618)	(0.0863)	(0.0978)	(0.0720)
Common Language (ij)	0.1156**	0.1358**	0.2435**	0.0975
	(0.0454)	(0.0642)	(0.0997)	(0.0877)
Common Colonizer (ij)	0.0437	0.1593*	0.3265***	−0.0240
	(0.0520)	(0.0831)	(0.1260)	(0.1167)
Tariff (ij, t)	−0.5034	−1.1821*	−1.2855*	−0.2408
	(0.4937)	(0.6750)	(0.7505)	(0.9801)
RTA (ij, t)	0.1973***	0.2704***	0.4177***	0.5091***
	(0.0579)	(0.0766)	(0.1052)	(0.1221)
Dependent variable (ij, t-1)	0.7579***	0.6314***	0.5284***	0.7088***
	(0.0522)	(0.0656)	(0.0658)	(0.0497)
Obs.	18,662	18,662	18,662	18,662
No. Groups	2392	2392	2392	2392
No. Instruments	208	208	208	208
AR(3)	0.394	0.699	0.397	0.327
Hansen p-value	0.792	0.712	0.707	0.742
diff-in Hansen p-value	0.953	0.899	0.832	0.779

direction of FLA impacts on VWT do not change, although the estimated GDP impact become not significant.

These results may be the (average) outcome of different patterns. One important feature in analysing the effect of FLA on water consumption which has been emphasized by previous studies is their origin (Breu et al., 2016). In our dataset, most of investors are from Europe[23] and North America (accounting for about 60% of world contracts involving African countries), although a not inconsiderable share originates from other regions. The motives for FLA – and, accordingly, the prevalent type of FLA - could differ depending upon the characteristics of the investor's area of origin. It is clear that regions very poor in water and/or land (such as the Middle East or Sub-Saharan African countries) are likely to make vertical FDI. Indeed, FLA are mostly driven by the need to ensure direct access (and control) over food production. These types of FLA generate a flow of exports back to the country of origin, which is likely to include products highly intensive in the use of water, given that water is their scarce resource. On the other hand, firms from developed countries well-endowed in water and land may have different reasons for embarking on FLA, hence their investments do not nec-

[21] One reason is the different perspective which is used in this paper with respect to previous studies. Indeed, to the best of our knowledge, this is the first econometric assessment of the impact of FLA on trade and on its virtual water content; previous studies, by combining data on the amount of land acquired with hydroclimatic indicators, computed the "potential" water content associated with the agricultural production in the land acquired by foreign investors (e.g. Rulli and D'Odorico, 2013; Breu et al., 2016; Dell'Angelo et al., 2018).

[22] Note that, although the short run effect of FLA appears barely affected by the introduction of our explanatory variables, the long run effect is clearly reduced.

[23] It is worth noting that Europe here includes central Asia and Russia.

Table 2
Impact of total FLA on exports and on virtual water trade of African Countries.

FLA - Number of contracts				
Dependent variable	Log(Trade Volume)	Log(VWT)	Log (GreenWT)	Log (BlueWT)
	(1)	(2)	(3)	(4)
FLA (i, t-1)	0.0058**	0.0096***	0.0150***	0.0102**
	(0.0026)	(0.0031)	(0.0042)	(0.0043)
LogGDP (j, t)	0.1461***	0.2842***	0.3285***	0.3371***
	(0.0515)	(0.0725)	(0.0905)	(0.1044)
LogGDP (i, t)	−0.0300	0.0678	0.1622	0.1567*
	(0.0550)	(0.0755)	(0.1056)	(0.0930)
LogPOP (j, t)	0.2142***	0.3767***	0.3992***	0.0703
	(0.0786)	(0.1067)	(0.1295)	(0.1093)
LogPOP (i, t)	0.0696**	0.2475***	0.5101***	−0.0302
	(0.0311)	(0.0575)	(0.1055)	(0.0520)
LogLand (j, t)	0.0146	−0.0104	0.0559	0.0351
	(0.0213)	(0.0347)	(0.0598)	(0.0452)
LogLand (i, t)	0.0304	0.2354***	0.6125***	−0.1652***
	(0.0250)	(0.0563)	(0.1095)	(0.0469)
LogWater (j, t)	−0.0538***	−0.0897***	−0.1347***	−0.0420**
	(0.0144)	(0.0208)	(0.0311)	(0.0214)
LogWater (i, t)	−0.0036	0.1834***	0.5129***	−0.3947***
	(0.0173)	(0.0437)	(0.0957)	(0.1005)
LogDistance (ij)	−0.1617**	−0.4469***	−0.5557***	−0.2505**
	(0.0651)	(0.1063)	(0.1348)	(0.0994)
Common Language (ij)	0.1492**	0.2373***	0.4697***	0.1368
	(0.0587)	(0.0838)	(0.1355)	(0.0992)
Common Colonizer (ij)	0.1308	0.2458**	0.3354**	−0.0560
	(0.0795)	(0.1175)	(0.1620)	(0.1522)
Tariff (ij, t)	−4.4752**	−5.1848*	−3.0453	−0.4577
	(2.1757)	(2.7197)	(3.3462)	(3.2427)
RTA (ij, t)	0.0718	0.2170**	0.4451***	0.5871***
	(0.0790)	(0.1082)	(0.1627)	(0.1731)
Dependent variable (ij, t-1)	0.7751***	0.5384***	0.4140***	0.6725***
	(0.0603)	(0.0809)	(0.0934)	(0.0744)
Obs.	18,662	18,662	18,662	18,662
No. Groups	2392	2392	2392	2392
No. Instruments	141	141	141	141
AR(3)	0.428	0.677	0.402	0.325
Hansen p-value	0.759	0.422	0.298	0.579
diff-in Hansen p-value	0.665	0.415	0.41	0.568

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFA and Tariff are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1.

essarily generate exports back to the home country or increase the amount of water intensive African exports.

To check the hypothesis of diverse regional patterns, we run our estimations by imposing a different impact of FLA by region.[24] Tables 3 and 4 report results from estimations of model 3 and model 4, respectively. Tables confirm our expectations, that is, the impact of FLA on total agri-food exports do vary with the region of origin of the investor.

Starting with the FLA effect on trade volume (column 1, Tables 3 and 4), one striking result is that FLA from the Americas (accounting for about the 15% of total FLA) do not influence the agri-food exports of African countries. Whatever model we use, the coefficient is never significant, in contrast with the positive and significant effect we observed in previous estimates. This suggests that FLA originating from the Americas do not follow a vertical-type or an export-platform pattern.

[24] Countries' composition for each region is reported in Table A2 of the Appendix.

Table 3
Impact of bilateral FLA on Exports and on VW Trade of African Countries by investing region.

FLA - Number of contracts				
Dependent variable	Log(Trade Volume)	Log(VWT)	Log (GreenWT)	Log (BlueWT)
	(1)	(2)	(3)	(4)
FLA (ji, t-1)*East Asia & Pacific	0.8230**	0.8033*	0.9474*	0.9320**
	(0.3291)	(0.4161)	(0.5002)	(0.4000)
FLA (ji, t-1)*Europe & Central Asia	0.1108	0.1864*	0.2433**	0.3192**
	(0.0857)	(0.0953)	(0.1081)	(0.1365)
FLA (ji, t-1)*Middle East & North Africa	0.1758**	0.1822*	0.2478**	0.2986**
	(0.0871)	(0.1031)	(0.1132)	(0.1317)
FLA (ji, t-1)* America	0.0286	0.0763	0.1717	−0.1076
	(0.0994)	(0.1248)	(0.1423)	(0.1437)
FLA (ji, t-1)*South Asia	0.1184	0.1171	0.1094	0.2804***
	(0.0935)	(0.1020)	(0.1001)	(0.1046)
FLA (ji, t-1)*Sub-Saharan Africa	0.2404**	0.1061**	0.0972**	0.4138***
	(0.1092)	(0.0450)	(0.0387)	(0.1283)
LogGDP (j, t)	0.1908***	0.2401***	0.2920***	0.5412***
	(0.0456)	(0.0546)	(0.0720)	(0.1174)
LogGDP (i, t)	0.2248***	0.1913***	0.1580**	0.0955
	(0.0483)	(0.0637)	(0.0766)	(0.0958)
LogPOP (j, t)	0.1581***	0.2868***	0.3622***	0.2404**
	(0.0588)	(0.0685)	(0.0948)	(0.1188)
LogPOP (i, t)	0.2137***	0.3221***	0.5263***	−0.0548
	(0.0473)	(0.0675)	(0.1049)	(0.0611)
LogLand (j, t)	0.0598*	−0.0002	0.0479	0.0283
	(0.0352)	(0.0395)	(0.0529)	(0.0547)
LogLand (i, t)	0.1053***	0.2729***	0.5688***	−0.1972***
	(0.0381)	(0.0563)	(0.1001)	(0.0551)
LogWater (j, t)	−0.0752***	−0.0835***	−0.1273***	−0.0627**
	(0.0178)	(0.0206)	(0.0287)	(0.0272)
LogWater (i, t)	0.0454*	0.2370***	0.5108***	−0.5504***
	(0.0258)	(0.0450)	(0.0836)	(0.1168)
LogDistance (ij)	−0.5371***	−0.5750***	−0.5351***	−0.2925***
	(0.0799)	(0.1081)	(0.1206)	(0.1085)
Common Language (ij)	0.2359***	0.2316***	0.3695***	0.2065*
	(0.0764)	(0.0852)	(0.1159)	(0.1237)
Common Colonizer (ij)	0.1127	0.1772	0.3514**	0.2142
	(0.1018)	(0.1179)	(0.1477)	(0.1715)
Tariff (ij, t)	0.1497	−1.0567	−1.4992	−5.3028
	(1.4579)	(1.7778)	(2.3943)	(3.3958)
RTA (ij, t)	0.4427***	0.3664***	0.4469***	0.6939***
	(0.1032)	(0.1122)	(0.1481)	(0.2189)
Dependent variable (ij, t-1)	0.4835***	0.4819***	0.4564***	0.5462***
	(0.0643)	(0.0726)	(0.0813)	(0.0854)
Obs.	17,656	17,656	17,656	17,656
No. Groups	2244	2244	2244	2244
No. Instruments	194	194	194	194
AR(3)	0.254	0.76	0.279	0.363
Hansen p-value	0.255	0.426	0.415	0.871
diff-in Hansen p-value	0.873	0.785	0.573	0.946

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFAs and Tariff are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1.

Second, we also note that the coefficient for Europe is positive and significant (at the 5% level) only when we use model 4 (column 1, Table 4), showing that only the aggregate European FLA increase the volume of African country exports toward European's countries. As for Europe, this may reflect the fact that European firms investing in land in Africa export the agricultural products back to Europe, even though not necessarily to the country of origin of the investment.

Table 4
Impact of regional FLA on exports and on VW trade of African Countries.

FLA - Number of contracts				
Dependent variable	Log(Trade Volume)	Log(VWT)	Log (GreenWT)	Log (BlueWT)
	(1)	(2)	(3)	(4)
FLA (ig, t-1)*East Asia & Pacific	0.1001	0.0316	−0.0092	0.2697**
	(0.0688)	(0.0844)	(0.0944)	(0.1349)
FLA (ig, t-1)*Europe & Central Asia	0.0294***	0.0295**	0.0418**	0.0186
	(0.0099)	(0.0136)	(0.0162)	(0.0185)
FLA (ig, t-1)*Middle East & North Africa	0.0491***	0.0780***	0.0877***	0.0544**
	(0.0145)	(0.0237)	(0.0254)	(0.0273)
FLA (ig, t-1)* America	−0.0124	−0.0405	0.0388	−0.1144**
	(0.0520)	(0.0695)	(0.1269)	(0.0485)
FLA (ig, t-1)*South Asia	0.0262	0.0156	0.0130	0.0777
	(0.0347)	(0.0394)	(0.0401)	(0.0852)
FLA (ig, t-1)*Sub-Saharan Africa	0.0507	0.0254	0.0165	0.1082
	(0.0337)	(0.0265)	(0.0266)	(0.0998)
LogGDP (j, t)	0.2457***	0.2781***	0.3059***	0.4021***
	(0.0452)	(0.0537)	(0.0685)	(0.0903)
LogGDP (i, t)	0.1725***	0.1947***	0.1706**	0.2255***
	(0.0438)	(0.0622)	(0.0715)	(0.0792)
LogPOP (j, t)	0.2473***	0.3454***	0.4073***	0.0748
	(0.0555)	(0.0695)	(0.0921)	(0.0869)
LogPOP (i, t)	0.1896***	0.3407***	0.5683***	0.0027
	(0.0478)	(0.0679)	(0.1058)	(0.0580)
LogLand (j, t)	0.0632*	0.0037	0.0475	0.0426
	(0.0368)	(0.0425)	(0.0543)	(0.0546)
LogLand (i, t)	0.1048***	0.2907***	0.6032***	−0.1933***
	(0.0395)	(0.0560)	(0.0977)	(0.0529)
LogWater (j, t)	−0.0850***	−0.0912***	−0.1336***	−0.0470*
	(0.0185)	(0.0213)	(0.0287)	(0.0251)
LogWater (i, t)	0.0304	0.2538***	0.5397***	−0.5158***
	(0.0275)	(0.0458)	(0.0824)	(0.1002)
LogDistance (ij)	−0.5175***	−0.6103***	−0.5633***	−0.2928***
	(0.0770)	(0.1048)	(0.1187)	(0.1036)
Common Language (ij)	0.3008***	0.2907***	0.4479***	0.1720
	(0.0790)	(0.0903)	(0.1174)	(0.1188)
Common Colonizer (ij)	0.2102**	0.2356*	0.3896***	0.0632
	(0.1069)	(0.1240)	(0.1460)	(0.1647)
Tariff (ij, t)	−2.2707*	−1.7195	−1.5624	−0.0613
	(1.3083)	(1.6637)	(2.1103)	(2.3054)
RTA (ij, t)	0.3648***	0.3738***	0.4859***	0.8426***
	(0.1016)	(0.1118)	(0.1423)	(0.1964)
Dependent variable (ij, t-1)	0.4691***	0.4353***	0.4174***	0.5776***
	(0.0589)	(0.0688)	(0.0800)	(0.0716)
Obs.	17,656	17,656	17,656	17,656
No. Groups	2244	2244	2244	2244
No. Instruments	193	193	193	193
AR(3)	0.241	0.778	0.279	0.371
Hansen p-value	0.279	0.392	0.744	0.52
diff-in Hansen p-value	0.817	0.962	0.98	0.799

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFAs and Tariff are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1

Third, for two regions relatively scarce in water and land, namely Middle East & North Africa and Sub-Saharan Africa, we find positive and significant coefficients; hence, bilateral FLA influence the volume of exports, consistently with the prevalence of vertical FDI, and in line with our expectations (see Table 3). Furthermore, for MENA countries the coefficient turns out to be significant also in model 4 (column 1, Table 4), suggesting export-platform investments as well.

Fourth, we find evidence that also FLA originating from East Asia and Pacific affect African agri-food exports back to the country of origin, suggesting vertical-type FDI (column 1, Table 3). This region includes important (developing and developed) countries relatively scarce in land and water (e.g. China and Japan), but also relatively abundant countries (such as Australia, New Zealand and Malaysia). However, 80% of contracts originate from only two countries, China and Singapore that are relatively poor in land and water.

Turning to the FLA impact on VWT by region, columns 2 to 4 of Tables 3 and 4 show a number of rather surprising results. The first is that investments from America do not affect VWT. In our estimations, the coefficient is never significant. Hence, investment in land by American firms in Africa does not increase the share of water intensive products exported by African countries. This does not seem to be the case for European investors. We find a positive and significant (at the 5% level) effect of the number of contracts on green and blue VW exports in model 3. One more contract by European investors implies, in the short-run, an increase in the African VW exports by 25%, and by 30% of green and blue water, respectively (columns 3 and 4, Table 3); the coefficients of VW flows reduce their size in Model 4 (Table 4), where the FLA effects seem limited to green VW component. Nevertheless, our findings show that European investments, unlike those originating from other developed countries such as North America, do increase the share of exported products which use water intensively, both in terms of its green and blue components.

For two regions, Sub-Saharan Africa and Middle East & North Africa, we find evidence that FLA cause an increase of both the green and blue water component of African agri-food exports (columns 3 and 4, Table 3). As mentioned, these two regions include developing countries mostly relatively scarce in land and water, whose FLAs turn out to increase the share of rainfed products as well as of irrigated products in African exports. Moreover, FLA contracts that originate from the two Asian regions, involving mainly three big investors (China, Singapore, and India), determine a significant increase of the blue VW component of exports in model 3. Finally, the blue water coefficient is significant for East Asia & the Pacific also when we run model 4 (column 4, Table 4).

6. Concluding remarks

This paper provides econometric evidence on the impact of FLA on the VW exports of African countries. Our basic idea is that because FLA in Africa are mostly export-oriented, by analysing the water content of exports we capture a large part of the effect of FLA on the use of water. Unlike previous papers investigating the determinants of VWT by means of gravity equations, we use a dynamic panel model to deal with the likely persistency of our dependent variable and overcome any problem of endogeneity bias. We check for different possible patterns of FLA ("pure" vertical or "export-platform" foreign investment) and whether the responsiveness of VWT to FLA depends upon the investor country of origin. We distinguish between the green and blue water content of exports. We address a number of methodological issues, concerning the measurement of time-varying VW flows and the panel gravity model specifications to be used to explain VWT.

Our results show, in the first place, that a great deal of the FLA in Africa involve agri-food exports to the investor's home country, confirming our main hypothesis, that is, FLA in Africa are mostly vertical-type and export-oriented. Second, we find overall empirical evidence that land deals in Africa increase the export share of water intensive products. Third, we find that FLA positively affect both components of VW exports, the green and the blue. Fourth, we find that the impact of FLA on African agri-food and VW exports varies with the origin of the investing firms. American based investments in Africa do not affect either general agri-food exports, or VW exports; FLA from Europe significantly affect both agri-food and VW exports, while FLA from other regions positively affect the blue water, implying an increase in the share of exported products, which demand large amounts of irrigated water.

Our approach differs from those used by previous studies. Indeed, while the latter compute the *potential* amount of "grabbed" water in different regions by combining data about that amount of land acquired by foreign firms with hydroclimatic, geophysical or socio-economic indicators, this is the first study providing (ex-post) econometric evidence of the *actual* impact of FLA on the water content of African exports. Our findings are more limited in scope and geographical coverage with respect to previous studies, however, they may complement available literature by providing empirical evidence about: a) the nature and reasons motivating FLA in Africa, which in previous studies were assumed: results confirm that the main reason is the need to access water and land, with the aim to export agricultural products back home; b) the positive and sizable impact of FLA on the water content of African exports; our estimations suggest, for instance, that in the short run one more acquisition by European firms increases by 25% and 30% the green and blue water content of African exports, respectively. These estimations confirm studies arguing that especially in Africa there is the potential for a large increase in water consumption due by FLA; c) the role of the blue water component which in our estimations turns out to be rather relevant, whereas in a number of previous studies, FLA potential impacts were estimated to be mainly through the green water component (e.g. Rulli and D'Odorico, 2013; Breu et al., 2016).

Our findings could also have implications on a number of debated issues. First, our (robust) evidence about the positive effect of FLA on African agri-food exports suggests that, in theory, African countries could benefit from FLA also in terms of gains from trade. This adds weight to those who consider FLA as a useful tool to foster development in Africa on the grounds that they provide an opportunity to reverse the long-term trend of under-investment in agriculture in developing countries (e.g. World Bank, 2011; FAO, 2013). Our results show that FLA could also be an important driver of exports and, hence of growth. Conversely, the second empirical finding in this paper supports the wide concerns about the risk of over-extraction leaving African small farmers and communities without water; indeed, our findings confirm that export-oriented FLA could lead to a notable intensification of consumption of blue water in particular, with potential negative social and environmental externalities.

Overall, our results may provide some support to the idea that, as regards agriculture, African countries face a trade-off between foreign investments/growth and social-environmental sustainability. However, our paper also shows that not all FLA increase water extraction to the detriment of local communities, and that this may depend, among others, upon the nature and drivers of FLA and on the country of origin of the investing firm.

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFA and Tariff are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1.

Uncited references

Dell'Angelo et al., 2017
Ito, 2013

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Appendix A. Appendix

Table A1. Exporting countries.

African Countries			
*	Angola	*	Mali
	Burundi	*	Mozambique
*	Benin		Mauritania
*	Burkina Faso	*	Mauritius
*	Central African Republic	*	Malawi
*	Cote d'Ivoire		Niger
*	Cameroon	*	Nigeria
*	Congo, Rep.	*	Rwanda
	Comoros	*	Senegal
	Cabo Verde	*	Sierra Leone
	Djibouti		Somalia
	Algeria		Sao Tome and Principe
*	Egypt, Arab Rep.		Chad
	Eritrea		Togo
*	Ethiopia	*	Tunisia
*	Gabon	*	Tanzania
*	Ghana	*	Uganda
	Gambia, The	*	South Africa
	Guinea-Bissau	*	Zambia
	Equatorial Guinea	*	Zimbabwe
*	Kenya		
*	Liberia		
	Libya		
*	Morocco		
*	Madagascar		

*Country hosting FLA.

Table A2. Importing countries.

East Asia & Pacific	Europe & Central Asia	Middle East & North Africa	America	South Asia	Sub-Saharan Africa
Australia	Albania	* United Arab Emirates	Argentina	Afghanistan	Angola
Brunei Darussalam	Armenia	Bahrain	Antigua and Barbuda	Bangladesh	Burundi
* China	* Austria	Djibouti	Bahamas, The	* India	Benin
Fiji	* Belgium	* Algeria	Bermuda	Sri Lanka	Burkina Faso
Hong Kong	Bulgaria	* Egypt, Arab Rep.	Bolivia	Maldives	Central African Rep.
Indonesia	Bosnia and Herzeg.	* Iran, Islamic Rep.	* Brazil	Nepal	* Cote d'Ivoire
* Japan	Belarus	* Israel	Barbados	* Pakistan	Cameroon
Cambodia	* Switzerland	Jordan	* Canada		Congo, Rep.
Korea, Rep.	Cyprus	Kuwait	Chile		Comoros
Lao PDR	Czech Republic	Lebanon	Colombia		Cabo Verde
Macao SAR, China	Germany	Libya	Costa Rica		Ethiopia
Myanmar	* Denmark	Morocco	Cuba		Gabon
Mongolia	* Spain	Malta	Dominican Republic		Ghana
* Malaysia	Estonia	Oman	Ecuador		Guinea
New Zealand	* Finland	Qatar	Guyana		Gambia, The
Philippines	* France	* Saudi Arabia	Honduras		* Kenya
Papua New Guinea	* United Kingdom	Tunisia	St. Kitts and Nevis		Madagascar
* Singapore	Georgia	Yemen, Rep.	St. Lucia		Mali
Thailand	Greece		Mexico		Mozambique
Vietnam	Croatia		Nicaragua		Mauritania
Vanuatu	Hungary		Panama		* Mauritius
	Ireland		Peru		Malawi
	Iceland		Paraguay		Niger
	* Italy		El Salvador		Rwanda
	Kazakhstan		Suriname		Sudan
	Kyrgyz Republic		Trinidad and Tobago		Senegal
	Latvia		Uruguay		Sierra Leone
	Moldova		* United States		Sao Tome and Princ.
	Macedonia, FYR		St. Vincent and the Gren.		Seychelles
	* Netherlands		Venezuela, RB		Togo
	* Norway				* Tanzania
	Poland				* South Africa
	Romania				Zambia
	* Russian Federation				* Zimbabwe
	Slovak Republic				
	* Sweden				
	* Turkey				
	Ukraine				

*Country originating FLA in African countries.

Table A3.

FLA - Number of contracts					
Dependent variable	Log(VWT)	Log(VWT)	Log(VWT)	Log(VWT)	Log(VWT)
	(1)	(2)	(3)	(4)	(5)
FLA (i, t-1)	0.1421**	0.1746***	0.1609***	0.1541***	0.1388***
	(0.0613)	(0.0474)	(0.0477)	(0.0461)	(0.0422)
LogGDP (j, t)		0.1827***	0.1012***	0.1111***	0.1735***
		(0.0385)	(0.0320)	(0.0330)	(0.0412)
LogGDP (i, t)		0.1920***	0.1134***	0.1165***	0.1279***
		(0.0452)	(0.0381)	(0.0394)	(0.0399)
LogPOP (j, t)			0.1924***	0.1880***	0.2049***
			(0.0427)	(0.0417)	(0.0425)
LogPOP (i, t)			0.2028***	0.2142***	0.2299***
			(0.0458)	(0.0476)	(0.0495)
LogLand (j, t)				−0.0035	−0.0047
				(0.0293)	(0.0299)
LogLand (i, t)				0.1658***	0.1763***
				(0.0438)	(0.0444)
LogWater (j, t)					−0.0676***
					(0.0158)
LogWater (i, t)					0.1643***
					(0.0368)
LogDistance (ij)		−0.3383***	−0.3203***	−0.3544***	−0.3750***
		(0.0833)	(0.0792)	(0.0847)	(0.0863)
Common Language (ij)		0.0454	0.1166*	0.1376**	0.1358**
		(0.0524)	(0.0607)	(0.0611)	(0.0642)
Common Colonizer (ij)		0.3528***	0.2425***	0.1935**	0.1593*
		(0.0929)	(0.0837)	(0.0802)	(0.0831)

FLA - Number of contracts					
Dependent variable	Log(VWT)	Log(VWT)	Log(VWT)	Log(VWT)	Log(VWT)
	(1)	(2)	(3)	(4)	(5)
Tariff (ij, t)		−0.8867	−1.1423*	−1.1213	−1.1821*
		(0.6729)	(0.6918)	(0.6871)	(0.6750)
RTA (ij, t)		0.1045*	0.2209***	0.2061***	0.2704***
		(0.0632)	(0.0723)	(0.0700)	(0.0766)
Dependent variable (ij, t-1)	0.8544***	0.7136***	0.6636***	0.6689***	0.6314***
	(0.0530)	(0.0598)	(0.0651)	(0.0638)	(0.0656)
Obs.	18,662	18,662	18,662	18,662	18,662
No. Groups	2392	2392	2392	2392	2392
No. Instruments	135	202	204	206	208
AR(3)	0.732	0.69	0.695	0.694	0.699
Hansen *p*-value	0.592	0.546	0.708	0.704	0.712
diff-in Hansen *p*-value	0.892	0.887	0.918	0.912	0.899

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFA and Tariff are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1.

Table A4. Robustness check of Table 1 results – country GDP included as endogenous variable

FLA - Number of contracts				
Dependent variable	Log(Trade Volume)	Log(VWT)	Log(GreenWT)	Log(BlueWT)
	(1)	(2)	(3)	(4)
FLA (ji, t-1)	0.0873***	0.1108***	0.1385***	0.1550***
	(0.0242)	(0.0339)	(0.0435)	(0.0414)
LogGDP (j, t)	0.0715*	0.0528	0.0217	0.0514
	(0.0373)	(0.0481)	(0.0608)	(0.0610)
LogGDP (i, t)	−0.0062	0.0530	0.0570	−0.0327
	(0.0354)	(0.0501)	(0.0645)	(0.0594)
LogPOP (j, t)	0.1412***	0.2006***	0.2311***	0.1211**
	(0.0277)	(0.0424)	(0.0575)	(0.0513)
LogPOP (i, t)	0.0790**	0.2470***	0.4419***	0.0713
	(0.0334)	(0.0502)	(0.0732)	(0.0554)
LogLand (j, t)	−0.0039	−0.0224	0.0217	−0.0173
	(0.0186)	(0.0283)	(0.0417)	(0.0317)
LogLand (i, t)	0.0196	0.1206***	0.3036***	−0.0931***
	(0.0166)	(0.0290)	(0.0481)	(0.0230)
LogWater (j, t)	−0.0416***	−0.0573***	−0.0877***	−0.0321***
	(0.0078)	(0.0118)	(0.0172)	(0.0117)
LogWater (i, t)	0.0085	0.1023***	0.2394***	−0.2239***
	(0.0155)	(0.0263)	(0.0435)	(0.0441)
LogDistance (ij)	−0.1276***	−0.2233***	−0.2076***	0.0164
	(0.0481)	(0.0647)	(0.0801)	(0.0624)
Common Language (ij)	0.1013***	0.1331***	0.1828***	0.0754
	(0.0316)	(0.0496)	(0.0698)	(0.0542)
Common Colonizer (ij)	−0.0110	0.0838	0.1628	−0.1400
	(0.0571)	(0.0852)	(0.1154)	(0.1006)
Tariff (ij, t)	−0.9522**	−1.2477**	−1.0276	−0.3489
	(0.4703)	(0.6288)	(0.7563)	(0.8571)
RTA (ij, t)	0.1726***	0.2759***	0.4120***	0.3609***
	(0.0467)	(0.0648)	(0.0895)	(0.0879)
Dependent variable (ij, t-1)	0.8086***	0.7162***	0.6815***	0.8521***
	(0.0292)	(0.0344)	(0.0383)	(0.0239)
Obs.	18,662	18,662	18,662	18,662
No. Groups	2392	2392	2392	2392
No. Instruments	326	326	326	326
AR(3)	0.393	0.691	0.386	0.294
Hansen p-value	0.386	0.276	0.179	0.264
diff-in Hansen p-value	0.766	0.689	0.56	0.477

Time dummies included in each regression. The lagged dependent variable is treated as predetermined. LFA, Tariff and GDPs are treated as endogenous. The SYS-GMM estimator is implemented in STATA using the xtabond2 routine. Windmeijer-corrected standard errors in parenthesis: *** < 0.01; ** < 0.05; * < 0.1.

Table Summary statistics.

	Mean	Std. Dev	Min	Max	Obs
Log(Trade Volume)	6.67	2.92	−5.81	16.19	18,662
Log(VWT)	14.03	3.61	−19.31	22.95	18,662
Log(GreenWT)	13.14	4.73	−2.16	22.94	18,662

	Mean	Std. Dev	Min	Max	Obs
Log(BlueWT)	9.26	5.28	−19.31	19.92	18,662
FLA (ji, t-1)	0.04	0.20	0.00	2.83	18,662
LogGDP (j, t)	25.61	2.17	18.25	30.45	18,662
LogGDP (i, t)	23.80	1.54	18.25	26.98	18,662
LogPOP (j, t)	2.83	1.62	−2.65	7.21	18,662
LogPOP (i, t)	3.07	1.07	−1.93	5.16	18,662
LogLand (j, t)	−1.09	0.84	−5.41	−0.16	18,662
LogLand (i, t)	−0.84	0.77	−3.37	−0.21	18,662
LogWater (j, t)	8.28	1.72	1.77	13.30	18,662
LogWater (i, t)	7.63	1.13	4.73	12.41	18,662
LogDistance (ij)	8.47	0.77	5.09	9.87	18,662
Common Language (ij)	0.26	0.44	0.00	1.00	18,662
Common Colonizer (ij)	0.14	0.35	0.00	1.00	18,662
Tariff (ij, t)	0.07	0.10	0.00	1.82	18,662
RTA (ij, t)	0.19	0.39	0.00	1.00	18,662

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