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BIOFUEL DEVELOPMENT AND LARGE-SCALE LAND DEALS IN SUB-SAHARAN AFRICA

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Abstract

Africa's biofuel potential over the last ten years has increasingly attracted foreign investors' attention. We estimate the determinants of foreign investors land demand for biofuel production in SSA, using Poisson specifications of the gravity model. Our estimates suggest that land availability, abundance of water resources and weak land governance are significant determinants of large-scale land acquisitions for biofuel production. This in turn suggests that this type of investment is mainly resource-seeking and investors might see land governance weaknesses as a way to access land and water resources at very favorable conditions. Results are robust to different specifications.

Key words: biofuels, land acquisitions, Poisson regression, Africa.

JEL Codes: O13, F21, N57, Q24.

1. INTRODUCTION

All over the world, the last ten years have witnessed a renewed interest in agriculture and land investments for production of food and energy crops. Sub-Saharan Africa (SSA) is at the forefront of this trend and it is the region which potentially can experience most the related risks and benefits since the continent simultaneously faces energy emergency, high vulnerability to climate change, widespread poverty, and food insecurity. The close nexus between land and energy investments in SSA finds an emblematic and representative illustration in the biofuel sector. This paper contributes to the analysis of this nexus by estimating foreign investors' main drivers of large-scale land deals by foreign investors in the continent. It has been estimated that between 2001 and 2012, Sub-Saharan Africa attracted about 57 percent of worldwide large-scale land deals to cultivate only crops that can be used as biofuel feedstocks covering almost half of the global targeted area for this purpose (i.e. 12 million out of 26 million hectares)[1]. Furthermore, in SSA international land acquisitions for biofuel crops accounted for a share of about 60 percent both in terms of total number of deals and in covered area[2]. Biofuel-related projects in SSA are very heterogeneous, but large international acquisitions with the purpose to cultivate biofuel crops are one of the main forms of investment. Hence, identifying the factors triggering this type of investment decisions helps in understanding to what direction the current prevailing trends of biofuel market are proceeding and can provide useful insights also to assess risks and potentials of increasing commercial interest in African farmland.

[1] Authors' calculations based on Land Matrix data (accessed in April 2012). This figure does not include land deals for multiple uses, namely for both biofuel crops and other categories of production. The difference in the definition, together with the different geographical coverage, explains why this figure does not exactly match the data reported in Anseeuw et al. (2012a), which is based on the same source. This report indicates that in Africa large-scale land deals for biofuel production cover 18.8 million of hectares, which correspond to 66 percent of total land acquisitions on the continent for all targeted sector (industry, other agricultural commodities, mining, forestry, tourism) and to 50 percent of global land deals for biofuel crops.

[2] Authors' calculations based on Land Matrix data (accessed in April 2012).

This approach has two main advantages. First, it focuses on land demand for biofuel projects rather than on implemented projects. It therefore allows assessing the need to introduce corrective measures before irreversible negative effects are fully generated. Second, it complements the empirical literature on economic, social and environmental impacts produced by the operative biofuel projects. Existing evidence on the ground, indeed, gives some indications but it is still incipient (Giovannetti and Ticci, 2012) also because the biofuel sector in SSA is at its very preliminary stage of development.

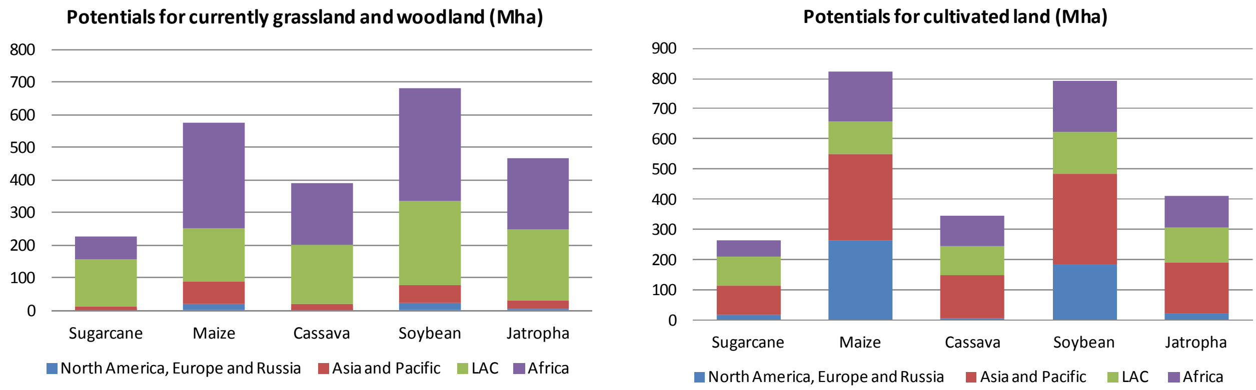
The paper is organized as follows. It first discusses biofuel potential in Sub-Saharan Africa, the debate on potential impacts and clarifies in detail the subject of the research. Section 3 presents the methodological approach and the data used and Section 4 estimates and discusses covariates of land demand for biofuel crops, while Section 5 concludes.

2. BIOFUEL POTENTIAL AND INVESTMENTS IN SUB-SAHARAN AFRICA

Sub-Saharan Africa is a marginal player in the biofuel market, but its role is increasing. In 2011, for instance, with an estimated ethanol production of 145 ML, Africa still accounted for only 0.17% of global production (Renewable Fuels Association, 2012). In the biodiesel sector, the continent plays even a smaller role: the first African large scale plant was inaugurated in Zimbabwe in 2007 and in 2009 was still operating at less than 5 percent of its capacity because of problems in the availability of raw materials. However, prospects for biofuel markets in Sub-Saharan Africa seem quite favorable. The southern Africa region, for example, has been described as a potential 'Middle East of biofuels'[3]. Indeed, Africa has a big potential for production of bioenergy since it accounts for the largest share of world's estimated non-protected grassland and woodland areas potentially suitable for the main biofuel feedstocks (maize, cassava, soybean, jatropha) and large areas of Africa's cultivated land are also potentially suitable for biofuel crops (Fig. 1a and 1b).

[3] Andrew Owens, CEO of Greenergy at Biofuels Markets Africa Conference, 30 November–1 December 2006, Cape Town.

Figure 1a and 1b: Potential suitable areas for sugarcane, maize, cassava, soybean and jatropha.

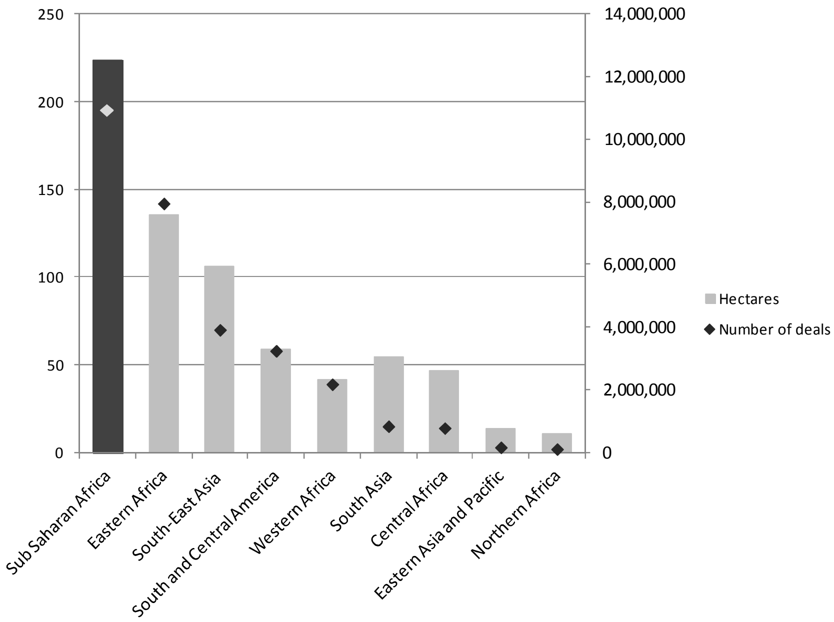


Source: estimates based on Global Agroecological Zones (GAEZ) methodology. IIASA 2009.

International investors are increasingly aware of this potential bioenergy wealth and some African countries have become the most targeted areas of land acquisitions for biofuel projects. Land Matrix data clearly shows this rising land demand. The Land Matrix is a database coordinated by the International Land Coalition which records rural land deals[4] covering 200 ha or larger, which have been reported since 2001 by media, international and non-governmental organizations, academic centers, and/or which have been posted on the *portal "Commercial Pressure on Land" of* the ILC and on the site of *farmlandgrab.org* maintained by the NGO GRAIN. It includes over 2,200 deals, but only about half (1,006) have been made public because after triangulation they have been considered reliable. Figure 2 draws from this dataset and reports data on deals for crops than can be used as biofuel feedstocks by target region. SSA accounts for more than half of this type of land deals: Eastern African countries are the most targeted, but also Western and Central Africa regions have been targeted.

[4] Land deals are defined as "transactions that entail a transfer of rights to use, control or own land through sale, lease or concession" (Anseeuw et al. 2012b, p.1).

Figure 2. Large land deals for crops than can be used as biofuel feedstocks by region, multiple uses excluded.



Source: Authors' elaboration based on the Land Matrix, accessed in April 12.

Note: Land deals for multiple uses, namely for both biofuel crops and other categories of production, are excluded. Crops that can be used as biofuel feedstocks include jatropha, oil palm, sugar sane, soya beans, croton, oil seeds, castor oil plant, and sorghum. Data interpretation should take into account that the purpose of about 10 percent of reported land deals is unknown.

Does this trend represent an opportunity or a risk? The debate on costs and benefits of biofuels is very controversial. Traditional use of biomass from wood and agriculture residues is the main source of energy on the continent, but under current practices and available technologies, it is not viable, can have unintended negative consequences on health, cause an excessive workload, especially for children and women, and create negative environmental pressures. There are some technical solutions to these problems in the use of unprocessed (wood, dung, agricultural residues) biomass as energy source (see Openshaw 2010), but biofuel and biogas are regarded as new and more efficient forms of carbon-based renewable energy. Liquid biofuels can be used in the transport sector without significant changes in the existing infrastructure and can be harnessed also for non-transport applications (cooking, lighting, and electricity-generation) (Mitchell, 2011). Decentralized production of biofuels or other forms of bioenergy might be suited to provide energy to rural areas, most often the poorest and the most excluded from energy access. Indeed, it has been calculated that decentralized renewable technologies are cost-competitive in remote and large rural areas of Sub-Saharan Africa (Deichmann et al. 2011). Other expected positive effects include diversification and improvement of income sources in rural areas, employment creation, improvement in energy security and reduced dependence on oil imports, foreign currencies earnings from biofuel exports, and reduction in GHGs emissions. The risks are, however, many. Expanding biofuel production can lead to increasing competition and pressures on water, land and forest and competition with uses of these resources. There is a consensus on the upward pressure of biofuels on food prices, despite a considerable variation in the estimates of the magnitude of this impact (Timilsina and Shrestha 2010). The carbon balance of biofuel expansion is also quite disputed. Net mitigation of GHG emissions is positive when land conversions for biofuel production are not considered, but the contribution of biofuels in mitigating climate change pressure is largely contested when land use changes are computed[5]. All these concerns, for example, have recently induced FAO, IFAD and the World Food Program to ask for adjustments[6] to biofuel mandates and the European Commission to rethink the EU's 2020 biofuel target.

In short, the production of biofuel feedstocks is more land and water intensive than other energy sources but biofuel production can open new income opportunities in rural areas and help Africa meet its energy needs. Among other factors, the real impact may also depend on organizational choices and technologies used. Biofuels fuels can be made from many different starting materials, from waste wood to algae (Grayson, 2011), and can be produced in different climatic conditions. First-generation biofuels are extremely water intensive[7], can cause frictions with alternative land and water uses and

[5] See Timilsina and Shrestha (2010) for a detailed literature review.

[6] Joint statement from FAO, IFAD and WFP on international food prices, 4 September 2012.

[7] Agricultural production of biomass for food and fiber is estimated to account for about 86 percent of global freshwater use (Gerbens-Leenes et al., 2009). Water footprint of biomass energy varies across climate conditions, agricultural production systems and the crops used, but Gerbens-Leenes et al. (2009) calculate that, on average, it is 70 to 400 times larger than that of the other energy sources (nuclear, crude oil, solar thermal, wind, natural gas energy). Several estimates suggested that

incentives for deforestation. Second-generation biofuels[8], instead, generally require less fertilizer and produce less CO2 emissions than first-generation ones (Delucchi 2010). Their impact on land use for food production might also be lower, since they can be produced from crops which grow on poor land and from waste products (Fonseca et al. 2010). The type of farming model is another factor at stake. Biofuel production can involve independent smallholder, farmers' cooperatives, small-scale contractors, large contract farming, large commercial farms and plantations. All these farming models can have different implications in terms of food security, employment and labor conditions, access to credit, access to local and international markets, to seeds and technology. The role of these factors, however, is beyond the scope of this paper. Our work is not about small scale projects, community-based biofuel programs and local farmers' cooperatives or organizations; it is not about second-generation biofuels from cellulose, hemicellulose or lignin. This paper deals with determinants of land demand by foreign investors for large scale farming to produce first-generation biofuels (projects to cultivate jatropha, oil palm, sugar sane, soya beans, croton, oil seeds, castor oil plant, sorghum). Interpretations of our results, therefore, relates to this type of projects. Despite this specific focus, the topic is particularly relevant since these investments in SSA, represent a significant share of biofuel-related existing initiatives. Moreover, concerns for equity and sustainability of the current rush for large scale land acquisitions (often called "land grabbing") are rising. A report of the High Level Panel of Experts on Food Security and Nutrition commissioned by the UN Committee on World Food Security, for instance, concludes that: "large scale investment is damaging the food security, incomes, livelihoods and environment for local people (p. 8)" (HLPE 2011).

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expansion of biofuel production, with their large water requirements, will increase demand and competition for water (Berndes 2002, De Fraiture et al. 2008, Yang et al. 2009, Galan-del-Castillo and Velazquez 2010)

[8] *Second-generation biofuels* are produced in processes which can use a variety of non-food crops and cellulosic sources such as grasses and trees. They include waste biomass, the stalks of wheat, corn, wood, and special-energy-or biomass crops. *Third-generation biofuels* are derived from algae.

3. THEORETICAL FOUNDATIONS AND MODEL SPECIFICATION

What are the main push and pull factors of international land demand for biofuel projects in Sub-Saharan Africa? In following, we estimate the determinants of international large-scale land deals concluded since 2001 in each Sub-Saharan Africa's country from any other country in the world with the purpose to cultivate crops that can be used as biofuel feedstocks. This section illustrates the methodology applied, we then clarify the variables used in the estimates and we discuss the results.

We adapt the analysis of land FDI flows to the gravity model framework widely used in the literature on trade flows and, more recently, on FDI determinants, as well as on FDI-trade complementarities (Wei 2000, Helpman et al. 2004; Braconier et al. 2005, Bellak and Leibercht 2009, de Mello-Sampayo 2009, Wagle 2011). We apply a Poisson pseudo-maximum likelihood model (PPML) since it has been convincingly observed (Santos Silva and Tenreyro 2006 and 2011) that the PPML estimator, unlike standard log-linearized models, not only represents a natural way to treat zero-value observations, but also performs well even with a large number of zeros and heteroskedastic errors. We follow specifications similar to that used by Arezki et al. (2011) in their recent study of the drivers of global trans-national land deals. However, the choice of the variables is adapted to our focus on land deals for biofuel crops in Sub-Saharan Africa and we rely on a different dataset, Land Matrix, which we believe is the most comprehensive and updated dataset of large-scale land deals currently available. Two main types of specifications are estimated. The first group follows a "traditional" gravity equation with country-specific variables both for the origin and the destination countries as in Arezki et al. (2011). These estimates assess the role of some characteristics of the origin countries which can act as drivers for FDI in land for biofuel projects and they provide benchmark results. The second group of specifications aims to improve the robustness and economic and theoretical foundation of the estimates compared with the benchmark model. It implements a quasi-fixed effect model by including source-country dummies meant to capture the combined impact of all origin-specific push factors[9] that may be relevant to the size of outward FDI in land. This second procedure allows us to apply a method

[9] In this case all origin-specific push factors are captured by country dummies and variables for characteristics of origin countries are not included in the model.

consistent with the random utility (profit) maximization (RUM) framework which is well established in the location choice literature. It also performs better in tackling the possibility of omitted variables bias.

Let us to clarify our methodological strategy by considering a simple RUM model that describes the location choice of potential investors in biofuel-oriented land acquisitions. We refer to the framework developed by Guimarães et al. (2003 and 2004) and we adapt and apply it to the context of bilateral investment flows. We consider a population of s_h investors from country $h \in H$ who decide the location of their investments among a *J* set of potential destination countries with *j*=1,…*J* by solving a RUM problem. We assume that the size of population s_h is a function of a vector $\boldsymbol{x}_h$ which includes characteristics specific to the origin country *h* ($s_h = f(\boldsymbol{x}_h)$ and that the profit obtained by investor *i* from country *h* if he invests in country *j* is expressed as:

$$\pi_{i,h,j} = V_{h,j} + \varepsilon_{i,h,j} = \boldsymbol{\beta}'\boldsymbol{z}_{h,j} + \boldsymbol{\theta}'\boldsymbol{y}_j + \varepsilon_{i,h,j} \qquad (1)$$

Where $\varepsilon_{i,j}$ includes unobserved features of locations and unobserved individual characteristics of investors. $V_{h,j}$ is the systematic component of the profits derived by alternative *j* for investors from country *h*. We have assumed that $V_{h,j}$ is a linear function of choice-specific attributes which are common to all investors from the same origin country, namely it depends on the vectors $\boldsymbol{y}_j, \boldsymbol{z}_{h,j}$ which collect, respectively, the destination country *j* and bilateral characteristics specific to each pair of countries *h* and *j*. Although profits might be unobserved, the probability that an investor from country *h* selects destination country *j* from a set of *J* alternatives is given by

$$p_{h,j} = \Pr\left[\pi_{i,j} > \{\pi_{i,j'}\}_{\forall j' \neq j}\right] \qquad (2)$$

Following McFadden (1974), we can observe that, if $\varepsilon_{i,h,j}$ is a i.i.d. EVT-1 random variable, then the probability that a investor from country *h* chooses country *j* is

$$p_{h,j} = \frac{\exp(\boldsymbol{\beta}'\boldsymbol{z}_{h,j} + \boldsymbol{\theta}'\boldsymbol{y}_j)}{\sum_{j=1}^{J} \exp(\boldsymbol{\beta}'\boldsymbol{z}_{h,j} + \boldsymbol{\theta}'\boldsymbol{y}_j)} \qquad (3)$$

We can now obtain the number $n_{h,j}$ of investments in country *j* from country *h* as

$$n_{h,j} = p_{h,j} s_h \eta_{h,j} \qquad (4)$$

\

Where $\eta_{h,j}$ is a vector of spatially uncorrelated errors, with $E(\eta_{h,j}) = 1$ for all *j*. By substituting equation (3) in equation (4), we can write

$$n_{h,j} = \frac{\exp(\beta' z_{h,j} + \theta' y_j)}{\sum_{j=1}^{J} \exp(\beta' z_{h,j} + \theta' y_j)} s_h \eta_{h,j} \qquad (5)$$

Which can be re-formulated as

$$n_{h,j} = \exp\left[\beta' z_{h,j} + \theta' y_j - \ln\left(\sum_{j=1}^{J} \exp(\beta' z_{h,j} + \theta' y_j)\right) + \ln(s_h)\right]\eta_{h,j} \qquad (6)$$

According to equation (6) the number of bilateral investments from *h* to *j* depends on bilateral features, on destination-specific characteristics, but also on the investors' population size in countries of origin s_h and on the factor $a_h = \ln\left(\sum_{j=1}^{J} \exp(\beta' z_{h,j} + \theta' y_j)\right)$ which represents the expected profit associated by investors from country *h* to all possible destinations. That is, the number of investment to country *j*, for example, differs from origin country *h* and origin country *h'* not only because of origin specific attributes and for different attributes associated with the pairs (*j*, *h*) and (*j*, *h'*) (such as different distance) but also because of decision of investors in *h* and *h'* is based on a different attractions of all destinations.

To give an idea of the role played by a_h, we can consider an hypothetical scenario in which two source countries *h* and *h'* have the same specific-characteristics ($s_h = s_{h'}$), but investors in *h* face higher transaction costs than investors in *h'* when they choose destination country *j* (vector $z_{h,j} \neq z_{h',j}$). Despite these conditions, if investors in *h'* face lower transaction costs in other potential destinations, the attractiveness of these alternatives might confound the effect of barriers towards country *j*. As a result, the difference $n_{h',j} - n_{h,j}$ might be lower than expected and omitting this confounding influence biases estimates. In other words, bilateral flows towards a destination depend not only on its absolute attractiveness but also on its relative performance compared to all possible destinations.

Origin country-specific features might be used as proxies for s_h, nevertheless their inclusion in PPML estimates of bilateral flows would fail to capture the role of the attractiveness of all possible target countries[10]. Moreover, both s_h and a_h enter equation (6) in a non linear way and, therefore, cannot be appropriately estimates by the Poisson pseudo-maximum estimator. These deterministic components of utility due to origin-country features and to attractiveness of all destinations, however, can be controlled for by including origin dummies[11], namely if we express the conditional mean of $n_{h,j}$ as

$$\mathrm{E}(n_{h,j}) = \exp(\alpha_h + \boldsymbol{\beta}'\boldsymbol{z}_{h,j} + \boldsymbol{\theta}'\boldsymbol{y}_j) \tag{7}$$

Where α_h is a dummy variable which takes value 1 for origin country *h*. The stochastic version of relation (7), which take into accounts the error term associated with each observation, can therefore expressed as

$$n_{h,j} = \exp\left(\alpha_h + \boldsymbol{\beta}'\boldsymbol{z}_{h,j} + \boldsymbol{\theta}'\boldsymbol{y}_j\right) + u_{i,j} \tag{8}$$

With $E\left(u_{i,j} \middle| \alpha_h, z_{h,j}, y_j\right) = 0.$ Equation (8) represents the Poisson model which accounts for the combined effect of origin-country determinants. This specification offers several advantages. Firstly, it allows us to rely on an empirical strategy with a well-established theoretical foundation. Guimarães et al. (2003 and 2004) show that the estimation of (8) through Poisson pseudo-maximum likelihood produces identical parameter estimates as the conditional logit formulation of location choice modeling in equation (3). In this way, PPML estimations are compatible with the RUM framework which underpins the conditional logit model.

Schmidheiny and Brülhart (2011), moreover, extend the equivalence between the conditional logit and fixed-effect Poisson model in Guimarães et al. (2003) to the nested logit case with a single outside option, namely in a two-stage structure in which investors first choose whether invest in the region *J* or in another set of countries and then they decide which country in *J* to select. This structure assumes that the error term associated with the output option is not correlated with the errors terms associated

[10] This applies also for other types of bilateral flows. In the international migration literature, for instance, Bertoli and Fernández-Huertas Moraga (2011 and 2012) show that the effects of determinants of migration flows (such as GDP and visa policies) from one country to another one can be biased when the attractiveness of other destinations is not appropriately controlled for and covariates do not include dummies capturing fixed-effects but only country-specific features.

[11] It can be noted that a_h depends on attributes of all destinations, which are common to all potential investors, and on bilateral characteristics associated by origin country *h* to all possible destinations. This factor therefore does not vary cross destinations but it changes across source countries, so that it can be absorbed by origin-fixed effect.

with the options to invest in one of the countries in *J*, but it not requires uncorrelated error terms across different location choice within the set of countries *J*. Therefore, as noted by Bertoli and Fernández-Huertas Moraga (2012) “the consistency of the estimation through Poisson pseudo-maximum likelihood with the underlying RUM model does not rest on the IIA assumption.”

The model equation (8) is also compliant with the gravity model framework which postulates that economic interactions between two countries can be expressed as function of their distance, of bilateral factors which affect costs of interactions (such as distance), their size and other “attractive” and “repulsive” factors in target and origin countries, respectively. Moreover, the model takes into account recent developments concerning the specification of the gravity equation (Anderson and van Wincoop 2003) which suggest to include fixed effects of source and destination countries in order to account for “multilateral resistance terms” that, if ignored, can create an omitted variables bias. In equation (8), $\boldsymbol{y}_j$ is the vector of regressors representing destination-pull factors, while $\boldsymbol{z}_{h,j}$ include distance and other bilateral variables affecting costs and α_h is the fixed effect which is expected to capture all relevant origin-specific push forces. Dummies for destination countries are not included since we are interested to assess the role of those characteristics of potential destination countries which are more likely to attract biofuel-related FDI in land within a cross-sectional structure. In order to validate the results, we check whether they are robust to slightly different sets of covariates. Finally, as mentioned above, the PPML can be a valid alternative to standard gravity models which are based on a logarithmic transformation of gravity equation augmented with a normal disturbance term. As noted by Santos Silva and Tenryero (2006) and Helpman et al. (2008), in this way, standard log-linearized OLS regression are likely to produce inconsistent estimates in presence of heteroskedastic errors and to generate a non-random sample because they eliminate zero-pairs in flow bilateral data. In contrast, Santos Silva and Tenryero (2006 and 2011) show that Poisson pseudo-maximum likelihood estimates appear to be robust to different patterns of heteroskedasticity[12], and they perform well even in presence of a very large proportion of zero values and of over-dispersion.

[12] Santos Silva and Tenryero (2006) discuss in detail why the standard log-linerarization of equation (9) is likely to produce inconsistent estimates. $E[\ln(u_{i,j})]$ depends not only on the expected value of the random variable $u_{i,j}$, but also on its

3.1. Data sources and variables for origin, destination and bilateral covariates

Bilateral variables used to control costs of interactions and geo-political proximity are past colonial ties and geographical mean distance between the main cities of origin and targeted countries. These variables come from the GeoDist dataset of CEPII (Mayer and Zignago, 2011). Specific attributes of origin countries are represented by a proxy of the size of origin countries, by a dummy for the presence of biofuel productive activities and a dummy that takes value 1 if the country of origin belongs to the top quintile of all countries in terms of agricultural land as a share of total land. We assume that a very high agricultural land share denotes that the country has a narrow margin for expanding its agriculture frontier, and is therefore more likely to invest abroad. As the size of origin country is concerned, given our specific focus on land deals, we use imports of agricultural products from FAO as indicator of potential demand for agriculture goods in origin countries[13].

In order to assess the role of land supply capacity in destination countries y_j includes total renewable internal freshwater resources and total agricultural land (from World Development Indicators - WDI)[14]. A set of variables that account for institutional factors in destination countries are also considered in y_j since, FDI literature highlights the importance for institutional quality in affecting investment decisions (Wei 2000, Alfaro et al. 2008, Bisson 2012). Variables on institutional quality draw from three main databases. First, we use the strength of investor protection index elaborated by the Doing Business database. The index ranges from 0 to 10, with low values indicating weaker

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variance. Therefore if $var(u_{i,j})$ depends on some of the regressors, the assumption that the error term is uncorrelated with the regressors is violated.

[13] Data from WDI, WGI and FAO refer to 2007 since, according to available information, the vast majority of all land deals were arranged after that year (Anseeuw et al. 2012b).

[14] The main findings of this paper are confirmed also when the model is estimated using a proxy of potential agricultural land namely the amount of non forest land area that in the *Global Agro-ecological Zone Dataset* of the International Institute for Applied Systems Analysis (GAEZ-IIASA) is classified as potentially very suitable or suitable for rain-fed cultivation by using maximizing technology (technical details available at http://www.iiasa.ac.at/Research/LUC/GAEZ/index.htm). Estimates are available from the authors on request.

protection of investors' rights which might be less conducive to a favorable investment climate. Second, we consider the role of control of corruption using the percentile of the distribution reported in World Governance Indicators (WGI)[15]. Finally, the Institutional Profiles Database 2009 (IPD), elaborated by the French Development Agency (AFD) provides an indicator for the "institutional capacity to define public policy" and some indicators for different aspects of land tenure systems in the destination countries. All institutional indicators from IPD range from 1 to 4. Indicators on land governance are introduced to test the hypothesis that a poor protection of land tenure rights might facilitate rent and resource-seeking strategies in land FDI for biofuel crops. Given the complexity[16] and the existence of multiple land tenure systems in Africa, security of land rights is very difficult to measure[17]. We try to circumvent this difficulty by testing our hypothesis by using three different indicators: importance of public property (*PubLand*) and of traditional collective property (*TradCollLand*) in rural areas and an index based on i. the proportion of the population with no formally recognized land rights, ii. the percentage of land disputes to the total number of disputes handled by the courts, and iii. the importance of land issues on the political agenda and in the press (Crombrugghe et al., 2009). We refer to this indicator as "index for formalization and lowly disputed land rights" (*FormLowDispLRs*)[18]. None of them is a perfect proxy of security (or insecurity) of land rights but each of them can capture a different dimension. In the African contest, the link between land titling and land security is not always confirmed (Cotula et al. 2004, Ngaido 2005, Fenske 2011): secondary rights holders, less-educated, disadvantaged or poorest farmers might be less likely to obtain and protect their land rights. However, the index *FormLowDispLR* can be considered an indicator of the degree of land conflicts which also relates to the sense of tenure security. Moreover, if customary

[15] WGI contains also other institutional variables for rule of law, political stability and government effectiveness. All these variables are highly correlated. In fact, we tested the use of these indicators, but the results remain substantially unchanged and therefore we omit them.

[16] Land rights include a bundle of rights (access, exclusion, alienation, withdraw rights) which might be even, legally or customarily, held by multiple agents or groups of agents.

[17] See Place (2009) for a detailed discussion on this issue.

[18] In IPD 2009 and in other studies (Arezky et al., 2011) is denoted as "security of land rights".

and informal arrangements can reduce the risk of expropriation, can provide a degree of security and can evolve to accommodate new demands of land access (Place 2009), they might fail to protect *de facto* rights holders when the competitors are large and politically well-connected investors. Therefore, we argue that the degree of formalization of land rights might reduce vulnerability to land claims by external investors. By the same token, we assume that traditionally collective lands and, to a greater extent, public lands are particularly vulnerable to commercial pressure. Several African countries have introduced laws for statutory recognition of customary lands. Tanzania, Uganda, Ghana, Mozambique are among the most prominent examples. However, in most countries, common property rights have received an ambivalent or weak support and in most cases communal lands are legally disposable by the state (Alden Wily 2011). Governments might be entitled to reallocate them to external investors, even if used by local communities, since they have lawful authority over them. Moreover, commons and public lands are often perceived as unutilized land available for investors and they can offer large tracts of uncultivated land which are well-suited for large scale investments (Alden Wily 2011). Thus, we expect that high relevance of traditionally collective and public land increases attractiveness of a country for large scale land investment in the biofuel sector.

4. ECONOMETRIC RESULTS

Table 1 and 2 report the PPML estimates of the "traditional" gravity model with country-specific variables and the gravity model with the fixed effects of the origin countries, respectively, while the key descriptive statistics are shown in appendix (Table A1 and A2). We focus on results obtained by controlling for *PubLand* and *FormLowDispLR*, while those with *TradCollLand* are reported in appendix (Table A3). As expected, distance between partner countries negatively influences the number of land FDI for biofuel crops, but, interestingly, the dummy for past colonial relationships, in most cases, is not significant. This might be due to fact that the group of the main biofuel producers does not include only ex-colonial powers but also several emerging economies (such as Brazil, China, South Korea, Malaysia). Econometric estimates of the "traditional" version show that land-scarce and biofuel producer countries are more likely to acquire overseas lands for biofuel projects than other countries.

Table 1: PPML estimates for the number of large scale land deals in Sub-Saharan African countries for crops that can be used as biofuel feedstocks. Focus on the role of public property in rural areas.

	A1	B1	C1	A2	B2	C3
Type of specification	Traditional	Traditional	Traditional	Fixed effect	Fixed effect	Fixed effect
Bilateral variables						
Colonial relationship	-0.111	0.0615	-0.0423	0.998*	1.142**	1.051**
	(0.515)	(0.492)	(0.505)	(0.554)	(0.526)	(0.536)
Distance	-0.722***	-0.735***	-0.712***	-0.767***	-0.809***	-0.704***
	(0.191)	(0.200)	(0.177)	(0.169)	(0.158)	(0.178)
					1.142**	
Origin country variables						
Agriculture imports	0.451***	0.463***	0.460***			
	(0.114)	(0.116)	(0.108)			
Land scarcity	0.676**	0.762***	0.681**			
	(0.286)	(0.272)	(0.278)			
Biofuel producer	3.876***	3.781***	3.869***			
	(0.445)	(0.438)	(0.419)			
Target country variables						
PubLand: Importance of rural public property, 1-4	0.585**	0.804***	0.688***	0.899***	1.136***	0.901***
	(0.272)	(0.308)	(0.263)	(0.238)	(0.278)	(0.220)
Investor protection index, 1-10	0.307***			0.309***		
	(0.0908)			(0.0796)		
Agricultural land (ha)	0.140*	0.220**	0.281***	0.283***	0.380***	0.450***
	(0.0745)	(0.0877)	(0.0890)	(0.0718)	(0.0866)	(0.0990)
Per capita freshwater resources	0.0582	0.0541	0.245**	0.161**	0.226***	0.295***
	(0.0812)	(0.0771)	(0.102)	(0.0778)	(0.0722)	(0.0946)
Control of Corruption		0.0286***			0.0306***	
		(0.00583)			(0.00502)	
Institutional capacity			0.942***			0.798***
			(0.237)			(0.209)
Observations	4622	4622	4622	5940	5940	5940
Pseudo R2	0.526	0.537	0.531	0.437	0.456	0.437
Log lik.	-283.4	-276.9	-280.7	-364.2	-352.3	-364.1
RESET	Failed	Failed	Failed	Ok	Ok	Ok
Linktest	Failed	Failed	Failed	Ok	Ok	Ok

Table 2: PPML estimates for the number of large scale land deals in Sub-Saharan African countries for crops that can be used as biofuel feedstocks. Focus on the role of formalization of and disputes over land rights.

	A1	B1	C1	A2	B2	C3
Type of specification	Traditional	Traditional	Traditional	Fixed effect	Fixed effect	Fixed effect
Bilateral variables						
Colonial relationship	-0.205	-0.169	-0.200	1.015	1.246*	1.113*
	(0.496)	(0.490)	(0.501)	(0.650)	(0.678)	(0.634)
Distance	-0.654***	-0.623***	-0.608***	-0.768***	-0.621**	-0.606**
	(0.171)	(0.197)	(0.175)	(0.167)	(0.272)	(0.239)
Origin country variables						
Agriculture imports	0.447***	0.440***	0.440***			
	(0.108)	(0.118)	(0.110)			
Land scarcity	0.695**	0.799***	0.728**			
	(0.294)	(0.299)	(0.299)			
Biofuel producer	3.838***	3.874***	3.899***			
	(0.380)	(0.391)	(0.373)			
Target country variables						
FormLowDispLRs, 1-4	-0.998***	-0.532***	-0.610***	-1.718***	-1.084***	-1.189***
	(0.259)	(0.206)	(0.201)	(0.318)	(0.210)	(0.234)
Investor protection index, 1-10	0.517***			0.754***		
	(0.136)			(0.160)		
Agricultural land (ha)	0.264**	0.510***	0.512***	0.452***	0.784***	0.823***
	(0.129)	(0.145)	(0.144)	(0.113)	(0.150)	(0.158)
Per capita freshwater resources	0.0466	0.0955	0.269**	0.144	0.239**	0.379***
	(0.0910)	(0.0887)	(0.110)	(0.0961)	(0.100)	(0.118)
Control of Corruption		0.0228***			0.0284***	
		(0.00519)			(0.00431)	
Institutional capacity			0.829***			1.040***
			(0.225)			(0.220)
Observations	4622	4622	4622	5940	5940	5940
Pseudo R^2	0.529	0.528	0.525	0.451	0.448	0.439
Log lik.	-281.5	-282.6	-284.4	-355.3	-357.5	-363.4
RESET	Failed	Failed	Failed	Ok	Ok	Ok
Linktest	Failed	Failed	Failed	Ok	Ok	Ok

Notes: Variables in logs. Robust standard errors. * p < 0.10, ** p < 0.05, *** p < 0.01. Constant included but not reported. The dependent variable is the number of all large scale agricultural FDI for cultivation of Jatropha, Oil Palm, Sugar Cane, Soya Beans, Croton, Oil Seeds, Castor Oil Plant, Sorghum. Land deals for multiple crops are excluded. Land scarcity is a dummy variable that takes value 1 if the country belongs to the top quintile of all countries in terms of agricultural land as a share of total land. A low value of investor protection index reflects weak protection of investors' rights. Data on agriculture imports draw are expressed in 1000 $. The dummy for biofuel producers is based on the International Energy Agency data on production of biodiesel and other liquid biofuels which are available from OECD iLibrary.

The dummy for biofuel producers has a very high coefficient suggesting that investors from countries already active in the biofuel markets are the most interested in transnational land investments to integrate and expand their access to biofuel feedstocks. The coefficient of agricultural imports, introduced as proxy for demand forces is also positive and highly significant. This is consistent with the fact that countries that are quite dependent on agricultural imports are particularly involved in the rush for Africa farmland to overcome the limits of their biocapacity potential. A note of caution, however, is needed. These findings should be interpreted as preliminary evidence. A heteroskedasticity-robust RESET test based on Santos Silva and Tenreyro (2006) is performed and the test is passed only by fixed-effect specifications. The results of the RESET test, therefore, reinforce our choice to use also the fixed-effect PPML method which, instead, provides more robust evidence on the role of target-country characteristics.

On the supply side, agricultural biocapacity and water abundance appears to act as a pull force. Both versions of the estimated models suggest that countries with large amount of agricultural land are more likely to attract investments than other Sub-Saharan African countries. This result is also confirmed when land supply capacity is measured by the estimated amount of potential land suitable for rain-fed cultivation (estimates available on request). Moreover, water abundance works as catalyst of international land investments for biofuel crops. The variable of per capita freshwater renewable resources has a positive and statistically significant coefficient in all fixed-effects specifications and in most specifications of the traditional version. This result is consistent with earlier evidence suggesting that purchase or lease of land results in investment in water in foreign countries (Anseeuw et al. 2012a, Woodhouse and Ganho 2011).

Finally, our estimates highlights the role played by institutional conditions in destination countries. Countries characterized by better institutional quality are more likely to attract a higher number of biofuel land deals, and this result is confirmed regardless the type of indicator for this dimension is used. This evidence diverges from Arezki et al. (2011), who find a negative and hardly significant effect of conventional governance variables. A possible explanation is our different focus. We concentrate on land acquisitions for biofuel production, namely a relatively new sector which, compared with traditional agricultural investments, imply a higher risk due to a greater uncertainty regarding yields, operational costs, processing difficulties and payback periods. For these decisions, therefore, foreign investors might give a particular attention to the general institutional conditions in the target area. Our focus on Sub-Saharan African countries can represent an additional factor. SSA countries have attracted a disproportionally large share of global large-scale land deals and are often characterized by poor institutional environments in the worldwide rankings. This correlation also emerges in Arezki et al. (2011). To a certain extent, therefore, Arezki et al. (2011) results are not inconsistent with ours since our analysis indicates that, once investors choose to invest in the continent, they prefer countries with better governance conditions. Finally, we find that countries with low formalization of and widespread disputes over land rights or where rural public property is prominent are more targeted by biofuel-related land acquisitions. The coefficients of variables *PubLand* and *FormLowDispLR* are, respectively, positive and negative and they are robust to changes in model specification. Interestingly, they are also higher than coefficients of other institutional factors affecting risks and transaction costs of investment decisions, such as protection of investors' rights and control of corruption. In conclusion, we find support for the hypothesis that weak protection of land tenure rights' of local populations represents an important signal of biofuel-related land acquisitions.

4. CONCLUDING REMARKS

Biofuel energy can have a role in reducing energy poverty and helping Africa to meet its future energy needs, but the balance between costs and benefits might not be positive. Biofuels, in particular, represent a very controversial form of renewable energy, even if it is likely to develop further since in the foreseeable future the transport sector seems likely to keep relying on liquid fuels. In Sub-Saharan Africa the biofuel sector has triggered a great attention from large investors. This paper has estimated the factors driving large-scale transnational land deals for biofuel crops towards Sub-Saharan African countries. We find that foreign investors acquiring large tracts of farmland for biofuel project tend to select countries with better institutional environments, higher endowments of land and water resources. However, they prefer countries with weaker protection of land rights and a stronger role of public property of rural land, namely land institutional settings which might facilitate acquisition of land and water resources at favorable conditions. These findings are consistent with a resource-seeking attitude behind large-scale land demand for biofuel crops.

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Appendix

Table A1. Key descriptive statistics: origin-country variables

Origin country variables	*Origin countries*	*Other countries*	*t-stat for equality of means*	*(a)*
Agriculture product imports (1,000,000$)	11,700	1,560	6.761	***
Land scarcity (dummy)	0.44	0.45	-0.098	
Biofuel producer (dummy)	0.08	0	3.2678	***
Number of countries	36	119		

Table A2. Key descriptive statistics: Destination variables, SSA target and non target countries.

Target country variable	*Target SSA countries*		*SSA non-target counttries*	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
Agricultural land (1000 ha)	32,600	6,930	31,000	9,636
Per capita freshwater resources (cubic meters)	16,015	2,980	7,470	11,487
Potentially non forest land suitable for cultivation (1000 ha)	31,607	6,299	11,324	4,596
Investor protection index (0-10)	4.41	0.23	4.83	0.58
Security of land rights (1-4)	1.86	0.10	2.35	0.22
Importance rural public property land (1-4)	2.53	0.19	2.18	0.24
Land tenure policy (1-4)	2.19	0.13	2.73	0.21
Control of Corruption Rank	27.42	4.03	38.70	8.80
Institutional capacity (1-4)	1.31	0.12	1.61	0.30
Number of countries	20		10	

Table A.3: PPML estimates for the number of large scale land deals in Sub-Saharan African countries for crops that can be used as biofuel feedstocks. Focus on the role of traditional rural collective property.

	A1	B1	C1	A2	B2	C3
Type of specification	Tradition al	Traditional	Traditional	Fixed effect of origin countries	Fixed effect of origin countries	Fixed effect of origin countries
Bilateral variables						
Colonial relationship	-0.314	-0.222	-0.272	1.070	1.234	1.143
	(0.535)	(0.500)	(0.526)	(0.791)	(0.781)	(0.768)
Distance	- 0.664***	-0.643***	-0.627***	-0.652**	-0.638**	-0.553*
	(0.196)	(0.206)	(0.190)	(0.280)	(0.291)	(0.323)
Origin country variables						
Agriculture imports	0.440***	0.437***	0.437***			
	(0.116)	(0.120)	(0.115)			
Land scarcity	0.751**	0.800***	0.762**			
	(0.308)	(0.305)	(0.307)			
Biofuel producer	3.894***	3.901***	3.920***			
	(0.389)	(0.398)	(0.386)			
Target country var.						
Importance traditionally rural collective property, 1-4	0.463***	0.290*	0.337**	0 .800***	0.679***	0.707***
	(0.142)	(0.149)	(0.146)	(0.148)	(0.157)	(0.146)
Investor protection index, 1-10	0.373***			0.402***		
	(0.107)			(0.0935)		
Agricultural land (ha)	0.363**	0.554***	0.559***	0.702***	0.924***	0.942***
	(0.153)	(0.146)	(0.146)	(0.148)	(0.146)	(0.160)
Per capita freshwater resources	0.115	0.140*	0.285***	0.294***	0.354***	0.456***
	(0.0873)	(0.0830)	(0.107)	(0.0912)	(0.0859)	(0.119)
Control of Corruption		0.0179***			0.0195***	
		(0.00482)			(0.00416)	
Institutional capacity			0.636***			0.639***
			(0.229)			(0.216)
Observations	4622	4622	4622	5940	5940	5940
Pseudo R^2	0.529	0.527	0.525	0.450	0.448	0.442
Log lik.	-281.4	-283.1	-284.2	-356.2	-357.0	-361.0

Notes: Variables in logs. Robust standard errors. * p < 0.10, ** p < 0.05, *** p < 0.01. Constant included but not reported. The dependent variable is the number of all large scale agricultural FDI for cultivation of Jatropha, Oil Palm, Sugar Cane, Soya Beans, Croton, Oil Seeds, Castor Oil Plant, Sorghum. Land deals for multiple crops are excluded. Land scarcity is a dummy variable that takes value 1 if the country belongs to the top quintile of all countries in terms of agricultural land as a share of total land. A low value of investor protection index reflects weak protection of investors' rights. Data on agriculture imports draw are expressed in 1000 $. The dummy for biofuel producers is based on the International Energy Agency data on production of biodiesel and other liquid biofuels which are available from OECD iLibrary.