Essays on International, Development and Environmental Economics

by

Yousef Aburodess Assaid Alkilany

A dissertation submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

Auburn, Alabama
Aug 06, 2022

Keywords: Foreign Direct Investment, Official Development Assistance, Market Analysis, Income Inequality, Environmental degradation, Spatial heterogeneity.

Approved by

Henry W. Kinnucan, Chair, Professor Emeritus, Dept. of Agricultural Economics and Rural Soci.
Ruiqing Miao, Co-Chair, Associate Professor, Dept. of Agricultural Economics and Rural Soci.
Denis A. Nadolnyak, Professor Dept. of Agricultural Economics and Rural Soci.
Asheber Abebe Professor Department Mathematics and Statistics

Abstract

This dissertation consists of three empirical essays in three chapters, which sheds light on select research questions on foreign inflows on the income inequality in low-income countries, the agricultural productivity of donor countries induced by the growth in recipient countries in biodiversity, and non-market analysis of the environmental degradation and externalities.

Chapter 1 is to extend de Janvry and Adult's (1988) analysis of the relationship between foreign aid and agricultural imports by including Foreign Direct Investment (FDI) and Official Development Assistance (ODA) as explicit policy instruments affecting growth rates in the industrial and agricultural sectors of less developed countries (LDCs). An equilibrium displacement model is specified to deduce hypotheses about increased FDI and ODA's effects on agricultural imports. The hypotheses are tested using unbalanced panel data for 28 least developed countries from 1994 to 2018. The elasticities are obtained by estimating the structural model using three-stage least squares (3SLS). For robustness checks, we use different subsamples, African and Asian LDCs, and the three- and five-year averages. Results of the structural model suggest FDI to LDCs deters the economic growth of recipient countries, while the opposite is true for increased ODA. Our findings match de Janvry and Sadoulet, although the magnitude of effect is smaller than they found. The frontier of harmony between LDCs' agricultural development and U.S. agricultural export interests is reached when the change in agricultural imports with respect to the change in the agricultural sector is zero. Aid and trade are in harmony when reduced-form elasticity of agricultural imports with respect to

foreign inflows has a positive sign and negative otherwise. Therefore, there will be harmony on the side of the frontier for FDI and ODA.

Chapter 2 investigates the impact of Chinese Outward Directed Investment (CODI) into Africa on income inequality, measured by the Gini coefficient. We use data for 21 low-income African countries over the period 2003 – 2014. The dynamic GMM/FE and 2SLS/FE are implemented by incorporating several lags as instrumental variables to correct endogeneity. Results suggest that CODI exacerbates income inequality. In line with the dependency hypothesis, an isolated 100% increase in CODI is significantly associated, on average, with a 5 % increase in income inequality in low-income African countries. Consistent with the modernization hypothesis, a 100% increase in non-CODI sources of FDI is estimated, on average, to decrease income inequality by 2%, reflecting the historical trade partnership between Africa and countries, such as EU and USA. The increase in trade openness and employment rate leads to better income distribution. In addition, an isolated 10% increase in secondary school enrollment rate relative to total population is significant and increases income inequality by 2.3%, widening the gap between population groups who are eligible to work. Therefore, income inequality is more sensitive to secondary school enrollment than to CODI. Increased natural resources rent results in higher income inequality in low-income African countries. We controlled for GDP and the inflation rate, which were found not to affect income inequality. Lastly, the relationship between the Gini coefficient and CODI is in line with the inverted U-curve - the Kuznets curve, however, the magnitude is small.

Results are consistent with findings for other countries and are robust to model specification.

Chapter 3 estimates the effects of environmental degradation on residential prices and locations in Rwanda (Eastern Africa). The main hypothesis is that average residential prices are negatively associated with extensive biomass use, and individuals are less likely to pay for degraded environmental conditions. The cross-sectional dataset includes five provinces, subdivided into 30 districts of Rwanda, and retrieved from the Statistics Integrated Household Living Conditions Survey, 2013-2014. Two stages of spatial quantile regression are employed to capture spatial spillovers and deal with spatial heterogeneity. The presence of negative externalities from the extensive use of biomass will cause housing prices to decrease and the willingness to pay for such houses to decline. Findings suggest that the use of inferior cooking and lighting fuel sources in residential dwellings, such as firewood and crop wastes, has a negative and significant impact on housing values, across quantiles, though different magnitudes. On the other hand, there are indications of willingness to pay for quality-of-life improvements. For example, living in a modern planned area and houses made from cement and bricks positively affect the dwelling values compared to houses made from different low-quality materials. As expected, housing values are also positively affected by floor area.

Acknowledgments

First and foremost, I would like to praise and thank the Almighty Allah, the most merciful and munificent, for giving me the strength, guidance, and patience to complete this dissertation.

I would like to sincerely express my appreciation and thank my major Professor Henry W. Kinnucan, for his time and energy. It has been an honor to be his Ph.D. student. I am grateful to him and appreciate everything he has done for me throughout this doctoral journey. His constant support during this time has been vital to growing as a researcher and developing a better understanding of economic theories.

My sincere thanks also go to Professor Denis Nadolnyak, Professor Ruiqing Miao, and Professor Asheber Abebe, thank you all for serving as the graduate committee members and for the invaluable comments on my dissertation committee. A Thanks also goes out to Professor Mark (Hamza) Dougherty for serving as a university reader.

I am also grateful to Professor Hyeongwoo Kim, Department of Economics at Auburn University, for providing teaching opportunities as a stand-alone instructor of Economics. Also, Professor George Flowers, Graduate School at Auburn University, and Professor Joshua Duke, Department of Agricultural Economics and Rural Sociology at Auburn University, for providing work opportunities and for extending generous support to ease the financial and administrative obstacles at the final stage of this journey.

A special thanks to my family. I am proud to have such loving family. My heartfelt gratitude to my beloved parents; my Father (Aburodess) and my Mother (Am Elkhir) for unconditional love and prayer. Without the support and guidance of my parents, I would have never been where I am today; I owe everything to you and more. Also, my greatest thank goes to my beloved brothers and sisters (my elder brother (Ahmed), Souad, Habeeb, Khadija, Nuri, Assaid, Amna, Esmail, Fatima, Salah, Aya, Heba, and Rawand) and my beloved wife (Basmah); Thank you all for continuous emotional support and encouragement during this challenging journey.

I truly appreciate the financial support and the help throughout my study; from The Libyan Ministry of Higher Education via the Canadian Bureau for International Education program, and Faculty of Agriculture Sebha University - Libya.

Finally, I am also grateful to all staff I am also thankful to Ms. Ashley Aston, Ms. Ashley Pangle, Ms. Ann Gulatte, Ms. Charisse Bowen, Ms. Connie Pope Ms. Sherry Smith, and Ms. Farah White, and students here in the Department of Agricultural Economics and Rural University at Auburn University for their usual support and assistance.

Table of Contents

List of Tables

List of Graphs and Figures

List of Abbreviations

AFDB	African development bank group
ARD	Agriculture and Rural Development
CPIA	Country Policy and Institutional Assessment
CODI	Chinese Outward Direct Investment
DAC	Development Assistance Committee
EDM	Equilibrium Displacement Model
FDI	Foreign Direct Investments
FE	Fixed effects
FD	First Differenced
GDP	Domestic Product per capita
GMM	Generalized Moments Methods
HDI	Human Development Index
ILO	International Labor Organization
IMF	International Monetary Fund
LAV	Least Absolute Value
LDCs	Least Development Countries
MAD	Minimum Absolute Deviation
ODA	Official Development Assistance
OLS	Ordinary Least Squares
QRM	Quantile Regressions Model
SDGs	Sustainable Development Goals

WDI	World Development Indicator
2SLS	Second Stages Least Square
3SLS	Three Stages Least Squares

Chapter 1
Harmony Or Conflict?
Effects of FDI and ODA on Agricultural Imports of Developing Countries

1.1 Introduction

Does foreign aid to least developed countries help or harm US agricultural interests? This question highlights US foreign assistance, especially in agriculture, where one of the US foreign assistance goals is to support creating new customers for US products. In this regard, published official reports and studies regarding rationales for foreign aid are trade interests. For example, there are ongoing debates about US policies and programs. Interviews were conducted about agricultural policy-related and the top priorities for investing in agricultural development and major budgetary issues for international food aid and agricultural development programs. Two basic approaches were suggested. The first would emphasize the moral and compassionate grounds for US engagement in such assistance and how well these efforts have succeeded. The second approach emphasized advancing agricultural economies in developing countries through US assistance and how improved economic growth frequently leads to the expansion of import demand for a range of products that benefit US exporters (Mercier, 2012, Congressional Research Service. 2019, April 2019).

Aid flows aim to improve the productivities of recipient economies, especially the agricultural sector (e.g., through technology adoption or diffusion), which might lead to decreasing agricultural import demand from the least developed countries (LDCs). It also, however, tends to increase the demand of agricultural imports through positive effects on LDCs' agricultural productivity leading to increasing economic growth, thus improving the local economies and spurring household income. Moreover, agricultural aid is one of the few areas

that could impact short-term economic growth (Clements et al., 2004; Chimhowu, 2013). In their study of this issue, de Janvry and Sadoulet (1988) developed the concept of a "harmony frontier" between agricultural growth (induced by technological change) and agricultural imports. The frontier of harmony between LDCs' agricultural growth and US agricultural export interests is reached when LDCs' foreign inflows- induced agricultural growth has no effects on agricultural imports.

Moreover, foreign aid and trade are in harmony when the inflows to foreign countries are of US agricultural export interest. de Janvry and Sadoulet found that an increase in income in LDCs due to agricultural growth leads to an increase in their imports and hence the exports of donor countries. Harmony prevails if growth in agricultural productivity matches the growth in productivity in the industrial sector. Not many studies investigate the relationship between foreign assistance flows given to the agricultural sector and showed varied impacts of aid on the agriculture sector of recipient countries. Norton et al., (1992) show that agricultural aid negatively affected the growth in agriculture in recipient countries. Dewbre et al., (2007) concluded that the effects of aid on agricultural productivity are both positive and negative, depending on different model specifications.

Therefore, the objective is to investigate how foreign aid to least developed countries helps or harms US agricultural interests? To so, we extend the classic paper by de Janvry and Sadoulet (1988) by incorporating the two foreign factors, which are Official Development Assistance (ODA) and Foreign Direct Investment (FDI), as explicit policy instruments affecting growth rates in the agricultural and industrial sectors of LDCs, under the assumption that foreign inflows into LDCs will indirectly affect agricultural imports through their effect on the agricultural sector. The data employed are updated to 1994 - 2018 (de Janvry and Sadoulet's

estimates are based on 1970 - 1980). The structural model links agricultural growth, agricultural imports, FDI and ODA; and goes beyond work of de Janvry and Sadoulet (1988) by incorporating additional variables over a different time. Details are presented in the following sections.

ODA and FDI effectiveness is attracting several debates. For instant, donor countries such as Development Assistance Committee (DAC) member countries and multilateral aid agencies group use ODA as a tool to assist LDCs economies and, at the same time, to achieve both donors' and recipients' goals (de Janvry and Sadoulet, 1988; Dewbre et al., 2007; Lensink and White, 2000; Riddel, 2007; Roodman, 2007; Doucouliagos and Paldam, 2009; Easterly and Williamson, 2011; Ravallion; 2014). Establishing multilateral and bilateral collaboration primarily supports agriculture and rural development (ARD) in LDCs. Several empirical studies reported positive effects of foreign aid on growth by, for instance, increasing the income in the recipient countries (e.g., Askarov and Doucouliagos, 2015; Bru¨ckner, 2013; Clemens et al., 2012; Wu and Hsu, 2008; Fayissa and El-Kaissy,1999; Hansen and Tarp, 2000, 2001; Morrissey, 2001; Lensink and White, 2000; Kherallah et al., 1994). However, other authors show that ODA and FDI hurt economic growth (Easterly,2003; Easterly et al., 2004; Dewbre et al., 2007) through the reduction of local price as a result of the increase in productivity and resulting increased supply.

In practice, exports establish the leading and most direct channel through which aid affects the domestic donor economy. It can be partially explained that, in most of the period studied (and in fact, in our study), a substantial share of aid is tied to exports from the donor country. However, as cited in Mendez-Parra and te Velde (2017), Arvin and Baum (1997) and Arvin et al. (2000) untied-aid generates the same export-promoting effects as tied-aid. The

findings suggest that other channels may explain the higher exports from donor countries, such as a sense of concern towards donor exporters or the existence of trade concessions towards donors' exports (Mendez-Parra and te Velde, 2017). Indeed, most of the literature has shed light mainly on the effect of foreign aid on economic growth in recipient economies, such as LDCs.

On the other hand, there is less attention given to the impact of ODA on the donors' economies, especially domestic agricultural producers. In particular, to what extent can the exports be affected by increased foreign inflows in the recipient countries? However, it is essential to identify how foreign aid affects the economy before an empirical finding can be concluded concerning the aid policy-growth relationship (Lensink and White, 2000). Otherwise, the results might provide a blurry idea of the effectiveness of the entire system of foreign inflows.

In this regard, our study extends de Janvry and Sadoulet's analysis by including FDI and ODA as explicit policy instruments affecting growth rates in the industrial and agricultural sectors of LDCs. The dataset used to estimate the model is updated to 1994-2018 (de Janvry and Sadoulet's estimates are based on 1970-1980) data. Therefore, the claim is evaluated by developing an equilibrium displacement model (EDM) through a system of five simultaneous equations. In the case of the correlation between regressors and disturbances in simultaneous equations, the OLS estimates will be biased and inconsistent. Thus, the 3SLS is preferred to account for the potential endogeneity and cross-equation error correlation.

1.1.1 Background and motivations

As shown, in terms of ODA and FDI, foreign inflows have been a significant economic growth factor throughout the past and nowadays. One of the prominent areas of concern in recent economic development literature is the effectiveness of foreign aid. Foreign aid can be simply

defined as the economic assistance provided to one country by another country or organization to support the development of recipient countries. Aid can be given for economic, political, or humanitarian purposes and can be provided as loans and grants. Aid can be received in various schemes, such as social infrastructure and economic infrastructure, aid for both services and production sectors (Morrissey, 2001).

In the earlier stage of the development campaign, (Byerlee, de Janvery, and Sadoulet, 2009) stated that large share of manufacturing is related to agriculture; thus, it often represents the lead export sector and foreign exchange earner. Also, investing in social infrastructure includes, for example, education and water supply, which intend to improve human development and eventually contribute to long-run sustainable economic growth and import capital goods or technology (de Janvry and Sadoulet, 1988; Lensink and White, 2000; Morrissey, 2001; Dalgaard et al. (2004); Addison and Tarp, 2015; Yiew and Lau, 2018).

Both bilateral and multilateral aid are denoted and received in terms of tied and untied aid. The former refers to the recipient's obligation to purchase donors produced goods and services as a part of the assistance package. Up to the 1990s, around 50% of donor development aid was tied to donor's exports (Martínez Zarzoso et al., 2008; Mendez-Parra and te Velde, 2017). Moreover, disbursing aid without tying generates the same export-promoting effects as tied-aid and generates goodwill for donors in recipients' economies (Arvin and Baum, 1997; Arvin et al., 2000). In almost all LDCs, ODA is the primary catalyst for investment in agriculture. Apart from donors' interests, a development model needed that would help LDCs in transferring them to sustainable development goals without relying heavily on external financial assistance.

Regarding the development of the agriculture sector (Byerlee, de Janvery, and Sadoulet, 2009, p15) concluded: “Today’s greater willingness to invest in agriculture requires careful prioritization of the functions of agriculture and selection of the corresponding instruments to achieve these functions.” In many cases, there are ways to link the recipient country to a donor country either by tied-aid or by creating a permanent link. Hence, the recipient becomes dependent on inputs required to be utilized for projects and investments organized by a particular donor. Another type of aid may take the shape of financial transfers, which increase the disposable income of host economies. This aid leads to an increase in demand effects in favor of the benefits of domestics and foreign producers, not tied to only one donor but also based on historical trade partnerships and recipient preference, as most aid recipients have many donors (Dalgaard et al., 2004; Easterly and Williamson, 2010; Mendez-Parra and te Velde, 2017).

In this light, we can briefly come up with an explanation of how ODA to least developed countries either arms or helps US agricultural interests. The activities of US agricultural aid include, for example, research and development, bilateral programs, markets, and partnerships. Some of the goals behind these programs is to increase the trade between US and the partners by increasing US worker income and the availability of different imported agricultural products. As we can see, the recipient country will gain access to advanced technology (e.g., modern tractors, hybrid seeds, disease, and pest controls), leading to the growth of agriculture by improving agricultural productivity, thus a robust local economy and higher household income. Both increases in income effect and food demand will not benefit only US but also other donors. Therefore, there will be a challenge to US agricultural exports.

As a key player in agricultural investments, the US's ongoing involvement in overseas agricultural projects, such as ODA and FDI, has influenced both domestic and global markets. US ODA-FDI nexus are globally well-known and have served as a strategic tool to assist LDCs in their development. US government departments and agencies committed about $18.2 billion in bilateral and multilateral development assistance, or 37% of total foreign aid, which was disbursed to more than 150 countries as both tied and untied aid. In 2017, the United States disbursed $34.12 billion in ODA, or about 24% of total net ODA payments by DAC donors (Congressional Research Services, 2019, p25). Tied aid is provides loans and grants to recipient countries and spends the money on goods and services produced by the donor.

However, to reduce tied-aid, the US joined other donors who gathered for the Paris Declaration in March 2005 on aid effectiveness. This led to a decline in overall tied-aid from 70% of total bilateral development assistance in 1985 to an average of 12% in 2016. The US has the highest percentage of estimated tied-aid, and bilateral development assistance in 2016 is 32% (Congregational Research Services, 2019, p 25). Moreover, under the international food aid title of the agriculture appropriations, USAID has $1.3 billion in obligations, mainly to purchase US agricultural commodities. Despite US aid programs, sensitive agricultural products are restricted under tariff quotas compared to EU. However, this list is not definitive, as it depends on a specific trade agreement and might include sugar, dairy, beef, citrus, some fruits, some fresh vegetables, and corn. For instance, in 1997, among the leading aid recipients there was only one Sub-Saharan country. Then in 2017, this number was raised to seven Sub-Saharan countries, i.e., almost half of the leading aid recipients for this specific year. Sub-Saharan African countries produced and exported many of these products to other markets, including the EU, in order to access the US market (Elliott, 2015. pp. 3,4).

Foreign inflows contribute to the market dynamics of LDCs, which might lead to fluctuation of demand and supply for a given product for both donor and recipient countries. However, exports from LDCs are highly focused on sectors such as agricultural and food products which make exports vulnerable to external shocks (Elliott, 2015). LDC exports made up 1.2 percent of all exports in 2014. Despite the failure to achieve the total ODA from DAC countries to represent 0.7 percent of their gross national income, the United Nations (2015) showed that there are overall positive impacts of ODA from the perspectives of LDCs. For instance, ODA reduces poverty and ensures environmental sustainability (Easterly and Williamson, 2011). Therefore, the extent to which the increase in LDC's exports might influence donors' agricultural imports is an ongoing point of research

This study is organized as follows. Section 2 delivers a review of previous studies. Section 3 discusses the empirical analysis employed to answer the research questions, including the structural equation, data, and methodology. Section 4 presents the empirical findings regarding the effects of ODA and FDI on donors' exports and discusses reduced form. Section 5 concludes.

1.2 Literature Review

The effectiveness of foreign inflows has two directions: directly influencing recipient economies by generating income effects and demand for donors' outputs. Thus, foreign aid is not only given to affect recipients' growth primarily but also donors' growth. In this regard, we provide a literature review, in two sub-sections, a literature review on these directions. Appendix Table 1.1 provides estimates of aid's effect on the growth of imports, exports, agriculture, and GDP for selected literature.

1.2.1 Foreign Aid for Recipients' Growth

A significant amount of literature has examined the effect of foreign aid on recipient economies' economic growth. Some researchers found that foreign aid deters growth in recipient economies (Gong and Zou, 2001; Dewbre et al., 2007; Mallik, 2008; Liew et al., 2012; Mitra and Hossain, 2013; Fielding and Gibson, 2013; Mitra et al., 2015). For example, Mitra et al. (2015) studied both short and long-run impacts for 13 Asian countries and found that a 1% increase in foreign aid causes a corresponding 0.18% decrease in economic growth. Mitra and Hossain (2013) found that a 1% increase in foreign aid led to a 0.51% decrease in Philippine economic growth. Also, Mallik (2008) stated that there is a "long-term deleterious effect of international aid on living standards." In the East African countries, Liew et al. (2012) employed panel data between 1985 and 2010 and found that ODA is associated with poor economic performance of recipient.

On the other hand, other previous researchers found foreign aid contributes to economic growth (e.g., Papanek, 1973; Burnside and Dollar, 2000a; Morrissey, 2001; Dalgaard et al., 2004; Burnside and Dollar, 2000b; Gomanee et al., 2005; Karras, 2006; Askarov and Doucouliagos, 2015; Galiani et al.,2017). These studies employed different empirical methods and datasets. For example, Galiani et al. (2017) studied the effect of foreign aid on growth using a quasi-experiment for 35 countries from 1987 to 2010 and found that aid is positively associated with real economic growth in recipient economies. Gomanee et al. (2005) analyzed a pooled panel of 25 Sub-Saharan African countries and found that, on average, aid inflows contributed only 0.6 percent in real per capita GDP growth over the period 1970 to 1997. Karras (2006) employed data from 1960 through 1997 for 71 developing countries. Results suggested that a one percent increase in aid received led to a permanent increase in the economic growth of the recipient by a range of 0.14 to 0.26.

Nevertheless, several factors limit the achievement of foreign inflow goals, including the size of the recipient government, the amount of aid disbursed, and the type of aid such as tied and untied-aid (Chatterjee et al., 2003). In this regard, some authors concluded that aid has no measurable impact on economic growth (Mosley et al., 1987; Boone, 1996; Lensink and Morrissey, 2000; Easterly, 2003; Easterly et al, 2004; Dreher and Langlotz, 2020). For a more recent analysis, Dreher and Langlotz (2020) implemented an excludable instrumental variable for 96 countries between 1974 - 2009 to investigate the impact of aid and growth and found an insignificant effect of aid across different models. Moreover, the same was found in Lensink and Morrissey (2000), Boone (1996), and Mosley et al. (1987). Easterly (2003) and Easterly et al. (2004) commented on Burnside and Dollar (2000) by increasing sample size and concluded that there are doubts about the aid effectiveness found by Burnside and Dollar. By studying 67 countries from 1972 to 2000, Chatterjee et al. (2007) found the existence of fungibility at the aggregate level; hence concluding no statistically significant relationship between aid and economic growth. Furthermore, Rajan and Subramanian (2008) studied the effect of aid to GDP ratio on the growth of both panel and cross-sectional data between 1960 and 2000. Their findings suggest that no evidence of the aid's impact can be recognized on the economic growth of the recipient countries.

Even though there is a vast literature on the effectiveness of foreign aid on economic growth, a minimal number of studies investigate the relationship between foreign assistance given to the agricultural sector for agricultural growth, and these results vary. For instance, (Norton et al.,1992) concluded that there is no specific direction of the effect of ODA on agricultural productivities, with estimates ranging between 1.27 to -0.003 percentage. This variation is due to the size of external debts and income levels of the recipient countries. The

higher the financial deficit, the less effective ODA. The development level is not a primary determinant of ODA. Dewbre et al., (2007) found that the effect of agricultural aid is statistically negative on agricultural GDP growth. They pointed out two reasons; either the reduction in the domestic market induced by aid-financed investments, or the intersection and the similarities between crops planted in the donors' and recipients' countries. Kherallah et al., (1994) estimated the elasticity of ODA with respect to agricultural imports to be about 0.5, other variables being fixed. This is because most of the ODA is tied-aid, which generates increasing donor exports and dependency of most of the recipient countries on these imports as a result of income and demand effects. Moreover, the authors found that an increase in the agricultural growth of LDCs causes a decline in their imports from donor countries (Kellogg et al., 1986; de Janvry and Sadoulet, 1988; Kherallah et al., 1994). For example, Kherallah et al., (1994) showed that agricultural income growth has a positive impact on food imports; the estimate was 0.40.

1.2.2 Foreign Aid for Donors' Growth

Effects of ODA on donor countries have received considerably less attention. In the present paper, we are studying how foreign inflows into LDCs and the induced growth in these countries will impact US farmer interests. A small number literature is explicitly focused on the donor's interests or jointly including recipient economies (de Janvry and Sadoulet,1988; Arvin and Baum, 1997; Arvin and Choudry, 1997; Arvin et al., 2000; Wagner, 2003; Massa and te Velde, 2009; Silva and Nelson, 2012; Mendez-Parra and te Velde, 2017). These interests range from increase in GDP, employment, and exports. The latter is based on altering recipient preference and technology in the sense of establishing a permanent link to donors in terms of inputs produced by donors (de Janvry and Sadoulet, 1988; Hsieh and Sadoulet, 2007; Djajic et al., 2004; Mercier, 2012), such as a variety of agriculture-related inputs.

For example, Wagner (2003) studied 20 donors between 1970 and 1990. Findings suggest that the elasticity of exports to aid was between 0.062 and 0.195. In other words, Each US dollar given in aid leads, on average, to an increase in exports of the donor countries including the US between $0.73 and $2.29. Massa and te Velde (2009) investigated discrepancies in the effects of different types of aid in bilateral exports of 15 donors and 73 recipients between 1980 and 2006 from a series of 15 donors. Results show that, on average, a 10% increase in aid given (loans and grants) leads to an increase in donor country exports to recipient countries of 0.2 and 0.17 percent, respectively. Silva and Nelson (2012) employed a panel from 1962 to 2000 to consider the export from donors to recipient countries and found an elasticity of export 0.020. Mendez-Parra and te Velde (2017) studied the effect of European aid on EU exports to recipient countries. Results suggest that aid has a positive effect on exports, and elasticity of exports to aid is between 0.007 and 0.024. Wamboye (2012) investigated the importance of foreign aid's quantity and quality to LDCs from 1975 - 2011. Findings suggested that foreign aid quantity contributes to LDCs' economic growth.

Thus, focusing on bilateral or multilateral trade is not sufficient to understand the impact of aid on recipient' growth rate. The amount of aid received is the key that give a boost to recipient economies. Other studies focus on other dimensions of aid's effects in the donor economy beyond exports or growth rate, such as employment, demand for labor, and employing different analytical tools (Holland and te Velde, 2012 and Carreras et al., 2016; Mendez-Parra and te Velde, 2017). From the literature survey above, one could conclude that foreign inflows' impact on agricultural imports' growth rate is inconclusive with differences in empirical results concerning data availability, econometric techniques, and geographical applications.

As per the authors' knowledge, there is a lack of studying the effect of foreign inflows to LDCs on the agricultural exports of donor countries. Specifically, Will farmer of donor countries be affected indirectly by the induced growth in the recipient countries, especially US farmers? In this paper, we study the effect of foreign inflows to LDCs on US agricultural interests by employing system of simultaneous equations and an equilibrium displacement model (EDM) to account for (1) the causal effect of foreign inflows and (2) to isolate the exogenous component of aid and FDI. The advantage of EDM is to deduce hypotheses about how selected variables and results are expressed in terms of elasticities, which simplifies interpretation (Piggott, 1992; Wohlgenant, 2011).

1.3 Empirical analysis

1.3.1 Structural Model

Following de Janvry and Sadoulet (1988, pp. 8-9), the conditions under which growth in a developing country's agricultural sector is compatible with growth in its imports of agricultural products can be established from the following sub-sections. Therefore, our goal is to model a set of variables into a system of structural equations A, I, T Y, C, M, POP, U, X_A, X_I, P, FDI and ODA to explore the links between the agriculture, agricultural imports, FDI, and ODA. As addressed earlier, the model, containing five endogenous variables and eight exogenous variables, is in the following general format

$I = f(\boldsymbol{A},\ X_I, P,\ FDI)$ (Manufacturing);

$\boldsymbol{A} = f(\boldsymbol{I}, X_A,\ ODA)$ (Agriculture);

$\boldsymbol{Y} = f(\mathbf{A},\ \boldsymbol{I},\ T)$ (GDP);

$\mathbf{C} = f(\mathbf{A}, U,\ POP)$ (Total consumption);

$\mathbf{M} = f(\mathbf{A}, \mathbf{C})$ (Agricultural imports).

The structural model is expressed as an equilibrium displacement model (EDM) by taking the total differential of each equation and converting absolute changes in the variable to relative changes to yield; A, $I,\ T, Y, C, M, POP, U,\ X_I,\ X_A,\ P,\ FDI\ and\ ODA$

(1) $I = \alpha_A \mathrm{A} + \alpha_X X_I + \alpha_P P + \alpha_{FDI} FDI; \quad \alpha_A > 0, \ \alpha_X > 0, \ \alpha_P < 0, \ \alpha_{FDI} > 0$

(2) $\mathrm{A} = \beta_I I + \beta_X X_A + \beta_{ODA} ODA; \quad \beta_I > 0, \ \beta_X > 0, \ \beta_{ODA} > 0$

(3) $Y = \gamma_A \mathrm{A} + \gamma_I I + \gamma_T T; \quad \gamma_A > 0, \ \gamma_I > 0, \ \gamma_T = ?$

(4) $C = \delta_Y Y + \delta_U U + \delta_{POP} POP; \quad \delta_Y > 0, \ \delta_U > 0, \ \delta_{POP} > 0$

(5) $M = \varepsilon_A \mathrm{A} + \varepsilon_C C; \quad \varepsilon_A < 0, \ \varepsilon_C > 0$

where Greek symbols represent structural elasticities. To obtain elasticities, we use $El. = \omega i * (\overline{Indp.}/\overline{Dep.})$, ωi the coefficient of each variable in a specific equation, ($\overline{Indp.}$) is the mean value of the independent variable in specific equation, and ($\overline{Dep.}$) is the mean value of the dependent variable. The hypothesized signs in each equation are as follows;

The manufacturing is hypothesized to be positively related to the value added of the agricultural sector and non-agricultural exports and foreign direct investment, and negatively related to inflation. The agricultural sector is hypothesized to be positively related to the manufacturing and agricultural exports and official development assistance. The per capita GDP is hypothesized to be positively related to growth in agricultural sector and manufacturing. But the relationship is ambiguous with the tax revenue. Total consumption is hypothesized to be positively related to per capita and the urbanization and total population. Lastly, agricultural imports are hypothesized to be associated with the agricultural productivity sector and total consumption.

In this paper, the model differs from de Janvrey and Sadoulet's in that FDI and ODA are included as explicit explanatory variables, with FDI entering equation (1) and ODA entering

equation (2). This specification of FDI and ODA are hypothesized to affect agricultural imports indirectly through their effects on agricultural growth and consumption. These indirect effects are found by solving the model for the reduced form, which is done after the structural model has been estimated.

1.3.2 Data

Initially, the unbalanced panel data covers 28 countries within least developed countries (LDCs) as defined by the UN from 1994 to 2018. Based on data availability, not all LDCs are included in our analysis because of systematic missing data for at least one of our policy variables or vital independent variables (see Appendix table 1.1). For variable selection, we follow de Janvry and Sadoulet (1988), and as one of our contributions, we add five variables; the growth rate of official development assistance, the growth rate of foreign direct investment, the growth rate of agricultural exports, the growth rate of tax revenues, and the value added of manufacturing (see Table 1.1. and 1.2). It is worth noting that not all countries have a complete series of observations for the targeted period, which causes a drop in the total number of observations. A total of 13 macroeconomic variables are employed to develop a system of five simultaneous equations. All data are in terms of annual growth rate with no transformation.

The dependent variables are selected to be endogenous are and include the value added of manufacturing (I), the value added of agriculture (A), the per capita gross domestic product (GDP), the Total consumption (C), and the agricultural imports (M). More variables were included, such as non-agricultural exports, deflated Inflation rate, GDP, tax revenues, total consumption, urbanization, and the population. Foreign direct investment, agricultural growth rates, inflation, and income per capita are collected from the World Bank and IMF. We use total GDP and agricultural GDP to get non-agricultural. Net total ODA and in dollar amount were

retrieved from OECD. Agricultural trade is the difference between agricultural exports and agricultural imports in percent of GDP. Most data sources contain total imports (exports) and agricultural imports (exports) and are retrieved from FAO. Thus, we subtract the latter from the former to get non-agricultural imports (exports). Furthermore, we calculate pairwise correlation (Appendix Table 1.2.), variables have mixed and moderate correlation and signs, ≤ 0.5. Values are based on the data on hand and local conditions of host countries. The highest positive correlations are between A and ODA, C and A, and ODA and C. the highest negative correlation is between A and T.

1.4 Methods and Estimation Procedures

A system of equations is employed when several endogenous variables are modeled simultaneously. Each endogenous variable is modeled using a separate regression equation. For the system to be solvable for the endogenous variables in terms of the exogenous variables, the number of equations in the system must equal the number of endogenous variables. This system of simultaneous structural equations, in general, can be written, as $y_t'\Gamma + z_t'B = \varepsilon_t'$; where $y_t' = (y_{1t}, \dots, y_{Mt})$ is a T×M vector of endogenous variables, i.e., dependent variables, B is an N×M array of coefficients, $z_t' = (z_{1t}, \dots, z_{Nt})$ is a T×N vector of exogenous variables. Γ is an M×M array of coefficients, and ε_t' is a T×M vector of disturbances. To get the reduced form $y_t' = z_t'\prod + v_t'$; where $\prod = -\Gamma B^{-1}$ and $v_t' = \varepsilon_t' B^{-1}$, thus the covariance matrix of v_t' is $\Omega = B'^{-1}\Sigma B^{-1}$. And B must be non-singular to get a well-defend system of equations

A system of simultaneous equations is estimated to obtain estimates of structural parameters to answer our main question (whether ODA harms US agricultural interests by decreasing recipient countries' imports of agricultural products). These parameters are then

inserted into the reduced-form equation for agricultural imports to determine whether the net effect of increased ODA on imports is harmful, as asserted by opponents of aid. i.e., eq (1) to (5) -- for more details see the next section, through the equilibrium displacement model (EDM). A significant advantage of the EDM is that results are expressed in terms of partial and total elasticities, which facilitates interpretation (for more on EDM, see Piggott, 1992, Kinnucan and Myrland, 2005, and Wohlgenant, 2011). Moreover, the reason behind estimating structural equations and not borrowing elasticities from previous literature is because the eq (2) does not exist in de Janvry and Sadoulet, 1988. Also, to estimate the reduced-form parameters, as stated in (Davis and Espinoza, 1998), one can choose to arbitrarily assume the parameters, borrow them from previous literature, or use the appropriate method to get estimates. Thus, we chose the latter to estimate the targeted parameter by employing 3SLS.

As discussed in the literature review, estimating the effect of foreign inflows, ODA and FDI, on the agricultural imports of LDCs is probably not adequate using a single equation to capture all unobserved effects. Although such an approach as a single equation may, in general, provide reasonable estimates, the actual unmasked effect of ODA and FDI on agricultural imports is not captured. Empirically, the choice of this system of equations method is subject to the nature of the relationship between dependent variables. Thus, the reason for employing 3SLS rather than 2SLS is because the former estimates are consistent and asymptotically normally distributed and more efficient than single equation estimates so that the 2SLS does not account for possible correlation among error terms. Therefore, 2SLS does not provide a clear idea of channels for ODA and FDI impact. Thus, the 3SLS estimator can provide an intuition of how foreign aid affects other factors in the growth equations and how these factors, in turn, affect ODA and FDI.

To be more precise, this system equation estimated by 3SLS accounts for cross-equation contemporaneous correlation of the errors caused by shared unobserved effects across the system of equation. In addition, the simultaneous equation bias caused by the presence of endogenous dependent variables leads to gains in efficiency over its 2SLS counterpart (see, Baltagi and Deng, 2015; Greene, 2012; Baltagi and Li, 1992; Cornwell et al., 1992). No assumptions are made about the distribution of the error terms. As stated, our dependent variables are selected as endogenous; we opt not to employ the SUR because it does not assume that the dependent variables are endogenous. We account for variances and covariances of the error term and the observed variables by fitting the moments of the observed variables' distribution, viz. means, variances, and covariances, instead of the observed values.

1.4.1 The identification

The identification behind the estimation of 3SLS is as follows; In Stage 1, a set of explanatory factors (referred to as instrumental variables) are used as regressors to obtain the projected value of the dependent variable. In stage 2, residuals are estimated for every equation, and the correlation terms are calculated using these residuals. The predicted value of endogenous dependent variables from Stage 1 is used to replace the endogenous variable on the right-hand side. The error terms correlation matrix is calculated from residuals obtained at this stage. In Stage 3, error terms correlation is used to improve parameter estimates from Stage 2.

Since estimation has been done simultaneously, 3SLS method allows a more accurate allocation of internal and external instruments for individual endogenous regressors and yields more consistent estimates. In this matter, we take the first lag of the right-hand side variables and are treated as predetermined. Since we include many lagged variables, our model can be treated as a distributed lag model. Therefore, the significant reduction in number of observations is

caused by missing data and the use of lag variables in models employed. Furthermore, we also provide two additional estimates to check how the main estimates perform by changing the model specification and dataset, e.g., 2SLS along with 3SLS three-year average.

1.5 Empirical Results

System of simultaneous equations (1) to (5) specified earlier are estimated with 3SLS, all equations are significant, Chi^2 (p-value = 0.000). The results are presented in Table 1.3. The system of equations is estimated using the 3SLS and 2SLS. The following discussion is based on Table 1.3 col (2). Our estimates almost have the expected sign, and most of the main variables of interest are significant across different methods and sub-samples.

The value-added manufacturing equation

The result of this equation is in line with the results of de Janvry and Sadoulet (1994, p,5) except inflation which is insignificant and not different from zero. The growth in nonagricultural exports will lead to robust increase in the manufacturing growth. Agriculture growth has a positive impact on increasing manufacturing sector in LDCs, where agriculture has the highest share of GDP in most of these countries, hence providing raw materials to industrial sectors and transfer the saving and tax toward different sectors. The impact of foreign direct investment on manufacturing sector does not appear in the analysis de Janvry and Sadoulet and is one of policy instrument in the present paper. FDI is strongly significant however contradicts the expected sign in the present study. This negative association could be a sign of Dutch decease which is associated with the abundance of natural resources and foreign inflows, (Ge and Kinnucan, 2017: Rajan and Subramanin, 2009), thus meeting the characteristics of most of LDCs.

Agriculture equation

This equation provides a valuable information on policy variables. The effect of official development assistance on agricultural growth is significant and positive. As expected, foreign aid mainly directed to agriculture and manufacturing will improve the agriculture sector in recipient countries. ODA helps in expanding the agricultural market in recipient countries because of the financial and technology transfer such as loan and grant, and seed and machinery, thus supporting the link between aid and agricultural productivity in the LDCs by promoting technological changes in agricultural sectors. Manufacturing sector has a statistically significant impact on agriculture. These findings and the results of the previous equation (5) show the existence of reverse causation, thus supporting the use of simultaneous equations. Agricultural exports are positively related to the agriculture sector, due to several factors such as foreign aids, results consistent with Kherallah et al., (1994).

GDP Equation

As expected, both the agriculture and manufacturing sectors contributes positively to GDP. Tax revenue is measured as a percentage of GDP and hypothesized, in this paper, to have an ambiguous effect on GDP. However, results suggest that tax revenue leads to increased GDP and improve on the government balances, one of the ways the government controls economic resources. The increase of the tax revenue is determined by improvements in administering the tax and the high growth of GDP, which is a reverse causation between GDP and tax revenue.

Total consumption equation

Income per capita will contribute positively to final consumption as a result of increased household income due to growth induced by foreign inflows. This implies that agricultural trade helps to secure foreign exchange and thus increases income per capita which in turn increases

savings in least developed countries. Consequently, income effects stimulate final consumption, especially the agricultural products. Total consumption will increase as the expansion of urbanization and population of the LDCs.

Agricultural imports equation

The increase in agriculture sector will reduce the amount of the imports from donors' countries, such as the US. Results show that agricultural growth, *ceteris paribus*, reduces agricultural imports due to the contribution of foreign aids to the agricultural sector in the LDCs. This is because increase in agricultural outputs leads to an increase in LDCs agricultural productivities, thus replacing agricultural imports. Furthermore, increased agricultural imports are also stimulated by increased final consumption of LDCs due to the increase of both income and population needs.

For the robustness check, we run the equations on sub-samples. We restricted the estimates for African and Asian countries subsamples each time, employing 3SLS, Table 1.2 col. (3) and (4). Results are consistent with the entire sample. However, the magnitude in Asian countries subsample is sometimes doubled. Moreover, estimates of seemingly unrelated regression (SUR), multivariate regression (MVreg), the average of three and five years are not reported.

1.5.1 Reduced Form

The effect of foreign inflows, ODA and FDI, has been broadly estimated by single-equation regression. However, our model contains a system of reduced-form based on structural elasticities in Table 1.4. Given the structure and the assumed signs of parameters, eq (1) to (5), under what conditions would FDI- or ODA-led growth in agriculture increase imports? To answer the question, let us treat all variables except $I,\ \mathrm{A}, Y, C,$ and M as exogenous. In this

instance, solving the model for the reduced-form equations for $I,\ \mathrm{A}, Y$ in terms of the policy variables ODA and FDI gives

(6) $$\dot{I} = \frac{\alpha_{FDI}}{1-\alpha_A\beta_I} FDI - \frac{\beta_{ODA}}{1-\alpha_A\beta_I} ODA.$$

(7) $$\mathrm{A} = \frac{\alpha_{FDI}\beta_I}{1-\alpha_A\beta_I} FDI - \frac{\beta_{ODA}}{1-\alpha_A\beta_I} ODA.$$

(8) $$Y = \frac{\alpha_{FDI}(\gamma_I+\gamma_A\beta_I)}{1-\alpha_A\beta_I} FDI - \frac{\beta_{ODA}(\gamma_I+\gamma_A\alpha_A)}{1-\alpha_A\beta_I} ODA.$$

Growth in FDI or ODA can be expected to stimulate growth in manufacturing, agriculture, and income provided ($\alpha_A\beta_I < 1$), which refers to the product of the elasticity of agriculture and manufacturing growth rates, respectively. It implies that growth in FDI or ODA will cause agriculture to grow, which, in turn, will cause imports to decrease, holding constant consumption. In their regressions of equation (1) using annual growth rates for 60 less developed countries (LDCs) between 1970 and 1980, de Janvry and Sadoulet (1988, p. 5) obtained estimates of α_A that ranged from 0.56 to 0.94 depending on the country's income category, for an overall estimate of 0.82. The study did not estimate equation (2), and thus an estimate of β_I is not available. The extent of FDI or ODA promotes the successful diffusion of technological change, the recipient countries' production capacity, and their incomes should increase. Hence, the analysis will proceed under the assumption that $\alpha_A\beta_I < 1$, this implies that growth in FDI or ODA will cause agriculture to grow, which, in turn, will cause imports to decrease, holding constant consumption.

In reality, consumption will increase with FDI- or ODA-induced increases in income. Because an increase in income causes imports to increase, agricultural growth supports can also promote imports under the right conditions. What are those conditions? The answer can be found

by substituting equations (4), (7), and (8) into equation (5) to yield the reduced form equation for imports in terms of ODA and $F\dot{D}I$

(9) $M = \frac{\alpha_{FDI}(\varepsilon_A\beta_I+\varepsilon_C\delta_Y(\gamma_I+\gamma_A\beta_I))}{1-\alpha_A\beta_I} FDI + \frac{\beta_{ODA}(\varepsilon_A+\varepsilon_C\delta_Y(\gamma_I+\gamma_A\alpha_A))}{1-\alpha_A\beta_I} ODA$; *from (4),(7), (8) into (5)*

The effects of growth in FDI and ODA on import growth are uncertain without further restrictions on model parameters. Following de Janvry and Sadoulet (1988, p. 9), however, the concept of a "harmony frontier" between agricultural growth (induced by FDI or ODA) and imports can be defined as the locus of parameter values where $\partial M/\partial\, FDI = \partial M/\partial\, ODA = 0$.

The harmony frontiers for the two instruments so defined are as follows

(10) $\frac{\partial M}{\partial FDI} = 0 \Rightarrow \varepsilon_A\beta_I + \varepsilon_C\delta_Y(\gamma_I + \gamma_A\beta_I) = 0 \Rightarrow \tau_{FDI} = \frac{-\varepsilon_A}{\varepsilon_C}$

(11) $\frac{\partial M}{\partial ODA} = 0 \Rightarrow \varepsilon_A + \varepsilon_C\delta_Y(\gamma_I + \gamma_A\alpha_A) = 0 \Rightarrow \tau_{ODA} = \frac{-\varepsilon_A}{\varepsilon_C}$

where both, $\tau_{FDI} = \frac{\delta_Y(\gamma_I+\gamma_A\beta_I)}{\beta_I}$ and $\tau_{ODA} = \delta_Y(\gamma_I + \gamma_A\alpha_A)$, are positive scalars. Three scalars characterize the frontier of harmony between LDCs' agricultural development and US agricultural export interests with respect to FDI: ε_A, ε_C and τ_{FDI}. The scalars ε_A and ε_C represent the responsiveness of agricultural imports to the agricultural value-added and total consumption, respectively (see equation (5)); the scalar τ_{FDI} represents the strength of income effects in the model induced by FDI. For a given value of ε_A the more robust the income effects, i.e., the larger τ_{FDI}, the smaller ε_C has to overcome the adverse effects of agricultural development (induced by FDI) on imports of agricultural products.

There will be harmony on the side of the frontier where $\partial M/\partial\, FDI > 0$ (implying $\tau_{FDI} > -\varepsilon_A/\varepsilon_C$), and conflict where $\partial M/\partial\, FDI < 0$ (implying $\tau_{FDI} < -\varepsilon_A/\varepsilon_C$). A similar interpretation applies to the frontier with respect to ODA. If agricultural growth is not dependent on the growth of the industrial sector, i.e., if $\beta_I = 0$, then equation (9) reduces to

(12) $M = \alpha_{FDI}\, \varepsilon_C \delta_Y \gamma_I\, FDI + \beta_{ODA}(\varepsilon_A + \varepsilon_C \tau_{ODA})\, ODA$

In this instance, agricultural interests need not be concerned about FDI as $\partial M/\partial\, FDI > 0$ and harmony prevails with respect to this policy instrument. Conflict, however, may still exist with respect to ODA depending on the relative size of $|\varepsilon_A|$ and $\varepsilon_C \tau_{ODA}$. Comparing the coefficients of ODA in equations (9) and (12), the main effect of a lack of interaction between the agricultural and industrial sectors (as measured by $\alpha_A \beta_I$) is to reduce the size of the absolute value of $|\partial M/\partial\, ODA|$. Thus, the two parameters, α_A and β_I, are critical parameters in the system, to which we now turn to estimate.

Therefore, to figure out the right conditions, that support how agriculture can increase imports, we use elasticities calculated from the structural equation to be substituted in eq (9) to get the reduced for imports in terms of FDI and ODA, Table 1.5. Thus, FDI and ODA's effect on import growth is uncertain without further restrictions on model parameters. Therefore, the reduced-form equation, results for the agricultural imports suggest that FDI (-0.07) negatively affects the LDCs. Several literatures support this (see Alfaro et al, 2010 and Alfaro, 2017), who discuss the ambiguous relationship between FDI and growth and rely on such adverse impact on the local condition of the host countries, especially FDI into the primary sector. On the other hand, foreign aids (0.17) into LDCs helps to increase the imports of food and agricultural products. Therefore, financial and technological transfers have positive influences on the income and demand effects in LDCs.

The harmony frontier for the two policy instruments is calculated by taking the partial derivative of the agricultural import (M) growth rate equation with respect to the parameters. Therefore, the frontier of harmony between LDCs' agricultural development and US agricultural export interests regarding FDI and ODA is characterized by three scalars for each. The first two

scalars are ε_A and ε_C and represent the responsiveness of import growth to agricultural growth and consumption growth, respectively, $(-\varepsilon_A / \varepsilon_C = 0.192)$. The third scalar for FDI is (t_{FDI}) and represents the strength of income effects in the model induced by FDI ($t_{FDI} = 2.956$). The third scalar for ODA is (t_{ODA}) and represents the strength of income effects in the model induced by ODA, ($t_{ODA} = 0.790$). There will be a harmony of the side of the frontier for FDI because of ($t_{FDI} > -\varepsilon_A / \varepsilon_C$). There will also be a harmony for ODA because of ($t_{ODA} > -\varepsilon_A / \varepsilon_C$). The results show that there will be harmony on the side of the frontier of ODA and FDI in the US agricultural interests.

However, ODA might indirectly affect agricultural productivity because it might be one reason workers move to industrial sectors. As a result, the substitution effect of ODA could be more than the income effects. Results suggest a harmony between ODA and FDI in US agricultural interests, which might lead to contrasting aid programs with the LDCs. Therefore, the increase in agricultural productivity in LDCs induced by foreign aid, more efficient producers; thus, the US farm exports raise if not remain the same. One possible reason is that ODA positively influences FDI, especially in the manufacturing sector, when the former directed the productive activities (Yiheyis and Cleeve, 2018) to attract more FDI in the manufacturing sector LDCs such as Sub-Saharan countries (World Bank, 2015). Another reason is the benefit of international trade under the assumption of an open-market relationship between large and small economies.

Assuming that the domestic price, P_D, in LDCs is less than the world price, P_W, since the US is a major producer of many main agriculture goods, will determine the market price. Therefore, LDCs exports will increase because of the difference between the prices, $P_D < P_W$, and relatively lower production costs, thus, increasing LDCs local producers' surplus is assumed

to be one of the causes of the drop in US local producers' surplus. However, amount of LDCs exports will cause a significant damage to the US share in the global agriculture trade due to the comparative advantages of US products and tied-aid.

1.6 Conclusion

The purpose of this study is to extend de Janvry and Sadoulet (1988) analysis by including Foreign Direct Investment (FDI) and Official Development Assistance (ODA) as explicit policy instruments affecting growth rates in the industrial and agricultural sectors of LDCs. The unbalanced panel data covers 28 least developed countries to estimate the model and updated to 1994-2018 (de Janvry and Sadoulet's estimates are based on 1970 to 1980) dataset. De Janvry and Sadoulet found that if harmony prevails, growth in agricultural productivity must be matched by growth in the industrial sector. At issue is the finding robustness and the extent to which FDI and ODA can be manipulated to achieve the result.

To answer the research question – Does foreign aid to developing countries help or harm US agricultural interests? We treaded the following variables as endogenous: the manufacturing (I), agricultural value-added (A), the gross domestic product (Y), the total consumption (C), and the agricultural imports (M). There are a few limitations. For example, the total number of observations is reduced due to missing data that follow a systematic pattern. Many LDCs are dropped from the data because of missing the entire observation of crucial variables, especially the FDI and ODA.

Therefore, five simultaneous equations are structured, and the equilibrium displacement model is developed, then we solve the model for the reduced form. The analysis was performed by employing three stages least squares (3SLS) for simultaneous equations systems to control for unobserved heterogeneity across the countries. Given structural and

assumed signs of parameters, our results suggest that an isolated 10% increase in ODA will result in a statistically significant increase in the growth rate of imports by 1.5%, holding other variables constant. The results are consistent with the previous literature in which the ODA contributes positively to the economy. Therefore, ODA increases will increase the economic growth of LDCs through productivity and efficiency gained.

Regarding the harmony frontier, FDI and ODA are treated as explicit policy instruments affecting LDC's industrial and agricultural sectors. After calculating, we concluded that there would be harmony on the side of the frontier for ODA and FDI. However, it also tends to increase import demand through the positive effects that improved efficiency has on the national income of the LDCs. Although the aid increases the capacity to import capital goods and technology transfers, thus promoting endogenous technical change, not all donors will benefit because most recipient economies tend to import from their historical trade partners (Morrissey, 2001; Mendez-Parra and te Velde, 2017).

1.7 Reference

Addison, T., and F. Tarp. 2015. "Aid policy and the macroeconomic management of aid." *World Development* 69:1-5. https://doi.org/10.1016/j.worlddev.2014.02.009.

Alfaro, L. 2017. "Gains from Foreign Direct Investment: Macro and Micro Approaches." The World Bank Economic Review 30:S2–S15., https://doi.org/10.1093/wber/lhw007

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek. 2010. "What explains developing country growth." *Journal of Development Economics* 91(2): 242–256. Also NBER working Paper No. 12522. Cambridge, MA.

Arvin, M., and C. Baum. 1997. "Tied and Untied Foreign Aid: A Theoretical and Empirical Analysis" Keio Economic Studies 34: 71-79.

Arvin, M., and S. Choudry. 1997. "Untied Aid and Exports: Do Untied Disbursements Create Goodwill for Donor Exports?" *Canadian Journal of Development Studies* 18(1): 9-22.

Arvin, M., Cater, B., and S. Choudry. 2000. "A Causality Analysis of Untied Foreign Assistance and Export Performance: The Case of Germany." *Applied Economics Letters* 7: 315-319.

Askarov, Z., and H. Doucouliagos. 2015. "Development Aid and Growth in Transition Countries." *World Development* 66: 383–399.

Baltagi, B. H., and Q. Li. 1992. "A note on the estimation of simultaneous equations with error components." *Econometric Theory* 8(1):113-119.

Baltagi, B. H., and Y. Deng. 2015. "EC3SLS Estimator for a Simultaneous System of Spatial Autoregressive Equations with Random Effects." *Econometric Reviews* 34:6-10,659-694.

Blomstrom, M., R. Lipsey, and M. Zejan. 1992. "What explains developing country growth." National Bureau of Economic Research (NBER) working Paper No. 4132. Cambridge.

Bloom, D., and J. D. Sachs. 1998. "Geography, demography and economic growth in Africa." *Brookings Papers on Economic Activity* 2: 207-273.

Boone, P. 1996. "Politics and the effectiveness of foreign aid." *European Economic Review* 40: 289-329. https://doi.org/10.3386/w5308.

Borensztein, E., J. De Gregorio, and J. W. Lee. 1998. "How does foreign direct investment affect economic growth?" *Journal of International Economics* 45: 115-135.

Burnside, C., and D. Dollar. 2000. "Aid, Policies, and Growth." *The American Economic Review* 90: 847-868. https://doi.org/10.1257/aer.90.4.847.

_____. 2004. "Aid, Policies, and Growth: Reply." *American Economic Review* 94: 781-784.

Bru¨ckner, M. 2013. "On the simultaneity problem in the aid and growth debate." *Journal of Applied Econometrics* 28(1):126–150.

Byerlee, D., A. de Janvery, and E. Sadoulet. 2009. "Agriculture for development: Toward a New Paradigm." *Annual Review of Resource Economics* 1(1): 15-35.

Chatterjee, S., P. Giuliano, and I. Kaya. 2007. "Where Has All the Money Gone? Foreign Aid and the Quest for Growth." IZA Discussion Paper No. 2858.

Chatterjee, S., G. Sakoulis, and S.J. Turnovsky. 2003. "Unilateral Capital Transfers, Public Investment, and Economic Growth." *European Economic Review* 47: 1077-1103.

Chimhowu, A. 2013. "Aid for agriculture and rural development in the global south: A changing landscape with new players and challenges." Working Paper No. 14 (Helsinki, United Nations University, World Institute for Development Economics Research (UNU-WIDER).

Clements, B., S. Gupta, A. Pivovarsky, and E.R. Tiongson. 2004. "Foreign Aid: Grants versus Loans." *Finance & Development* 41: 46-49.

Clemens, M., S. Radelet, R. Bhavnani, and S. Bazzi. 2012. "Counting chickens when they hatch: Timing and the effects of aid on growth." *Economic Journal* 122: 590-619. https://doi.org/10.1111/j.1468-0297.2011.02482.x

Congressional Research Service. 2019. "Foreign Aid: An Introduction to US Programs and Policy," Updated April 16, 2019.

Cornwell, C., P., Schmidt, and D. Wyhowski. 1992. "Simultaneous equations and panel data." *Journal of Econometrics* 51(1-2):151-181.

Dalgaard, C.-J., and H. Hansen. 2001. "On Aid, Growth and Good Policies." *Journal of Development Studies* 37: 17-41.

Dalgaard, C. J., H. Hansen, and F. Tarp. 2004. "On the empirics of foreign aid and growth." *The Economic Journal* 114: 191-216. doi: 10.1111/j.1468-0297.2004.00219.x.

Deaton, A. 2013. The Great Escape: Health, Wealth, and the Origins of Inequality, Princeton University Press, Princeton, NJ.

Dreher, A., and S. Langlotz. 2020. "Aid and growth. New evidence using an excludable instrument." *Canadian Journal of Economic* 53(3) 1162-1198.

de Janvry, A., and E. Sadoulet. 1988. "The conditions for compatibility between aid and trade in agriculture." *Economic Development and Cultural Change 37*(1): 1-30.

Doucouliagos, H., and M. Paldam. 2009. "The aid effectiveness literature: The sad results of 40 years of research." *Journal of Economic Surveys* 23(3): 433-461.

Dewbre, J., W. Thompson, and J. Dewbre. 2007. "Consistency or Conflict in OECD Agricultural Trade and Aid Policies." *American Journal of Agricultural Economics* 89: 1161-1167.

Easterly, W. 2003. “Can Foreign Aid Buy Growth?” *Journal of Economic Perspectives* 17: 23-48.

Easterly, W., R. Levine, and D. Roodman. 2004. “Aid, Policies, and Growth: Comment.” *American Economic Review* 94: 774-780.

Easterly, W., and Claudia R Williamson. 2011. “Rhetoric versus Reality: The Best and Worst of Aid Agency Practices.” *World Development* 39(11):1930-1949.

Elliott, Kimberly Ann. 2015. “Trade Preferences for the Least Developed Countries: Opportunities Not Panaceas.” E15 Initiative. Geneva: International Centre for Trade and Sustainable Development (ICTSD) and World Economic Forum, 2015. www.e15initiative.org/

Fayissa, B., and M. El-Kaissy. 1999. “Foreign aid and the economic growth of developing countries (LDCs): Further evidence.” *Studies in Comparative International Development* 34(3): 37–50.

Fielding, D. and Gibson, F. 2013. “Aid and Dutch Disease in Sub-Sahara Africa*.” Journal of African Economies* 22: 1-21.

Galiani, S., S. Knack, L. C. Xu, and B. Zou. 2017. “The effect of aid on growth: evidence from a quasi-experiment.” *Journal of Economic Growth* 22: 1–33. https://doi.org/10.1007/s10887-016-9137-4

Gates, B., and M. Gates. 2014. “Three Myths on the World’s Poor.” *Wall Street Journal* January 17, 2014. Retrieved from http://online.wsj.com/news/articles/SB10001424052702304149404579324530112590864.

Gomanee, K., S. Girma, and O. Morrissey. 2005. "Aid and growth in Sub-Saharan Africa: Accounting for transmission mechanisms." *Journal of International Development* 17: 105-1075. https://doi.org/10.1002/jid.1259

Gong, L., and Zou, H. F. 2001. "Foreign aid reduces labor supply and capital accumulation." *Review of Development Economics* 5: 105-118.

Greene, W. H. 2012. "Econometric Analysis." 7th ed. Upper Saddle River, NJ.

Gyimah-Brempong, K., and J. S. Racine. 2014. "Aid and economic growth: A robust approach." *Journal of Africa Development* 16: 1-35.

Hansen, H., and F. Tarp. 2000. "Policy arena: Aid effectiveness disputed." *Journal of International Development* 12(3): 375–398.

_____. 2001. "Aid and growth regressions." *Journal of Development Economics* 64(2): 547–570.

Heidelberg, E. M., and Chatrna, D. 2010. "The effect of foreign aid on economic growth in developing countries." *Journal of International Business and Cultural Studies* 3: 1-13.

Hsieh, C., and E. Sadoulet. 2007. "Agriculture and Development." Background note for the World Development Report 2008, The World Bank, Washington, DC.

Karras, G. 2006. "Foreign aid and long run economic growth: Empirical evidence for a panel of developing countries." *Journal of International Development* 18: 15-28. https://doi.org/10.1002/jid.1187.

Kellogg, E., Kod L, R., and Garcia, P. 1986. "The effects of agricultural growth on agricultural imports in developing countries." *American Journal of Agricultural Economics* 68(5): 1347-1352.

Kherallah, M. W., J. C. Beghin, E. W. F. Peterson, and F. J. Ruppel. 1994. "Impacts of official development assistance on agricultural growth, savings, and agricultural imports." *Agricultural Economics* 11(2–3): 99-110.

Lee, J. E. JR., and M. Shane. 1987. "US agricultural interests and growth in the developing economies: The critical linkage." National Planning Association. Food and Agriculture Committee, Washington, DC.

Lensink, R., and O. Morrissey. 2000. "Aid instability as a measure of uncertainty and the positive impact of aid on growth." *Journal of Development Studies* 36: 31-49.

Lensink, R., and H. White. 2000. "Aid allocation, poverty reduction, and the assessing aid report." *Journal of International Development* 12(3): 399–412.

Liew, C. Y., M. R., Mohamed, and SS Mzee. 2012. "The impact of foreign aid on economic growth of East African countries." *Journal of Economics and Sustainable Development* 3: 129-138.

Massa, I. and te Velde, D.W. 2009. "The trade distortion implications of loans and grants: An econometric examination", in, the trade implications of aid instruments and tying practices. Bonn: KFW -Development Research. 23-51

Mallik, G. 2008. "Foreign aid and economic growth: A cointegration analysis of the six poorest African countries." *Economic Analysis and Policy* 38: 251–260. https://doi.org/10.1016/S0313-5926(08)50020-8

Mendez-Parra M. and D. W. te Velde. 2017. "The effects of aid on EU employment and trade An econometric investigation". Working paper 510, May 2017. London: Overseas Development Institute (ODI).

Mercier, S. 2012. “US Agricultural Development Assistance and Food Aid: Programs and Issues.” Agree Transforming Food and Ag Policy, Nov 2012, pp29-31.

Mitra, R., and M. S. Hossain. 2013. “Foreign aid and economic growth in the Philippines.” *Economics Bulletin* 33: 1706-1714.

Mitra, R., M. S. Hossain, and M. I. Hossain. 2015. “Aid and per-capita economic growth in Asia: A panel cointegration tests.” *Economics Bulletin* 35: 1693-1699.

Morrissey, O. 2001. “Does aid increase growth?” *Progress in Development Studies* 1: 37-50. https://doi.org/10.1191/146499301701571354

Mosley, P., J. Hudson, and S. Horrell. 1987. “Aid, the public sector and the market in less developed countries.” *Economic Journal* 97: 616-641.

Norton, G., and J. Ortiz. 1992. “The impact of foreign assistance on agricultural growth.” *Economic Development & Cultural Change* 40: 775.

Organisation for Economic Co-operation and Development (OECD). 2016. Net ODA. Retrieved November 30, 2016, from https://data.oecd.org/oda/net-oda.htm#indicator-chart

Papanek, G. 1973. “Aid, private foreign investment, savings and growth in less developed countries.” *Journal of Political Economy* 81: 120-130. https://doi.org/10.1086/260009

Piggott, R. R. 1992. “Some old truths revisited.” *Australian Journal of Agricultural Economics*, 36: 117-140.

Rajan, R., and A. Subramanian. 2008. “Aid and Growth: What does the cross-country evidence really show?” *Review of Economics and Statistics* 90(4): 643–665.

Ravallion, M. 2014. “On the role of aid in The Great Escape.” *Review of Income Wealth* 60: 967-984.

Riddel, R.C. 2007. “Does Foreign Aid Really Work?” 1st ed. Oxford University Press.

Roodman, D. 2007. “The anarchy of numbers: Aid, development, and cross-country empirics.” *The World Bank Economic Review* 21(2): 255-277.

United Nations. 2015. “The Millennium development goals report 2015.” United Nations, New York, NY.

World Bank. 2015. “Manufacturing FDI in Sub-Saharan Africa: Trends, Determinants, and Impact.” World Bank, Washington, DC.

World Health Organization. 2017. “UN sustainable development summit 2015: Sustainable Development goals.” Retrieved May 26, 2017, from http://www.who.int/mediacentre/events/meetings/2015/un-sustainable-developmentsummit/en/

Wamboye, E. 2012. “Quantity or quality? Foreign aid implications on economic growth in least developed countries.” Munich Personal RePEc Archive (MPRA) paper 39518, University Library of Munich, Germany.

Wohlgenant, M. K. 2011. “Consumer demand and welfare in equilibrium displacement models.” The Oxford Handbook of the Economics of Food Consumption and Policy, 0-44.

Wu, J. Y., and C. C. Hsu. 2008. “Does foreign direct investment promote economic growth? Evidence from a threshold regression analysis.” *Economics Bulletin* 15: 1-10.

Zelealem Yiheyis & Emmanuel Cleeve, 2018. “Official Development Assistance and Foreign Direct Investment: An Empirical Investigation of Their Implications for Domestic Capital Formation in Africa.” *Annals of Economics and Finance* 9(2):625-651.

Yiew, T. H., and Lau, E. 2018. “Does foreign aid contributes to or impeded economic growth.” *Journal of International Studies* 11(3): 21-30. doi:10.14254/20718330.2018/11-3/2

Table 1.1. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
I	642	9.220	4.660	0.1	24.6
A	677	28.780	11.750	4.8	61.4
M	639	1.040	0.223	0.400	2.465
FDI	699	3.415	5.380	-6.1	46.5
ODA	577	29.882	25.860	0.4	249.5
Y	699	4.420	5.200	-50.2	35.2
XA	671	23.300	12.173	4.7	89.7
XI	637	1.070	0.450	0.121	7.154
C	641	77.390	12.190	28.8	137.3
T	556	12.471	7.820	2.130	56.920
U	699	4.100	1.530	0.3	17.5
POP	699	2.520	0.970	-5.4	8.1
Country name	699	-	-	1	28
Time	699	-	-	1994	2018

Source: Authors' calculations. Numbers are rounded to three decimals. Please see table 2. regarding the definitions of the variables.

Table 1.2. Variable Names, Descriptions and Data Sources

Variables	Classification	Appear in de Janvry and Sadoulet (1988)*		Source
FDI	Exogenous	NO	Foreign direct investment, net inflows (% of GDP)	WDI
X_A	Exogenous	NO	Agricultural raw materials exports (%)	Cal. from FAO
ODA	Exogenous	NO	Net ODA received (% of GDP)	OCED
T	Exogenous	NO	Tax revenue (% of GDP)	WDI and IMF
A	Endogenous	YES	Agriculture, value added (annual % growth)	WDI
I	Endogenous	YES	Manufacturing, value added (annual % growth)	WDI
Y	Endogenous	YES	GDP growth (annual %)	WDI
C	Endogenous	YES	Final consumption expenditure (annual % growth)	WDI
M	Endogenous	YES	Growth rate of Agricultural imports	FAO
X_I	Exogenous	YES	Exports of goods and services (annual % growth)	WDI
P	Exogenous	YES	Inflation, GDP deflator (annual %)	WDI
U	Exogenous	YES	Urban population growth (annual %)	WDI
POP	Exogenous	YES	Population growth (annual %)	WDI

(*) "NO" indicates the variable is used to extend de Janvry and sadoulet (1988) paper along with our different period and estimation methods employed.

Table 1.3. The Estimates of Simultaneous Equations, Least Developed Countries, 1994-2018

VARIABLES		(1) 2SLS All	(2) 3SLS All	(3) 3SLS African	(4) 3SLS Asian
Manufacturing value added equation					
Exports of goods and services	XI	0.179***	0.141***	0.175***	0.393***
		(0.017)	(0.016)	(0.017)	(0.120)
Agriculture, value added	A	0.150***	0.181***	0.147***	0.103
		(0.014)	(0.013)	(0.013)	(0.070)
Inflation, GDP deflator	P	0.006	0.000	-0.012	0.082
		(0.015)	(0.014)	(0.013)	(0.153)
Foreign direct investment, net inflows	FDI	-0.175***	-0.100**	-0.064	-0.902
		(0.051)	(0.047)	(0.045)	(0.604)
Constant		16.625***	18.050***	15.833***	23.813**
		(0.912)	(0.872)	(1.062)	(1.133)
Agriculture, value added equation					
Manufacturing, value added	I	0.255**	0.771***	0.507***	1.016***
		(0.114)	(0.105)	(0.129)	(0.156)
Agricultural raw materials exports	XA	12.283***	9.718***	11.965***	1.959
		(1.088)	(1.007)	(1.255)	(1.463)

Net ODA received (% of GDP)	ODA	0.404***	0.345***	0.346***	0.714***
		(0.025)	(0.023)	(0.026)	(0.082)
Constant		24.592***	30.775***	30.728***	41.270***
		(1.920)	(1.732)	(2.221)	(2.530)
GDP growth equation					
Agriculture, value added	A	0.071***	0.092***	0.104***	0.002
		(0.012)	(0.012)	(0.014)	(0.019)
Manufacturing, value added	I	0.141***	0.119***	0.018	0.267***
		(0.044)	(0.042)	(0.056)	(0.031)
Tax revenue	T	0.115***	0.102***	0.134***	0.316***
		(0.024)	(0.024)	(0.028)	(0.049)
Constant		7.020***	6.216***	6.841***	10.900***
		(1.320)	(1.301)	(1.550)	(3.100)
Final consumption equation					
GDP	Y	0.984***	1.191***	0.881**	6.795***
		(0.365)	(0.321)	(0.344)	(0.847)
Urban population	U	11.528***	10.913***	6.654***	8.292***
		(1.205)	(1.070)	(1.545)	(1.938)
Population	POP	7.703***	8.024***	14.266***	0.101
		(1.802)	(1.600)	(2.246)	(4.622)

Constant		94.004***	91.706***	98.195***	91.710***
		(2.380)	(2.132)	(2.663)	(2.132)
Agricultural imports equation					
Agriculture, value added	A	-0.003**	-0.003**	-0.003**	-0.001
		(0.001)	(0.001)	(0.001)	(0.003)
Final consumption	C	0.014***	0.015***	0.015***	0.014***
		(0.001)	(0.001)	(0.001)	(0.001)
Constant		1.050***	1.683***	1.014***	1.683***
		(0.070)	(0.400)	(0.080)	(0.400)
Observations		356	356	275	60

Source: the authors estimations of equation (1 to 5) and employing Three-stages least squares (3SLS) method. Dependent variables and lagged independent variables. Parameters estimates are rounded to three decimals. Numbers in parentheses = robust standard errors. Least Developed Countries is based on the UN definition. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.1$, ** $p<0.05$, *** $p<0.001$.

Table 1.4. Structural Elasticities

Elasticities	2SLS	3SLS
α_{FDI}	-0.065	-0.120
ε_A	-0.083	-0.160
β_I	0.462	0.210
ε_C	1.042	0.820
δ_Y	0.056	0.510
γ_I	0.611	1.400
γ_A	0.056	0.510
β_{ODA}	0.325	0.153
α_A	0.452	0.370

Source: the authors calculations using $\beta_i(\bar{x}/\bar{y})$ of equation (1 to 5) on the overall means from Table 1.1 and parameters from Table 1.3. Parameters estimates are rounded to three decimals. Least Developed Countries is based on the UN definition. These values are used in the remain equations (6 and so forth) to calculate any values needed. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * p<0.1, ** p<0.05, *** p<0.001

Table 1.5. Reduced Elasticities

Elasticities	2SLS	3SLS
Ag Imports/FDI	9.0283E-05	-0.0727312
Ag Imports/ODA	-0.0187794	0.1723449

Source: the authors calculations using the elasticities from Table 1.5 and then plug into eq (9)

$$\dot{M} = \frac{\alpha_{FDI}(\varepsilon_A\beta_I + \varepsilon_C\delta_Y(\gamma_I + \gamma_A\beta_I))}{1-\alpha_A\beta_I}\dot{FDI} + \frac{\beta_{ODA}(\varepsilon_A + \varepsilon_C\delta_Y(\gamma_I + \gamma_A\alpha_A))}{1-\alpha_A\beta_I}\dot{ODA}$$

Appendix Table 1.1. The effect of Aid on the growth of imports, Exports, Agricultural and GDP

	Agricultural growth	Agricultural import (recipients)	Export (donors)	Economics growth
Dewbre et al., 2007	-0.003			
Norton et al., 1992	1.27 to -0.003			
Kherallah et al., 1994	0.007	0.38 to 0.45		
Mendez-Parra and te Velde (2017)			0.007 and 0.024	
Silva and Nelson (2012)			0.020	
Massa and te Velde (2009)			0.02 and 0.017	
Wagner (2003)			0.062 and 0.195	
Mitra et al. (2015)				0.18
Mitra and Hossain (2013)				0.51
Gomanee et al. (2005)				0.6
Karras (2006)				0.14 to 0.26

Collected from literature discussed in literature review section

Appendix Table 1.2. Least Develop Countries*, 1994-2018

Country Name	Country Name
Angola	Madagascar
Bangladesh	Malawi
Benin	Mauritania
Burkina Faso	Mozambique
Burundi	Nepal
Central African Republic	Niger
Chad	Rwanda
Congo, Dem. Rep.	Senegal
The Gambia	Sierra Leone
Guinea	Sudan
Guinea-Bissau	Tanzania
Haiti	Togo
Lao PDR	Uganda
Lesotho	Vanuatu

*****The panel data covers 28 countries within least developed countries (LDCs) as defined by UN, over the period of 1994-2018. Based on and data availability, not all LDCs are included in our analysis because of systematic missing data of at least one off our policy variables.

Appendix Table 1.3. Correlation of variables, LDCs countries, 1994-2018

	ODA	FDI	M	A	X_A	C	POP	U	T	Y	X_I	P	I
ODA	1.000												
FDI	-0.159	1.000											
M	0.022	-0.010	1.000										
A	0.562	-0.045	-0.002	1.000									
X_A	-0.007	-0.006	0.149	0.022	1.000								
C	0.428	-0.174	-0.001	0.501	-0.023	1.000							
POP	0.260	0.147	-0.009	0.189	-0.010	-0.300	1.000						
U	0.072	0.061	-0.023	-0.033	-0.028	-0.350	0.523	1.000					
T	-0.351	0.173	-0.013	-0.557	-0.034	-0.315	-0.093	-0.072	1.000				
Y	0.047	0.099	0.089	-0.031	0.024	-0.131	0.086	0.170	-0.002	1.000			
X_I	-0.350	0.288	0.000	-0.480	0.011	-0.446	0.011	-0.015	0.650	0.010	1.000		
P	0.102	0.040	0.040	-0.011	-0.024	-0.024	0.020	0.015	0.027	0.004	0.100	1.000	
I	-0.142	-0.209	0.018	-0.321	-0.007	0.157	-0.254	-0.011	0.006	0.004	-0.111	-0.066	1.000

Chapter 2
The effect of the Chinese Outward Directed Investment on the Level of Income Inequality: Evidence from Low-income African Countries

2.1 Introduction

In recent decades, ongoing debates have taken place regarding the relationship between income inequality and globalization. Reducing inequality is one of the sustainable development goals (SDGs) to deal with global and local issues and achieve a sustainable future. Several studies shed light on the determinants of income inequality in host countries, such as trade openness and financial development, governance, economic growth, and education. Many studies show that the influences of increased globalization on within-country inequalities are mixed (see Wei and Wu, 2001; Mah, 2002; Milanovic, 2002; Bhagwati, 2004; Stiglitz, 2006; Harjes, 2007; Neutel and Heshmati, 2006; Atkinson et al., 2011; Cabral, et al., 2016; Urata and Narjoko, 2017).

A key factor hypothesized to affect income inequality is Foreign Direct Investment (FDI), often employed in the literature as a proxy for globalization (Huang et al., 2020; Xu et al, 2021). As a source of external finance for recipient economies, FDI, in general, leads to increased employment and wage levels but might also increase wage inequality. As consequence, FDI-induced growth has not necessarily led to a reduction in the level of income inequality of the recipient countries (Goldberg and Pavcnik, 2007; Chen, Ge, and Lai., 2011; Kaulihowa and Adjasi, 2018; Song et al., 2021), as the GDP per capita increased, the level of income inequality decreased (Huang et al., 2020; and Xu et al., 2021).In this matter, if host countries are relatively abundant in less-skilled labor, such as low-income African countries, then FDI should be directed toward activities that hire less-skilled laborers so that the society will benefit from increased income redistribution (Kaulihowa and Adjasi, 2018; Chen et al., 2018; Song et al., 2021). African countries have a higher population growth rate so the impact of foreign direct investment on employment and technological change is of particular research interest (e.g.,

Adams, 2009; Adams and Kloboudu, 2017; Kaulihowa et al., 2018; Fosu, 2018; Huang et al., 2020; Song et al., 2021).

The effect of globalization on international development is perceptible. For example, FDI[1] during the period 1970 to 2012 increased from 13.5 billion USD to 1.32 trillion USD and then increased by 10.9 percent in 2013, reaching US1.46 trillion USD (UNCTAD, 2015). In 2015, total FDI was $1.7 trillion, up 36% from 2008. Several international development organizations have reported that African countries have received significant investments from different sources in 2015, such as the European Union (EU), led by France and the United Kingdom; USA; China; India; Brazil; and Intra-Africa with 54 billion USD. FDI stocks[2] of EU, USA, and China were, in 2012, about 175; 61; and 22 billion USD, respectively (UNCTAD 2014.)

Although the EU and USA are significant trade and aid partners for Africa, Chinese FDI has increased remarkably up to 4,000 percent over 2003-2012, from 491 million USD to 21.7 billion USD (Ross, 2015, p.6). The significant increase of Chinese outward direct investments, hereafter (CODI), is shown in Graph 2.1, CODI flow and stock to African countries, 2003-2014. From either state-owned firms or the private sector, these Chinese investments cover 49 African countries in various sectors regardless of the governance environment in these countries. Chinese enterprises currently exceed 2,200 operating in Sub-Saharan Africa (UNCTAD, 2014; Pigato and Tang, 2015), and Chinese authorities reported in

[1] FDI is measured as a flow or a stock. FDI flow refers to the value of FDI over an interval of time, e.g., one-quarter or one year. An FDI stock represents amount of FDI assets accumulated in the past at a given point in time (Wikipedia).

2 There are two types of FDI stocks, inward and outward. “The outward FDI stock is the value of the resident investors' equity in and net loans to enterprises in foreign economies. The inward FDI stock is the value of foreign investors' equity in and net loans to enterprises resident in the reporting economy [e.g., low-income African countries]” (OECD). Also, “FDI stocks are estimated by either cumulating FDI flows over time or adding flows to an FDI stock that has been obtained for a particular year from national official sources” (UNCTAD, 2014).

2014 that Chinese workers in Africa reached 250,059 workers[3]. China-SSA trade reached 170 billion US dollars in 2013 (UNCTAD, 2013). It appears in Graph 2.2 that Chinese exports drastically increased, making China the most significant export partner in Africa (Pigato and Tang, 2015.)

In theoretical and empirical research, various models are employed to evaluate the consequences of FDI and income inequality, especially in developing countries. For instance, two international development hypotheses have emerged from the theoretical analysis: the modernization theory and the dependency theory. These hypotheses distinguish the relationship between developed and developing countries. The former is the home economy of a multinational enterprise, and the latter is a host economy. Thus, based on the returns of production factors and other host country local conditions, these two hypotheses arguably explain how FDI to host economies is ambiguously associated with income inequality (Bornschier, 1983 and Tsai, 1995). If foreign inflows contribute positively to income distribution, the case will be in favor of the modernization hypothesis. Otherwise, the case will be in support of the dependency hypothesis.

Several international organizations have reported income inequality in Africa (UNDP, WDI, IMF, AFDB). In the present research, most low-income African countries have almost the same mean value of income inequality measured by the Gini coefficient. This measure's value ranges between 0%, which reflects complete equality, and 100% which indicates complete inequality. For low-income African countries, mean values of the Gini index over the period 2003-2014, on average, are between 38% and 46% (Table 1.1). Some countries exhibit high-

[3] The Chinese workers is one of the controversial points about China-Africa relationship because of the differences between revealed-data from different sources. Park (2009) estimated the total number of total Chinese laborers in different African countries about 700,000 workers, which is much larger comparing to the Chinses Authorities' numbers.

income inequality levels, such as Tanzania, Madagascar, and Zimbabwe, with about 53%, 51%, and 50%, respectively. That makes the low-income African countries among the least efficient countries regarding the income redistribution policy.

The effect of Chinese African trade relationships on the economic growth of recipient countries has been discussed in numerous studies. The findings vary, authors show that both China and Africa are benefiting equally from these relationships. Benefits are conditioned on the set of policies to be adopted by the host countries, such as institutional improvement and human capacity (Kaplinsky and Morris, 2009; Pigato and Tang, 2015; Doku et al., 2017; Miao et al., 2020). Therefore, the pattern of China's flows into African countries varies based on location motives and targeted economic sectors, e.g., natural resources, infrastructural and market efficiencies (Ashido, 2002; Fedderke and Romm, 2006; Song, 2011; Ross, 2015; Pigato and Tang, 2015; Okafor, Piesse, and Webster, 2015; Chen et al., 2018). Thus, there is still an open question regarding the relationship between foreign investments and income inequality in recipient countries. Therefore, the purpose of this study is to investigate the effect of increased Chinese outward direct investments on the income inequality levels of low-income African countries by using panel data over 2003-2014 and employing 2SLS/FE and GMM/FE estimators.

The remaining sections of the present study are as follows: Section 2 provides an overview of the literature, theoretical and empirical literatures. Section 3 presents data description and variables definitions. Section 4 discusses empirical methods and identification. Section 5 discusses the empirical results. Finally, section 6 concludes the study and discusses policy implications.

2.2 Literature review

2.2.1 Theoretical literature

Numerous empirical studies have investigated the association between FDI and income inequality for several time periods and countries and discussed their theoretical link. Therefore, the two contending international trade hypotheses, the dependency and the modernization theory, are tested in different studies (e.g., Bornschier, 1983; Evan and Timberlake, 1980; Tsai, 1995; Mihaylova, 2015; Mihalache-O'keef and Li, 2011). These hypotheses provided a theoretical basis for explaining income distribution patterns, and they continued to inform the debate about the relationship between globalization and income inequality, where the predicted relationship differs significantly. Modernization theory focuses on the internal factors of host countries, including concepts of saving, consumption propensities, and marginal productivity. As per this theory, foreign inflows into host economies will increase the absolute income of different income groups. This improvement of income occurred only at the advanced stages of increased outputs and labor transfers to industrial sectors, following the Kuznets's inverted-U curve, thus improved income distribution (Deardorff and Stern, 1994; Tsai, 1995).

On the other hand, dependency theory has been developed as a contradiction to the modernization hypothesis. "[The dependency theory] maintains that it is the social control and organization of production, rather than economic output and wealth, that affect income inequality" (Tsai, 1995, p. 471). Therefore, the more a country relies on foreign inflows, the worse the income distribution will be due to hiring of skilled workers and targeting of technology-intensive sectors. This illustrates that the inward FDI increases income inequality of host countries by generating losses for low-income groups, worsening income distribution.

2.2.2 Empirical literature

Based on the two contending trade theories, we carry the analysis of the present paper. Accordingly, we briefly review the foundations of these theories to explain how FDI inflows may affect income distribution trends in the host economy. Firstly, modernization theory is discussed by authors (Bornschier, 1983; Deardorff and Stern 1994; Tsai, 1995; Mihalache-O'keef and Li, 2011). This argument focuses on each country's internal factors. For instance, FDI and foreign aid promote economic growth by stimulating domestic investments (de Soysa and Oneal, 1999). At the same time, developed economies will also benefit from investing and gain access to the natural resources of recipient countries. The advantages of interdependence are determined by host countries' economic levels, human capital, and targeted economic sectors (Alfaro, 2003; Alfaro et al., 2004).

In general, modernization rarely deals with FDI-led distributional issues. However, this argument emphasizes that the country's output must be produced before it can be redistributed. Empirically, the findings of several pieces of literature are in line with of this hypothesis. Findings suggest that the stock of FDI cause income inequality to decrease. For example, Mushtaq et al. (2014) studied five South Asian Association for Regional Cooperation (SAARC) countries. Their findings suggest that inward FDI stock causes income inequality to decrease. Moreover, Ucal et al. (2016) by applying nonlinear autoregressive distributed lag (ARDL) on Turkish data and found that FDI led the Gini index to decline in the short- and long run. Studying Sub-Saharan countries, Xu et al., (2021showed FDI and income per capita contribute on average to decreased income inequality. However, the increase of trade openness, education, political stability, corruption, and have a positive effect income inequality in the recipient countries.

Second, the dependency theory is examined by authors (Bornschier, 1983; Tsai 1995; Mah 2002; Zhang and Zhang 2003; Taylor and Driffield, 2005; and Stiglitz 2006; Mihalache-O'keef and L, 2011). It has been developed to provide a different approach contradicting the modernization theory regarding factors impacts income redistribution in host countries. In other words, the increase of foreign capital inflow into less-developed countries is very likely to affect income distributions negatively. Such dependency will lead to a higher inequality, less access to education, more inferior quality of life (Kentor and Boswell, 2003; Jorgenson et al., 2007; Lee et al., 2007).

The dependency hypothesis has been supported in many studies, where the estimated relationship shows a positive influence of FDI on the level of income inequality of host countries. This direction of this relationship is demonstrated by Choi (2006) who investigated the effect of foreign direct investment, measured as a percentage of GDP, on domestic income inequality for 119 countries from 1993 to 2002. Findings suggest that income inequality will increase as FDI stocks increase, and GDP growth per capita causes income inequality to decrease. Herzer, Hühne, and Nunnenkamp (2014) investigated the FDI inward for Latin American countries' panel data. Results suggest that FDI inward leads to increased income inequality in Latin American. However, Mihaylova (2015), by investigating ten Central and Eastern European countries, found that the stock of FDI tends to increase income inequality, but the effect depends on the economic development and education of those countries. Adams and Klobodu (2017) studied 21 Sub-Saharan African countries, with findings suggesting that capital inflows worsen income redistribution.

Some studies show that FDI stock has mixed effects on the extent of income inequality, or even no effect, based on sample size, development level for each region, and time

effects of the inflows. For example, in a sample of 100 countries, the findings of Figini and G¨org (2011) suggest that wage inequality increased with an increase of inward FDI stock in developing countries. However, in developed countries, inward FDI stock causes wage decreases inequality. Herzer and Nunnenkamp (2011) examined a panel of ten European countries and found that FDI leads to increase income inequality in the short and long run. However, in the long run, on average, FDI leads to decreased income inequality. In studying different panel data of developing and developed countries, Lin et al. (2013) found that FDI stock increases income inequality when secondary enrollment reaches six years or more. Income inequality decreases in countries with less than six years of secondary enrollment. Studying sets of developed and developing countries, Nguyen (2021) found that increased in FDI inflows increased causes income inequality in developing countries and, however, lead to decreased income inequality in the developing countries. Bhandari (2007) studied 19 transition countries and found no evidence that FDI inward stocks affect overall income inequality. The ambiguity of FDI effect of on income inequality appears also in studies conducted in Africa. For example, Kaulihowa et al. (2018) conducted their study on a panel of 16 countries from 1980 to 2013 and found that FDI inflow first increased the income inequality. However, this effect diminished with further expansions of FDI inflow showing the U-shaped effect of FDI on income inequality in 16 of the host countries.

Above-reviewed papers provide significant contribution to the literature. Most of the previous studies have investigated the effect of FDI on income inequality across countries. A few pieces of research were conducted with a comparable analysis of the African-foreign investment relationship, explicitly focused on Chinese-FDI (e.g., Kaulihowa and Adjasi, 2018; Huang et al., 2020; Song et al., 2021). The present study is characterized by the following contributions: it

deals with a gap in knowledge concerning the relationship between Chinese Outward Directed Investment (CODI) into low-income African countries and income inequality in these countries. To the best of the authors' knowledge, it is the first research that empirically examines CODI's impact on income inequality in low-income African countries by using the most recent data from 2003-2014 and employing dynamic panel data methods. Also, we divide the foreign factor into CODI and other sources of FDI.

2.3 Data Description

In this section, we use available panel data from low-income African countries over the period 2003-2014. Although the targeted sample size is 252 observations, the actual total number of observations varies [4], per Table 2.2, as there is an apparent reduction in the total number of observations. Thus, the remaining seven low-income African countries have not been included because of systematic missing data or the absence of specific variables of interest.

Income inequality has two main factors (UNDP, 2013). First, external factors include trade globalization, financial globalization, and technical change. Second, internal factors are macroeconomic policies, labor market policies, wealth inequality, fiscal policies: taxation and transfers, fiscal policies, and government expenditure. Empirically, these factors are widely employed in investigating the association between FDI and income inequality. In our empirical model, we employ the dataset compiled from several sources, Appendix Table 2.2. The Gini coefficient is the dependent variable measure of income inequality. Its numerical value ranges between 0%, indicating better income distribution, and 100%, indicating perfect income inequality. The source of this variable is from UNU-WIDER, World Development Indicator

[4] The existence of extensive and systematic missing observations, especially in the main variables (Gini and CODI), causes to eliminate seven counties – Burkina Faso, Eretria, Gambia, Guinea-Bissau, Somalia, and South Sudan – from our dataset so that only 21 low-income African countries are included

(WDI), African development bank group (AFDB), and Human Development Report, which is calculated from actual household surveys. These low-income countries have almost similar mean values, Gini around 42% over 2003-2014, Appendix graph.2.1.

The variable of interest is the Chinese outward direct investment (CODI) stock, measured as GDP per capita. CODI is expected to cause income inequality to increase because Chinese investments are mostly skilled-intensive and employ more Chinese workers than local workers who compete with domestic investors for recipient countries resources. To count for potential nonlinearity, we incorporate the squared term of CODI. We also include several control variables derived from the internal development control model and reduce the omitted variable bias. The non-CODI refers to the FDI inward to Africa from other sources, as per capita GDP. However, the expected value is ambiguous, as stated previously in the literature review (e.g., Urata and Narjoko. 2017). The two foreign factors are collected from UNCTAD and MOFCOM. Based on pairwise correlation, Appendix Table 3, results suggest that only the correlation between CODI and non-CODI is relatively strong positive, i.e., 0.62, significant at the 1% level. However, the other exhibit no strong correlation between variables compared.

Gross Domestic Product (GDP) per capita is taken in current US dollars and is used as a proxy to account for overall development, market size, and economic trajectory collected from WDI. GDP is anticipated to have a positive impact on income inequality when its benefits are not equally distributed. On the contrary, if a country employs an excellent policy to distribute GDP equally, economic growth leads to decreased income inequality. We also included the square of GPDPC to account for nonlinearity relationship between CODI and Gini. The country policy and institutional assessment (CPIA) measures the quality and performance of institutional frameworks and is constructed based on an annual exercise in the 54 African countries of the

African development bank group. The AFDB overall CPIA score is calculated as the average of the five clusters: economic management, structural policies, social inclusion/equity, governance, infrastructure, and regional integration. Scores range from 1, very weak, to 6, very strong. Total secondary school enrollment is the total enrollment ratio to the total population, a proxy for human capital, and is collected from WDI. It should help improve income distribution if there is an increase in human capital. Otherwise, if there is no equality or spread of education, that is expected worsen income distribution and in the case of low-income countries to increase income inequality. Labor force participation rate is the proportion of the population aged 15 or older collected from WDI and the International Labor Organization (ILO), and is expected to decrease income inequality.

Inflation rate refers to an annual percentage change in CPI. The impact of this variable might be negative or positive. The negative effect occurs because, at a certain level, it might lead to raising the level of investment. Thus, it will increase the employment rate. However, the positive effects lead to increasing income inequality due to reducing individuals' purchasing power. In contrast, inflation may improve income distribution by raising the return to labor due to increased production investment. Trade Openness is included to account for the complementary relationship between trade and FDI and is calculated as the sum of a country's imports and exports as a percentage of GDP. The values of exports, imports, and GDP have been taken in millions of US dollars. If a country's exports exceed import, trade openness increases labor demand and the return to labor, thus a decreased income inequality. On the contrary, if imports go above exports, trade openness leads to a reduction in labor demand, the return to labor, income inequality will increase. Both inflation and trade openness are collected from WDI. Moreover, as determinants of FDI, we include total natural resource rents as percentage of

GDP, adjusted saving, natural resources depletion as % GNI, the expected values dependent on the level of institutional assessments and corruption, and how foreign investment is resources driven.

2.4 Empirical Methods

In this section, prior to applying appropriate econometric methods, several model diagnostics need to be done. Therefore, several structural equations are estimated, focusing on the modernization and dependency hypotheses, and examined to determine which control variables need to be incorporated. Based on the F-statistic, the most appropriate equation has a more significant value at a 1% level, and the signs of the main coefficients appear as expected. The empirical analysis is designed by examining panel data estimators to control unobserved heterogeneity. Although we target low-income African countries with many similarities in this paper, there are still a few differences.

Therefore, we follow the following authors (Tsai, 1995; Mahutga and Bandelj, 2008; Figini and G¨org, 2011; Mihaylova, 2015; Ucle et al., 2016; Kaulihowa and Adjasi, 2018), who specify the Gini coefficient as a function of FDI/GDP, GDPPC, inflation, and education. Like them, we specify equation (1). The squared term of CODI is included to capture nonlinearities and to test for the Kuznets curve hypothesis (Kuznets,1955; Kaulihowa and Adjasi, 2018; Huang et al., 2020; Song et al., 2021; Nguyen, 2021) known as the inverted-U curve. As a result, o that the increase of FDI causes income inequality first to increase and then decrease as the recipient country develops. However, unlike other authers, we split foreign investments into CODI/GDP and Non-CODI/GDP. We also use country policy and institutional assessment, and labor force participation rate to account for political and social status with the baseline model as follows;

(1) $$Gini_{c,t} = \beta_0 + \beta_{CODI}\left(\frac{\text{CODI}}{\text{GDP}}\right)_{c,t} + \beta_{SQRD}\left(\frac{\text{CODI}}{\text{GDP}}\right)^2_{c,t} + \beta_{RFDI}\left(\frac{\text{Non-CODI}_{\text{FDI}}}{\text{GDP}}\right)_{c,t} + \beta_{GDP}(\text{GDPPC})_{c,t} + \beta_{CPIA}(\text{CPIA}_{\text{AD}})_{c,t} + \beta_{SECEnr}\left(\text{Sec}_{\text{Enro}_{\text{Pop}}}\right)_{c,t} + \beta_{Labor}(\text{Labor})_{c,t} + \beta_{inflation}(\text{Inflation})_{c,t} + \beta_{Trade}(\text{Trade Openess})_{c,t}$$

where, c denotes country 1, 2, …, 21 and *i* represents year =2003, 2004, …, 2014. The error term is suppressed. Hence, the presence of unobserved heterogeneity across countries that may be correlated with regressors was dealt with by employing a fixed effect estimator, eliminating the country-specific effect. We will primarily provide a short discussion regarding panel data methods which enables the empirics to control for individual heterogeneity? Panel data methods provide informative data and less collinearity among variables. Unlike the time series analysis, the latter suffers from nonstandard distribution runs into unit root tests (Cameron and Trivedi, 2005; Baltagi, 2013). as so-called pooled-OLS as follows:

(2) $$\text{Y}_{i,t} = \alpha_i + \text{X}'_{i,t}\beta + u_{it}\ ; \quad \text{where } i = 1,2,\dots,N; t = 1,2,\dots T$$

where, *i* denotes individual countries, *t* denotes time, and α_i denotes the individual country intercept. X_{it} is the i^{th} observation of a vector of one globalization measure and control variables. (β) denotes the coefficients to be estimated. u_{it} denotes the component model of disturbance error $u_{it} = \mu_i + \nu_{it}$; where μ_i represents the time-invariant unobservable individual effect and whether fixed-effect or random-effects is selected and ν_{it} represents the error disturbance, the idiosyncratic error.

The fixed effects (FE) estimator is appropriate if we need to examine a selected *N* country. Under assumptions that need to be met: μ_i is a fixed-parameter to be estimated for each cross-sectional observation *i* (Wooldridge, 2002) and combined with the intercept; The stochastic disturbance, in this case, is independent and identically distributed where $\nu_{it} \sim IID(0, \sigma_\nu^2)$; X_{it} is independent of the ν_{it} for all *i* and *t*.

(3) $Y_{it} = (\alpha \quad + \mu_i) + X'_{i,t}\beta \quad + \nu_{it} \;\; ; \;\;$ where $i = 1,2,\dots,N; t = 1,2,\dots T$

Choosing the appropriate estimator is a controversial point and not as easy as it seems to be, in particular, between FE and RE. This process has been addressed in the literature (Wooldridge, 2002; Cameron and Trivedi, 2005; Wooldridge, 2010; Baltagi, 2013). Most applied researchers used the Hausman test to distinguish between RE and FE under the null hypothesis, i.e., there is no correlation between individual effects and X_{it}. The approval of FE is based on rejecting H_0, or RE is otherwise. However, Hausman's command gives us an incorrect statistic because it assumes RE is fully efficient, and it is usually not (Cameron and Trivedi, 2005; Baltagi, 2013). Several tests are proposed to solve these issues. For example, doing a panel bootstrap or using the robust version of Hausman, the so-called Wooldridge test (2002). The latter is a test of FE vs. RE and overidentifying restrictions. FE uses independent variables that are uncorrelated with the idiosyncratic error, i.e., $E[X_{it}\ \nu_{it}] = 0$, and RE uses additional conditions which are overidentifying restrictions that are independent variables uncorrelated with the country-specific error $E[X_{it}\ u_{it}] = 0$ (Schaffer and Stillman, 2010).

2.4.1 Identification

The endogeneity of the independent variables usually exists because of three reasons; measurement error in the independent variables, omitted variables, and simultaneity of an explanatory variable (Wooldridge, 2002; Hausman, 2003). Reverse causation can also occur, for example, between FDI and income inequality. The presence of endogeneity implies that the assumption of strict exogeneity, i.e., zero correlation between X_i and the error term $E[X_{it}\ \nu_{it}] \neq 0$, is violated because of measurement error, omitted variables, and simultaneity. Therefore, instrumental variables need to be introduced under the assumption of $E[Z_{it}\ \nu_{it}] = 0$, where Z_i is a vector of instrumental variables uncorrelated with the error term and so should be valid.

To account for potential endogeneity between Gini and FDI, different methods have been adopted. For example, Bhandari (2007) used lagged-FDI variables. Herzer and Nunnenkamp (2011) lagged variables and applied panel co-integration and causality techniques. Figini and G¨org (2011) and Basu and Guariglia (2007) employed GMM. The two-step GMM specifications allow different instruments, and once the instrumental variables included are more than the endogenous regressors, i.e., overidentified. Regading the existence of the heteroskedastic and overidentified equation, GMM cluster-robust estimates will be more efficient than 2SLS estimates (Baum, Schaffer, and Stillman. 2003 and 2007; Schaffer and Stillman, 2010.)

We make two identifying assumptions of 1) no-serial correlation among the error terms and 2) that the endogenous independent variables are not considered predetermined for $v_{i,t}$ but are so for $v_{i,t+2}$. The same model is estimated using dynamic (GMM/FE) and (2SLS/FE). If all explanatory variables are strictly exogenous, both estimators are consistent, but the latter is efficient. Moreover, to test for strict exogeneity of the explanatory variables, we run the Hausman test. As instruments, we include lags of CODI, the non-CODI, trade, adjusted saving, and natural resources depletion. The validity of these instrumental variables can be tested using a Sargan-type test. The consistency of these estimates centers on the assumption of lack of autocorrelation of error terms. Therefore, we check for first-order serial correlation of error terms. We also perform the Sargan test of over-identifying restrictions, a joint test of the instrument vector's model specification and appropriateness. Moreover, the Hansen J-statistic supports the use of instruments. Also, autocorrelation is tested by the Wooldridge test under the null hypothesis of no first-order autocorrelation.

As a result, instrumental variables successfully passed tests for under-identification, validity, and overidentifying restrictions. Additionally, we included the rent of natural resources as it is considered a determinant of foreign investment in Africa (Ross, 2015; Pigato and Tang, 2015; Okafor, Piesse, and Webster, 2015; Chen et al., 2018). Our analysis includes total natural rents that satisfy the relevant condition instead of separate rents (such as minerals and oil). To avoid any direct correlation between dependent variable and the instrument, we included several lags instead of the levels these variables. In addition to the regressors $X'_{c,t,t-1}$, we include the lag dependent $Gini_{c,t-1}$to capture the effect of the previous period of income inequality.

Therefore, we employed dynamic GMM/FE and 2SLS/FE and rewritten equation (3). By including the lag of the dependent variable, we obtain the following empirical model:

(4) $Gini_{c,t} = (\alpha_i + \mu_i) + \beta_{Gini_{c,t-1}} Gini_{c,t-1} + \beta_{CODI} CODI_{c,t} + \sum_{c=1}^{c=21} \gamma_c X'_{c,t,t-1} + \nu_{c,t}$;

where, ($Gini_{ct}$) is the dependent variable, c = country, t = time, and N= a selected number of countries. Further, $c = 1,2,\dots,21; t = 2003,\dots,2014$, α_c refers to the intercept of each country, μ_c is a fixed parameter. (X_{ct}) represents a vector of control variables, including one-period lagged control variables, (β) is the variable of interest coefficient. (γ_c) are the coefficients of the set of control variables, and (ν_{ct}) is the error term assumed to be independent. Thus, the tested hypotheses of the present study are constructed based on two international development theories, i.e., the modernization and dependency theories, below:

$$H_N: \beta_{CODI} \leq 0; \qquad H_A: \beta_{CODI} > 0.$$

The null hypothesis supports the claim that CODI either does not have any statistical effect or will decrease income inequality by improving the host countries' economic status, i.e., in line with what was stated by modernization theory. The alternative hypothesis is that CODI leads to increasing income inequality.

Proposition 1

Although Chinese investments in Africa have increased drastically in recent decades, most of these investments target and employ high-skilled workers. Therefore, it would be expected that income inequality is widening by CODI, thus unambiguously affected by increasing education enrollments (Knight and Sabot, 1983).

$$\beta_{CODI} > 0 \; ; \qquad \beta_{SECEnr} = ?$$

This conjectural relationship can be tested by calculating the isolated impact of each explanatory variable as follows:

(5) $$Elas. = \frac{\partial Gini}{\partial X}\frac{X}{Gini} = \beta_j \frac{\bar{X}_j}{\overline{Gini}}$$

where β_j refers to coefficient estimates. $\overline{Gini}$ denotes the mean value of the Gini index for the data set used. $\bar{X}_j$ represents the mean values of the explanatory variables incorporated.

2.5 Discussion and Empirical Results

We investigate the effect of CODI on income distribution by regressing the Gini index of income distribution on CODI and other regressors using 2SLS/FE and GMM/FE estimation methods, Table 2.3. Moreover, we use a panel dataset covering 21 low-income African countries from 2003 to 2014. Equation (4) is used as our empirical model to examine the relationship between CODI and Gini level in the selected countries. Therefore, the coefficients' estimates align with our previous results regarding effects significance and direction. The order of magnitude of the CODI coefficient is relatively similar between the fixed effects and 2SLS/FE, while the GMM/FE estimator is slightly larger. Table 2.3 presents the full model estimates of 2SLS/FE and GMM/FE in column 2, respectively. In 2SLS/FE, the CODI coefficient is statistically positive and significant, with a p-value <0.05. This implies that a 1% increase in CODI causes, on average, income inequality in the selected countries to increase by

0.075 units keeping everything else constant. The goodness to fit results suggest that GMM/FE is appropriate. Estimates of J-statistic are insignificant in all models suggesting that the instruments are valid. The coefficient of lagged dependent variables is significant and positive as evidence that the income inequality in low-income African countries also depends on its value from the previous period. Therefore, CODI has a statistically significant positive impact on income inequality in low-income African countries, suggesting that, on average, an increase by one percent worsens the income distribution by 0.1 unit when everything else is fixed.

Estimates in Table 2.3 bear out the central hypothesis of this paper: the influence of CODI on income inequality in low-income African countries is positive and statistically significant for all specifications considered (FE, GMM/FE, and 2SLS/FE). These estimates align with the theoretical discussion, i.e., the dependency hypothesis approach (Bornschier, 1983; Tsai 1995; Mah 2002; Zhang and Zhang 2003; Herzer, Hühne and Nunnenkamp, 2014). Table 2.3 Column (2) represents the estimates of country-FE indicating that CODI's coefficient is positive and statistically significant at the 1% level, which leads to increasing income inequality in the host countries. In other words, an increase in FDI leads to worsening income distribution in low-income countries. This implies that a one percentage point increase in CODI stock tends, on average, to increase income inequality by approximately 0.075 percentage points in the selected 21 low-income African economies holding other varies constant. These results are consistent with findings by Adams and Klobodu (2017), Kaulihowa and Adjasi, (2018), Huang et al.'s (2020) and Song et al. (2021).

However, coefficient results show that FDI from other sources decreases income inequality in host economies, following the modernization theory (Tsai, 1995; Ucal et al., 2016). On the other word, results suggests that, on average, an increase in non-CODI by 100 unit leads

to a decreased income inequality of 0.2 points in the selected countries holding other variables fixed consistent with findings of Xu et al.'s (2021). This effect might be due to the amount of these investments, as a total, compared with CODI and the long historical relationships with the African countries.

We control for secondary school enrollment and country institutional assessment. For example, the degree of human capital level, i.e., secondary school enrollment, is a positive sign and significant at p-value <0.0001, which is in line with several researchers (Figini and G¨org, 2011; Kaulihowa and Adjasi, 2018; Xu et al., 2021). The country policy and institutional assessment has no statistical impact on decreases in income inequality. Thus, holding other variables fixed, the coefficient suggests that a one percentage point increase in the secondary school enrollment causes to increased income inequality. This association may reflect the absence of equality and education quality in low-income African countries. Increasing trade openness and labor force improve income distribution as more local workers get involved in the increased local productivity. Inflation rate and GDP per capita have the expected sign consistent with previous work, although they are not statistically significant. Although small in magnitude the estimate of the squared term of CODI is statistically significant and supports the inverted U-curve (-0.012). CODI will initially increase the income inequality in low-income African countries, then in more advanced stages the income inequality will decrease (see, Tsai, 1995; Kaulihowa and Adjasi, 2018 and Huang et al., 2020).

In columns (3), (4), and (5), we exclude the effect of secondary school enrollment and government institutional assessments. Estimates suggest that CODI does not affect income inequality in the selected countries without these variables. Moreover, to check the accuracy of our estimates, we perform the isolated effect concerning the estimates in Table 2.4., column 3.

Results are consistent with the dependency hypothesis, Table 2.4, with an isolated 10% increase in CODI significantly associated with a 0.5% increase in income inequality. An isolated 10% increase in secondary school enrollment relative to total population is significant and increases income inequality by 2.3%. Income inequality is more sensitive to secondary school enrollment than CODI, showing the importance of investing in the human capital in African countries that typically lack skilled and trained workers. These findings support the claim that most Chinese investments mainly target sectors with high-skilled laborers (Chen et al., 2018).

Furthermore, we follow several methods, such as relaxing a few assumptions from the previous estimation, replacing missing values in the outcome with means, and employing a different model. In this, we use only the baseline model equation (1). In these estimates, we eliminate a few control variables, such as squared GDPPC, total rent of natural resources, adjusted savings, and did not control the previous income inequality. First, the first-differencing, FD, estimate uses a one-period change for each. The reasons behind using FD are as follows. It is known that if T=2, the period is only two years and FE and FD will produce the same results; thus, they are identical. Since the dataset used in our paper has T=12, FE and FD will be expected to produce substantively different results. Therefore, we will relax some assumptions in estimating the country-FE and employ the same dataset. Moreover, we assumed previously in estimating FE that u_{ct} are serially uncorrelated over time. Nevertheless, there is sometimes no reason why such a condition might hold in the dataset. Therefore, when the first difference of the error term $(u_{c,t} - u_{c,t-1})$ is uncorrelated and u_{ct} follows a random walk process, then using FD estimator will be the appropriate one to use. Equation (6) represents OLS estimation of one period changes of the dependent variable on one-period changes in the independent variables.

$$(6)\quad \text{Gini}_{c,t} - \text{Gini}_{c,t-1} = (\text{CODI}_{c,t} - \text{CODI}_{c,t-1})\beta_{D.CODI} + (X_{c,t} - X_{c,t-1})\gamma_i \quad + (u_{c,t} - u_{c,t-1})$$

where, $\text{Gini}_{c,t-1}$, $\text{CODI}_{c,t-1}$, and $X_{c,t-1}$ are a one-year lag of Gini_{ct}, CODI_{ct} and X_{ct} , respectively. β and γ_i are the coefficients of the first differences. u_{ct} is the error term.

By subtracting each value from its previous year, estimating different models, and using precisely the same dataset, as shown in Table 2.3, estimates of the variable of interest, CODI, are similar to FE estimates with a smaller magnitude. Thus, CODI's impact is positive and statistically significant and leads to increased income inequality levels of the 21 low-income African countries.

Second, as addressed earlier in the data description section, we replaced missing values of Gini index with mean values reported by the World Bank and UNDP. This process is based on the assumption that our data is normally distributed. following the exponential family. Then we run dynamic GMM instead of 2SLS and GMM, using benchmark model Table 2.5, column (1) emphasizes that CODI causes Gini's level in low-income African countries to increase.

Third, we introduced a new index to measure economic status, the Human Development Index (HDI). This index is constructed to reflect a combination of different indices, i.e., life expectancy and education. In contrast to the Gini index, the higher the HDI value, the better the human development status. Therefore, we incorporate this index as an alternative outcome variable instead of the Gini's income inequality index. As reported in Table 2.5, column (6), other sources of FDI have a significantly positive impact on HDI. In contrast, CODI has no effect and is not different from zero. Empirically, estimates of the remaining control variables suggest that countries with increased GDP and total number of laborers are highly likely to enjoy higher human development status.

2.6 Conclusion and Policy Implications

There is an increasing trend of empirical studies analyzing the relationship between FDI and income inequality in the literature. Some of this recent study is in line with the dependency hypothesis and enjoys more robust support so that FDI increases income inequality. On contrast, other researchers found that the relationship causes income inequality to decrease in which findings are in light of the modernization hypothesis. These findings that make a distinction between the dependency and the modernization hypotheses have no clear explanation. The contradictory results in literature could be partly due to the variables used, the sample data included, and the region or the country studied. Therefore, it might appear in several literature works in which employing panel data, choosing the Gini coefficient as the dependent variable, and using the ratio of FDI stock to GDP as the main independent variable. Thus, findings can show a positive, negative, or both in the same particular research.

In the present study, the central inquiry examines CODI stock's effect, as a proxy of globalization, on the income inequality in low-income African countries. The hypotheses and the expected results are built on existing studies. Moreover, the theoretical perspective follows several previous studies. In this research, we use panel data for 21 low-income African countries observed over the period 2003-2014 to examine CODI's impact on the Gini coefficient by employing 2SLS/FE and GMM/FE. The model passes various diagnostic and specification tests. Results support our alternative hypothesis that there is a positive relationship between CODI and income inequality across low-income African countries (Choi, 2006; Mahutga and Bandelj, 2008; Figini and Gorg, 2011; Herzer, Hühne and Nunnenkamp, 2014; Adams and Klobodu (2017) and Kaulihowa and Adjasi, 2018; Huang et al., 2020; and Song et al., 2021). Thus, these

findings are consistent with the dependency hypothesis's assertion, (Bornschier, 1983; Tsai 1995; Mah 2002; Zhang and Zhang 2003).

The findings also suggest that increased CODI stock has increased income inequality in the selected countries. However, these effects are inverted in non-CODI and lead to a decrease in the income inequality. Thus, this effect is relatively small though statistically significant. The most considerable effect on income inequality comes from country policy and institutional assessment, causing a statistically significant reduction in income inequality. On the other hand, an increase in per capita secondary school enrollment has a positive and statistically significant effect on the Gini coefficient. Accordingly, several inquiries regarding African laborers' characteristics and education status, especially in low-income economies, are needed.

The implications of these results for economic policy for the low-income African economies are as follows. They first focus on the quality of education and technical training that meets the skills' quality needed to bridge the gap between the foreign firms' skill requirements and the more local labor market. Hence, African governments should encourage Chinese firms to hire and train local laborers and transfer knowledge. As suggested by literature in the case of developing countries and the role of taxation (e.g., Atkinson, 2015; Atkinson, Piketty, and Saez, 2011; Stiglitz, 2006), making changes in the financial and investment regulations and taxation system will make sending foreign workers to African-located firms more expensive because that will place more financial burdens on the foreign investors. Thus, FDI will increase the demand for less-skilled laborers, and then the wages will go up compared to skilled labor in the host country. Moreover, African countries and their partners will benefit from contributing and diversifying their investments into manufacturing and services.

Other theoretical models and descriptions of the relationship between income inequality and FDI have been proposed in the literature. For example, as stated in the Stolper-Samuelson theorem, low-income countries should encourage enough foreign investors to invest in projects not requiring skilled workers. This theorem is constructed on the condition that if host economies are relatively abundant in low-skilled labor, then FDI should be focused on investments that use unskilled labor to contribute to solving income inequality (Deardorff and Stern, 1994). The presents research offers further possibilities for future research using micro-data and, in this regard, focusing on the household and firm-level, including both Chinese laborers and local workers who work for foreign firms, providing a more comprehensive understanding of the influences of FDI and foreign aid on the host economy regarding income distribution.

2.7 References

Adams, S. 2009. "Can foreign direct investment (FDI) help to promote growth in Africa?" *African Journal of Business Management* 3(5):178-183.

Adams, S.and E. Klobodu. 2017. "Capital flows and the distribution of income in Sub-Saharan Africa." *Economic Analysis and Policy* 55:169–178.

AFDB (African Development Bank Group). 2014. "*Country Policy and Institutional Assessment (CPIA)*." African Development Bank Group, Abidjan. http://www.afdb.org/en/documents/document/2004-2013-country-policy-and-institutional-assessment-cpia-47411/ (accessed July 20, 2016).

Alfaro, L. 2003. "Foreign Direct Investment and Growth: Does the Sector Matter?" Unpublished manuscript. Boston, MA: Harvard Business School.

Alfaro, L., A. Chanda, S. Kalemli-Ozcan, and S. Sayek. 2004. "FDI and Economic Growth: The Role of Local Financial Markets." *Journal of International Economics* 64:89–112.

Anyanwu, J. C. 2011. International Remittances and Income Inequality in Africa. Working Paper 135, African Development Bank group.

Atkinson, B. A. 2015. *Inequality, What can be done?* Harvard University Press. 1st edition. The USA. P. 303.

Atkinson, A, B., T. Piketty, and E. Saez, 2011. "Top Incomes in the Long Run of History," *Journal of Economic Literature*, American Economic Association, vol. 49(1), pages 3-71, March.

Baltagi, B.H. 2013. *Econometric Analysis of Panel Data.* 2nd editions, New York, John Wiley.

Baum, Ch. F., M E. Schaffer, S. Stillman. 2003. "Instrumental variables and GMM: Estimation and testing." *The Stata Journal* 3(1):1-31.

_____. 2007. “Enhanced routines for instrumental variables/generalized method of moments estimation and testing”. *The Stata Journal*. 7(4):465-506.

Basu, P., and A. Guariglia. 2007. “Foreign Direct Investment, inequality, and growth.” *Journal of Macroeconomics* 29: 824–839.

Bhagwati, J. 2004. In Defense of Globalization, Oxford University Press.

Bhandari, B. 2007. “Effect of Inward Foreign Direct Investment on Income Inequality in Transition Countries.” *Journal of Economic Integration* 22(4):888-928.

Bornschier, V. 1983. “World economy, level development and income distribution: An integration of different approaches to the explanation of income inequality.” *World Development* 11(1):11-20.

Box, G. E. P., and D. R. Cox. 1964. An analysis of transformations. *Journal of the Royal Statistical Society*, Series B 26: 211-252.

Cabral, R, R. García-Díaz, and A. V. Mollick. 2016. “Does globalization affect top income inequality?” *Journal of Policy Modeling* 38:916–940.

Cameron, C., and P. K. Trivedi. 2005. *Microeconometrics Methods and Applications*.Cambridge University Press. The UK. p. 697.

Chen, W., D. Dollar, and H. Tang. 2018. “Why Is China Investing in Africa? Evidence from the Firm.” *The World Bank Economic Review* 32(3): 610–632.

Chen, Z., Y. Ge, H. Lai. 2011. “Foreign Direct Investment and Wage Inequality: Evidence from China.” *World Development* 39(8):1322-1332.

Chintrakarn, P., D. Herzer, and P. Nunnenkamp. 2012. “FDI and Income Inequality: Evidence from a panel of the US States.” *Economic Inquiry* 50:788–801.

Choi, C. 2006. “Does foreign direct investment affect domestic income inequality?” *Applied Economics Letters* 13(12):811-814.

Cleeve, E. A. Y. Debrah, and Z. Yiheyis. 2015. “Human Capital and FDI Inflow: An Assessment of the African Case.” *World Development* 74:1-14.

de Soysa, I. and J. R. Oneal. 1999. “Boon or Bane? Reassessing the Productivity of Foreign Direct Investment.” *American Sociological Review* 64(5): 766-782.

Deardorff, A. and Stern, R. 1994. The Stolper–Samuelson Theorem: A Golden Jubilee, University of Michigan Press, Ann Arbor, NI.

Doku, I., J. Akuma, and J. Owusu-Afriyie. 2017. “Effect of Chinese Foreign Direct Investment on Economic Growth in Africa.” *Journal of Chinese Economic and Foreign Trade Studies* 10:1–11

Evans, P. B., and M. Timberlake. 1980. “Dependence, Inequality, and the Growth of the Tertiary: A Comparative Analysis of Less Developed Countries.” *American Sociological Review* 45:531-552.

Fedderke, J.W., and A.T. Romm. 2006. “Growth impact and determinants of foreign direct investment into South Africa 1956-2003.” *Economic Modelling* 23:738-760.

Figini, P., and H. G¨org. 2011. “Does Foreign Direct Investment Affect Wage Inequality? An Empirical Investigation.” *The World Economy* 1456-1475.

Fosu, A. K. 2018. “Economic structure, growth, and evolution of inequality and poverty in Africa: An overview.” *Journal of African Economies* 27(1):1–9. https://doi.org/10.1093/jae/ejx036

Goldberg, P. and N. Pavcnik. 2007. “Distributional Effects of Globalization in Developing Countries.” *Journal of Economic Literature* 45 (1): 39-82.

Harjes, T. 2007. Globalization and income inequality: a European perspective. IMF Working Paper WP/07/169. International Monetary Fund, Washington DC.

Hausman, J. 2003. "Mismeasured Variables in Econometric Analysis: Problems from the right and Problems from the Left." *Journal of Economic Perspectives* 15(4): 57-67.

Herzer, D., P. Hühne, and P. Nunnenkamp. 2014. "FDI and Income Inequality-Evidence from Latin American Economics." *Review of Development Economics* 18(4): 778–793.

Herzer, D., and P. Nunnenkamp. 2011. FDI and Income Inequality: Evidence from Europe. Working Paper No. 1675, Kiel.

Huang, K., N. Sim, and H. Zhao. 2020. "Does FDI actually affect income inequality? Insights from 25 years of research." *Journal of Economic Surveys* 34: 630-659.

Human Development Reports. http://hdr.undp.org/en/content/income-gini-coefficient . (accessed July 15, 2016).

Hyman, D. N. 2011. *Public Finance A Contemporary Application of Theory to Policy.* 10th edition, South-Western, Cengage Learning, p. 474.

Jorgenson, A., C. Dick, and M. C. Mahutga. 2007. "Foreign Investment Dependence and the Environment: An Eco Structural Approach." *Social Problems* 54: 371-394.

Kaplinsky, R., and M. Morris. 2009. "Chinese FDI in Sub-Saharan Africa: Engaging with Large Dragons." European Journal of Development Research 21:551–569.

Kaulihowa, T. and C. Adjasi. 2018. "FDI and income inequality in Africa." *Oxford Development Studies* 46: 250-265.

Kentor, J., and T. Boswell. 2003. "Foreign Capital Dependence and Development: A New Direction." *American Sociological Review* 68: 301-313.

Knight, J. B., and R. H. Sabot. 1983.“Educational Expansion and the Kuznets Effect.” *American Economic Review* 73 (5):1132-1136.

Kuznets, S. 1955. “Economic growth and income inequality.” *The American Economic Review* 45(1):1–28.

Lee, Cheol-Sung, Francois Nielsen, and Arthur S. Alderson. 2007. “Income Inequality, Global Economy and the State.” *Social Forces* 86: 77-112.

Lin, S., K. Dong-Hyeon, and Y. Wu. 2013. “Foreign Direct Investment and Income Inequality: Human Capital Matters.” *Journal of regional science* 3(5):874-896.

London, B., and T. Robinson. 1989. “The Effects of International Dependence on Income Inequality and Political Violence.” *American Sociological Review* 54:305-308.

Mah, J. S. 2002. “The impact of globalization on income distribution: The Korean experience.” *Applied Economics Letters* 9:1007-1009.

Mahutga C. M. and N. Bandelj, and M. 2008. “Foreign investment and income inequality: the natural experiment of Central and Eastern Europe.” *International Journal of Comparative Sociology* 49(6):429-454.

Miao, M., Q. Lang, D. G. Borojo, J. Yushi and X. Zhang. 2020. “The Impacts of Chinese FDI and China–Africa Trade on Economic Growth of African Countries: The Role of Institutional Quality.” *Economies* 8(3): 53.

Mihalache-O’keef, A., and Q. Li. 2011. “Modernization vs. Dependency Revisited: Effects of Foreign Direct Investment on Food Security in Less Developed Countries.” *International Studies Quarterly* 55(1):71-93.

Mihaylova, S. 2015. “Foreign direct investment and income inequality in Central and Eastern Europe.” *Theoretical and Applied Economics* 2(603):23-42.

Milanovic, B. 2002. Can we discern the Effect of Globalization on Income Distribution?, *World Bank Policy Research Working Paper No. 2876*, World Bank, Washington DC, https://openknowledge.worldbank.org/bitstream/handle/10986/19276/multi0page.pdf?sequence=1&isAllowed=y

Mushtaq, M., K. Ahmad, S. Ahmed, and M. Nadeem. 2014. "Impact of FDI on Income Distribution in Selected SAARC Countries." Text Road Publication, *Journal of Applied Environmental and Biological Sciences* 4(7S):1-10.

Neutel, M., and A. Heshmati. 2006. Globalisation, Inequality and Poverty Relationships: A Cross Country Evidence IZA DP working paper No. 2223.

Nguyen, V.B. 2021. "The difference in the FDI inflows–Income inequality relationship between developed and developing countries." *The Journal of International Trade & Economic Development* 30(8): 1123-1137. DOI: 10.1080/09638199.2021.1925331

Okafor G., J. Piesse, and A. Webster. 2015. "The motives for inward FDI into Sub-Saharan African countries." *Journal of Policy Modeling* 378:75–890.

Park, Y.J. 2009. Chinese migration in Africa. Occasional Paper No.24, China in Africa Project, South African Institute of International Affairs.

Pigato, M., and W. Tang. 2015. "China and Africa: Expanding Economic Ties in an Evolving Global Context." Downloaded from: http://www.worldbank.org/content/dam/Worldbank/Event/Africa/Investing%20in%20Africa%20Forum/2015/investing-in-africa-forum-china-and-africa-expanding-economic-ties-in-an-evolving-global-context.pdf

Renard, M. 2011. China's Trade and FDI in Africa. Working Paper 126, African Development Bank Group, May, p19.

Ross, A. G. 2015. “An empirical analysis of Chinese outward foreign direct investment in Africa.” *Journal of Chinese Economic and Foreign Trade Studies* 8 (1):4-19.

Salvatore, D. 2013. *International Economics*. Eleventh Edition. Fordham University. Wiley. p.157.

Schaffer, M.E., Stillman, S. 2010. xtoverid: Stata module to calculate tests of overidentifying restrictions after xtreg, xtivreg, xtivreg2, and xthtaylor http://ideas.repec.org/c/boc/bocode/s456779.html.

Song, H. 2011. “Chinese Private Direct Investment and Overseas Chinese Network in Africa.” *China &World Economy* 19(4):109-126.

Stiglitz, Joseph. 2006. *Making Globalization Work*. New York: W. W. Norton & Company.

Song, Y., S. R. Paramati, M. Ummalla, A. Zakari and H. R. Kummitha. 2021. “The effect of remittances and FDI inflows on income distribution in developing countries.” *Economic Analysis and Policy* 72: 255-267.

Taylor, K. and N. Driffield. 2005. “Wage Inequality and the Role of Multinationals: Evidence from UK Panel Data” *Labour Economics* 12:223-249.

Tsai, P. 1995. “Foreign Direct Investment and Income Inequality: Further Evidence.” *Elsevier Science Ltd, World Development* 23(3):469-483.

Ucal, M., A. A. Haug, and M. H. Bilgin. 2016. “Income Inequality and FDI: evidence with Turkish data.” *Applied Economics* 48 (11):1030-1045.

UNCTAD (United Nations Conference on Trade and Development). 2013. *World Investment Report 2013*: *Global Value Chains: Investment And Trade For Development*: An Action Plan. Geneva: United Nations.

UNCTAD (United Nations Conference on Trade and Development). 2014. *World Investment Report 2014*: *Investing in the SDGs*: *An Action Plan*. Geneva: United Nations.

United Nations Development Programme (UNDP). 2013. Humanity Divided: Confronting Inequality in Developing Countries. http://www.undp.org/content/dam/undp/library/Poverty%20Reduction/Inclusive%20development/Humanity%20Divided/HumanityDivided_Full-Report.pdf (accessed Jan 04, 2017).

Urata, S. and D. A. Narjoko. 2017. *International Trade and Inequality*. ADBI Working Paper 675. Tokyo: Asian Development Bank Institute. Available:https://www.adb.org/publications/international-trade-and-inequality

Wei, S.-J., Y. Wu. 2001. Globalization and inequality: evidence from within China. NBER working paper, 8611 (November).

Wooldridge, J.M. 2002, 2010, *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA, MIT Press.

World Bank. All Indicators. *World Development Indicators*. Washington, DC: World Bank. http://data.worldbank.org/indicator/ (accessed Jan 19, 2016).

Xu, C., M Han, T. Dossou. 2021. "Trade openness, FDI, and income inequality: Evidence from sub-Saharan Africa." *African Development Review* 33:193–203.

Zhang, X. and K. H. Zhang. 2003. "How Does Globalization Affect Regional Inequality within a Developing Country? Evidence from China." *Journal of Development Studies* 39(4): 47-67.

Table 1.1 Summary Statistics for the Gini coefficient for low-income African countries, 2003-2014.

Country Name	No. of obs.	Mean	SD.	Min.	Max.
Benin	12	41.45	4.15	36.56	48.00
Burundi	9	39.42	0.69	38.47	40.99
Central African Republic	11	37.42	1.90	34.80	40.99
Chad	12	38.80	1.61	36.56	42.20
Comoros	8	45.87	5.32	38.47	50.30
Congo, Dem. Rep.	11	40.24	2.32	36.56	43.30
Ethiopia	12	40.66	2.54	36.56	44.20
Guinea	12	39.62	1.74	36.56	42.20
Liberia	10	40.53	1.68	38.20	43.00
Madagascar	12	43.92	6.15	36.56	51.00
Malawi	10	39.81	2.35	36.56	43.90
Mali	12	40.86	2.70	36.56	44.50
Mozambique	12	40.12	2.39	36.56	45.70
Niger	12	38.14	2.77	34.20	42.20
Rwanda	12	42.43	4.45	36.56	48.30
Senegal	12	42.01	3.90	36.56	46.60
Sierra Leone	7	38.45	3.02	33.99	41.30
Tanzania	10	45.02	6.46	36.99	52.10
Togo	12	41.41	4.09	36.56	48.40
Uganda	12	41.49	4.22	36.56	48.30
Zimbabwe	12	42.03	5.13	36.56	50.90

Table 2.2 Descriptive statistics for the dataset used in estimating the effect of CODI on income inequality in 21 low-income African countries over the period 2003 to 2014

Variable	Mean	Std. Dev.	Min	Max	No. Observations
Gini %	40.9	4.82	33.99	52.1	232
Chinese Outward Direct Investment Stock (*CODI*/*GDP*) %	25.540	41.400	0.0013	266.432	243
Total FDI stock from Other Sources (n*on-CODI /GDP*) %	589.1601	857.401	0.510	5664.306	243

Country policy and institutional assessment measured on (1-6) scale, average score	3.38	0.597	1.7	4.76	231
Gross Domestic Product per Capita, US Dollars	526.31	207.61	194.1	1010.9	252
Secondary school enrollment for both genders, %	3.921	1.72	0.937	8.971	188
Labor Force, % of total population ages 15 over	75.9	9.62	51.3	89.6	252
Inflation Rate %	114.9	1557.3	-35.8	24411	246
Trade Openness % of GDP	70.30	41.5	27.3	321.6	244

Total natural resources rents % of GDP	13.910	9.680	1.236	53.627	252
Adjusted savings: natural resources depletion, % GNI	8.573	8.170	0	40.904	252
Squared CODI/GDP	2358.757	7627.671	1.68e-06	70985.87	243

Note: N= total number of observations. Numbers are rounded to three decimals. The dataset does not include seven countries – Burkina Faso, Eretria, Gambia, Guinea-Bissau, Somalia, and South Sudan because of severe missing data in a different variable.

Table 2.3 The Estimates of income inequality on Chinese Outward Direct Investment Stock into low-income African countries, 2003-2014

	(1)	(2)		(3)		(4)		(5)	
VARIABLES	**FE**	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**	**2SLS**	**GMM**	**2SLS**
Chinese Outward Direct Investment	0.034**	0.088***	0.068**	0.084***	0.072***	-0.006	-0.064	-0.007	0.023
	(0.014)	(0.029)	(0.032)	(0.022)	(0.024)	(0.015)	(0.052)	(0.015)	(0.026)
Lagged Gini	0.703***	0.573***	0.489***	0.608***	0.521***	0.894***	0.694***	0.915***	0.776***
	(0.107)	(0.097)	(0.142)	(0.104)	(0.142)	(0.068)	(0.112)	(0.061)	(0.088)
Other sources of FDI stocks	-0.001*	-0.002**	-0.001	-0.002*	-0.001	-0.001	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
Secondary school enrollment	0.981	2.426***	2.206**	2.358***	2.060**				
	(0.703)	(0.635)	(0.859)	(0.706)	(0.914)				
Country policy and inst. assessment	-1.748	-0.240	-1.213			-1.463	-3.799**		

	(1.326)	(1.158)	(1.373)			(1.071)	(1.643)		
Labor force over age 15	-0.085	-0.204	-0.337**	-0.244**	-0.265**	-0.196*	-0.180	-0.109	-0.060
	(0.109)	(0.123)	(0.155)	(0.107)	(0.129)	(0.107)	(0.133)	(0.098)	(0.124)
Trade Openness	0.002	-0.081***	-0.088***	-0.079***	-0.091***	0.003	0.003	0.004	0.003
	(0.014)	(0.026)	(0.031)	(0.025)	(0.029)	(0.006)	(0.008)	(0.006)	(0.006)
Gross Domestic Product per capita	0.004	0.001	0.007	0.004	0.003	0.006	0.009	0.003	0.002
	(0.005)	(0.004)	(0.006)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)
Inflation rate	0.009	-0.000	0.051	-0.028	0.018	-0.028	0.018	-0.000	-0.000
	(0.032)	(0.048)	(0.054)	(0.049)	(0.063)	(0.049)	(0.063)	(0.000)	(0.000)
Squared CODI/GDPPC	-0.0001	-0.0002***	-0.0003***	-0.000***	-0.000***	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted Saving Res	-0.053	-0.210	-0.040	-0.157	-0.082	0.124*	0.071	0.066	0.053
	(0.079)	(0.178)	(0.211)	(0.153)	(0.191)	(0.069)	(0.075)	(0.059)	(0.067)
Total natural resources rents	0.145	0.413**	0.272	0.377**	0.270	-0.049	0.021	-0.037	-0.013
	(0.093)	(0.170)	(0.210)	(0.166)	(0.210)	(0.034)	(0.054)	(0.038)	(0.047)

Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	134	102	102	101	101	101	101	124	124
Number of Countries	21	21	21	21	21	21	21	21	21
Hansen		0.1316		0.2036		0.2036		0.3555	

Notes: Dependent variable is Gini coefficient. Fixed effects is selected based on Hausman test with robust standard error to correct for heteroscedasticity. Two step dynamic GMM/IV and 2SLS/ IV. Numbers are rounded to three decimals. Numbers in parentheses = t-statistics. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.1$, ** $p<0.05$, *** $p<0.001$.

Table 2.4 The isolated impact of the main explanatory variables

Variables	FE	GMM	2SLS-FE
$\left(\frac{\dot{\text{CODI}}}{\text{GDP}}\right)_{it}$	0.021	0.050	0.042
$\left(\frac{\dot{\text{RestofFDI}}}{\text{GDP}}\right)_{it}$	-0.015	-0.030	0
$\left(\dot{\text{Sec}}_{\text{Enro}_{\text{Pop}}}\right)_{it}$	0	0.234	0.213
$(\dot{Labor})_{it}$	0	0	-0.627
$(\dot{\text{Trade}})_{it}$	0	-0.138	-0.152
$(\dot{\text{REs\_rents}})_{it}$	0	0.141	0
$(\text{Sqrd\_}\dot{\text{CODIe}})_{it}$	0	-0.0125	-0.017

Note: the calculation based on and Table 2.3. col (1) , (2) and (3). Numbers are rounded up to three decimals. Zero values denote insignificant coefficient in Table 2.3.

Table 2.5 Robustness check, Regression Income inequality on Chinese Outward Direct Investment Stock into low-income African countries, 2003 - 2014

VARIABLES	(1) FE- **Gini %**	(2) SYS GMM **Gini %**	(3) FE-2SLS/IV **Gini %**	(4) FE-GMM **Gini %**	(5) 1st Diff. **D.Gini %**	(6) 1st Diff. **D.HDI %**
Chinese Outward Direct Investment (GDP) %	0.058***	0.160*	0.230**	0.246***	0.046*	0.005
	(4.13)	(0.090)	(3.18)	(3.60)	(2.76)	(0.003)
Other FDI stocks from other sources (/GDP) %	-0.002**	-0.006	-0.009**	-0.010***	0.000	0.001*
	(-2.70)	(0.004)	(-2.84)	(-3.34)	(-0.37)	(0.000)
Gross Domestic Product Per capita U.S dollar (GDPPC)	0.003	0.0028	0.003	0.001	-0.014	0.015***
	(0.010)	(0.010)	(0.27)	(0.11)	(-1.12)	(0.003)
Country policy and the institutional assessment, average .	-4.173	-5.360**	-5.868*	-5.759*	-4.092*	0.802*
	(2.482)	(2.138)	(-2.39)	(-2.45)	(-2.16)	(0.004)
Secondary school enrollment % (Sec_Enro_Pop)	2.866***	3.177***	3.641***	3.711***	1.523	0.0013

	(0.505)	(0.576)	(7.35)	(7.57)	(1.73)	(0.008)
Labor Force, % of total population ages 15+	-0.024	-0.334	-0.566	-0.514	0.411	1.494***
	(-0.195)	(0.383)	(-1.57)	(-1.43)	(0.93)	(0.177)
Inflation Rate, Annual %	-0.040	-0.078	0.105	0.112	-0.030	0.710*
	(-0.040)	(0.067)	(1.14)	(1.22)	(-0.73)	(0.393)
Trade Openness % of GDP	0.008	0.017	0.025	0.050	-0.062	-0.050
	(0.024)	(0.027)	(0.64)	(1.94)	(-1.80)	(0.093)
No. of countries	21	21	21	21	21	21
FE countries	Yes	Yes	Yes	Yes	Yes	Yes
Observations	150	133	111	111	112	120
F-stat.	19.93		19.64	20.41	2.81	21.37

Notes: in column (1) to (5) Dependent variable is Gini coefficient, and the missing values of Gini were replaced by the averages. In column (6) the Dependent variable was replaced by HDI (Human development indicator). The table reports the coefficients on the level of all variables. These models are implemented as robustness check and falsification. Numbers are rounded to three decimals. Numbers in parentheses = t-statistics. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.1$, ** $p<0.05$, *** $p<0.001$.

Appendix Table 1.2 Definitions and sources of the variables used in the empirical analysis, For Low-income African countries, 2003-2014

Variable	Definition		Source
Dependent:			
Gini	Income inequality measured as Gini index %		UNU-WIDER World Development Indicator (WDI) and the African development bank group Human Development Report
Independent:		**expected sign***	
(CODI/GDP) %	Chinese outward direct Investment stocks as a percentage of GDPPC	+	UNCTAD- MOFCOM- SIAS-CARI
Control variables:			
(Non-CODI /GDP) %	Total FDI stocks from other sources as percentage of GDPPC	-/+	UNCTAD
GDPPC	GDP per capita country (constant 2010 US$)	+	World Development Indicators
Sec_Enro_Pop.	The ratio of total secondary both genders enrollment to the population	+	WDI, Human Development Report African development bank group

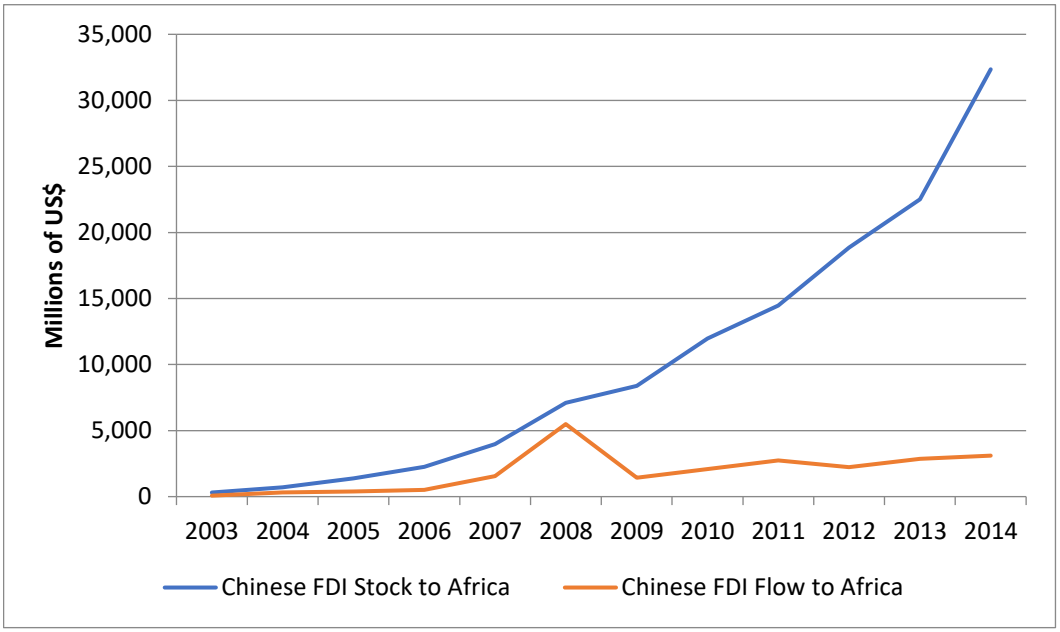
CPIA	Country Policy and Institutional Assessment measured on (1-6) scale, average score.	-	WDI, African development bank
Lab.	Labor force participation rate (% of total population ages 15+).	-	International Labour Organization (ILO) World Development indicator
Inf.	Inflation rate = Annual % change in CPI	-/+	WDI
Trad.	Trade Openness (Exports + Imports) as a % of GDP	-/+	WDI
TotRent	Total Natural Resources rents	-/+	WDI
Adj. Saving	Adjusted savain: natural resources deplition	-/+	WDI

*The expected values are assigned based on both Modernization and Dependency hypotheses discussed in different studies ((Tsai, 1995 and Bornschier, 1983), and some characteristics of both CODI and low-income African countries.

Appendix Table 2.2 Pairwise Correlation of variables used for regression of Gini on CODI stock into Low-income African countries, 2003-2014

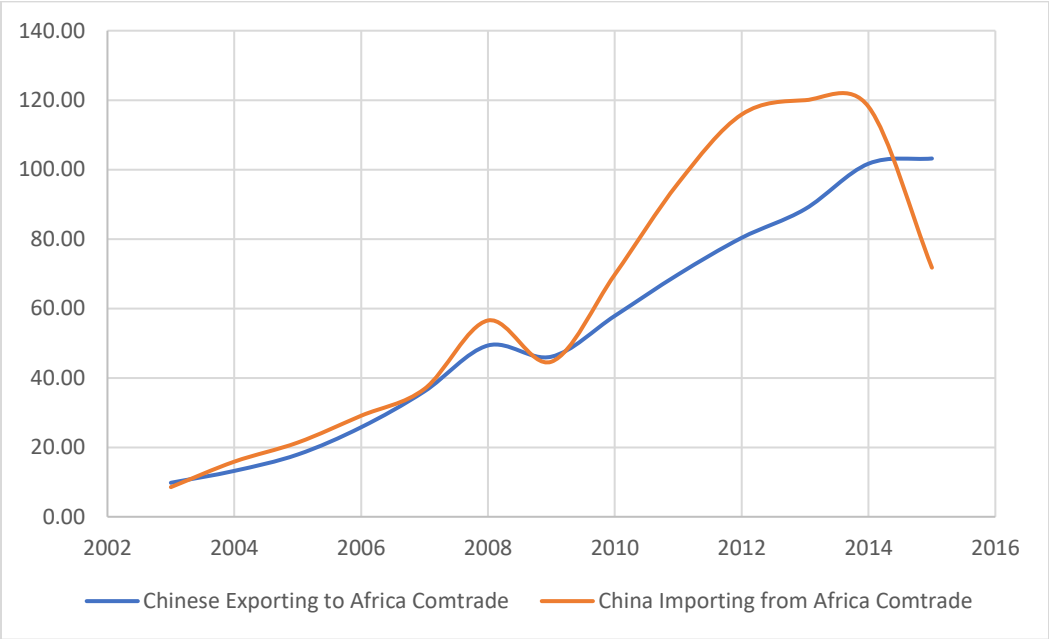
	Gini %	CODI/GDP	non-CODI /GDP	GDPPC	CPIA	ENRO_POP	Lab	INF	TRAD
Gini %	1.0000								
(CODI/GDP) %	0.358***	1.0000							
(Non-CODI /GDP) %	0.154**	0.621***	1.0000						
(GDPPC)	0.297***	-0.079	-0.251***	1.0000					
(CPIA)	0.140**	0.043	0.093	0.137**	1.0000				
(ENRO_POP)	0.473***	0.102	-0.057	0.293***	-0.182***	1.0000			
(Lab)	0.139**	0.150**	0.064	-0.079	0.111*	-0.070	1.0000		
(INF)	-0.068	-0.031	-0.033	0.067	-0.194**	0.081	0.076	1.0000	
(TRAD)	0.008	0.054	0.288***	-0.082	-0.170**	0.304***	-0.260 ***	0.023	1.0000

Note: Numbers are rounded to three decimals. Numbers in parentheses = t-statistics. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.05$, ** $p<0.01$, *** $p<0.001$.



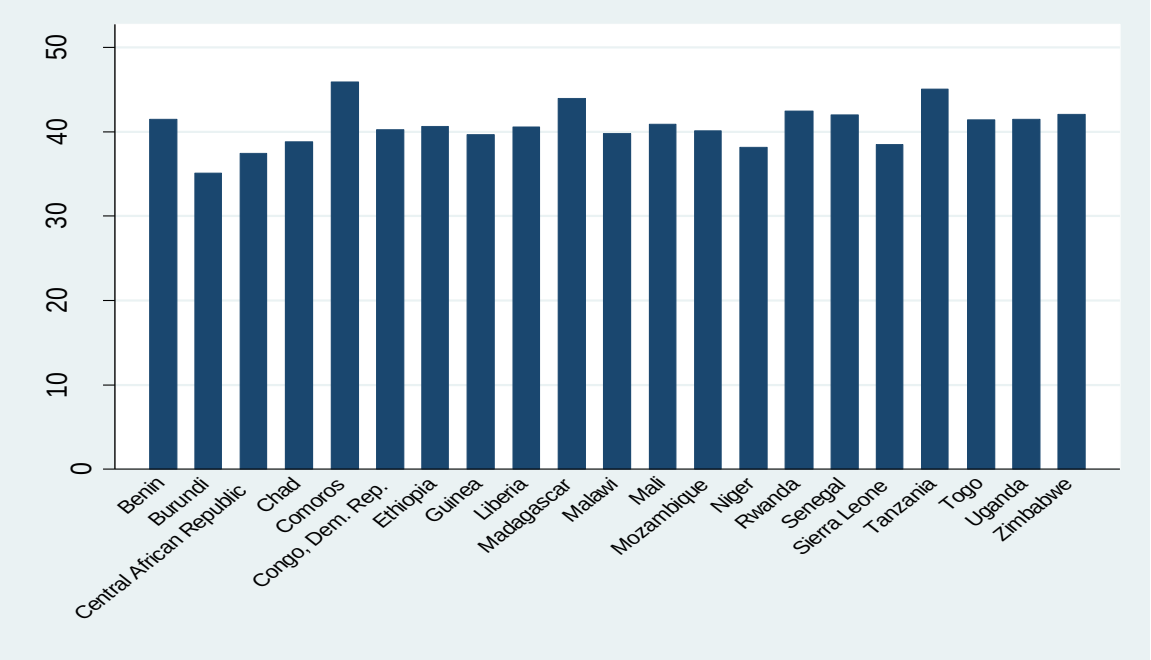
Graph 1.2 Chinese FDI Flow and Stock to African countries, 2003-2014

Source: based on the data collected from UNCTAD; MOFCOM.



Graph 2.2 The China - Africa Trade, 2003-2014

Source: UNCTAD; UN Comtrade; and MOFCOM.



Appendix graph 2.3 Mean value of Gini coefficient for each 21 low-income African countries, 2003-2014

Source: The author's calculations based on the dataset used in this research.

Chapter 3
The effect of using Biomass Energy on Housing Prices in Eastern Africa

3.1 Introduction

Environmental degradation and resource depletion, mainly deforestation, are a concern in studying the sustainability and development of Africa. At a deforestation rate of 7% every decade, the African forests is cut in half every 100 years (Sadoule and de Janvry, 2016.) For example, Rwanda faces significant environmental challenges. The decline in forests of Rwanda reached approximately 65% in the period 1960 to 2002. One significant problem is that forest biomass use is the primary energy source, covering about 94% of the total need for households and industries. For example, the number of households using firewood and charcoal as cooking energy is about 82% and 13% of the total population in Rwanda, respectively (Environmental Profile of Rwanda, 2006 and REMA, 2011.) Several regulations are in place for sustainable protection and management of natural resources and the environment to decrease national consumption rates of dirty energy. Included is Rwanda's current focus on public policies to expand renewable energy use.

As per the national energy policy and strategy for Rwanda (2011), the primary goal of the accelerated electricity development strategy for the period 2011 to 2017 is to generate an additional 1,000 MW of electricity at least-cost. In addition, the Biomass Energy Strategy envisages further improvement, setting a target of 15% of average transformation to clean energy efficiency to be attained by 50% of electricity producers by 2015 and over 60% of producers by 2020. The planned extensive use of biomass can be related to existing power supply constraints: The tariff per kWh is relatively high due to the size of the system and the exclusive use of fossil fuels. Moreover, there is limited access for poor and rural households to modern energy, such as solar panels and natural gas, as access to electricity in Rwanda is low at around 14%.

Nevertheless, the Government of Rwanda has made tremendous efforts in providing 60% of households with improved stoves.

Affordability and accessibility of energy sources are the major players in household fuel decisions, Appendix Figure 1. Therefore, the impact of growing population on natural resources leads to increasing demand for specific housing characteristics, such as locations and access to energy --variables vital to this study. There are special features that make housing a unique commodity. For instance, first, one characteristic that distinguishes housing from other commodities is its heterogeneity. Second, housing is spatially immobile in which the housing market is affected by neighborhood characteristics such as accessibility, local public services, environmental quality, and consumption externalities. These externalities are generated when household well-being is affected or declines because of others' activities, such as energy consumption. For example, it is not difficult to realize that housing values tend to be lower in neighborhoods with poor environmental conditions, all other attributes being fixed.

Moreover, the environmental externalities of one district or city will also contribute to the environmental degradation of other locations, such as pollution spillover. For example, the use of firewood continues to have a highly negative impact on public health. Such negative externalities will eventually affect the social optimum if not accounted as asocial cost. Therefore, determining households' willingness to avoid environmental degradation is crucial in the design of national environmental policies. Hedonic housing models can capture differences of residential locations, especially the environmental effects (Freeman et al., 2014). In the present study, we built our theoretical framework based on the classic demand estimation framework (Rosen, 1974; Follain and Jimenez, 1985; Epple, 1987; Sheppard, 1999.) The analysis is

performed via two-stage bootstrapped spatial quantile regression to account for the potential endogeneity caused by spatial correlation among house locations such as provinces and districts.

This paper is structured as follows. Section 2 presents the literature review. Section 3 explains methods and empirical model specifications. Section 4 presents the data description and variable definitions. Section 5 discusses the empirical results. We conclude in Section 6 with a discussion of the results and some policy implications.

3.2 Literature Review

This section initiates a literature review to shed light on the impact of environmental characteristics in estimating the hedonic price model. The use of dirty energy such as firewood and crop wastes have multiple adverse effects on land cover and air quality, extending to life quality. The role of environmental degradation on dwelling values and location choices have been investigated in the literature. Many studies in the housing valuation literature estimate the impact of negative externalities on property prices (Palmquist,1992; Boyle and Kiel, 2001; Hite et al., 2001; Hilber, 2005. Chay and Greenstone, 2005; Hanna 2007; Cho et al., 2011; Freeman et al., 2014; Chiarazzo et al. 2014). In studying the air quality hedonic price studies, for instance, Batalhone et al. (2002) and Trijonis et al. (2002) provide empirical evidence to show how air pollution affects property values and household location decisions.

Moreover, the analysis of location choices reflects the role of amenities on local economic change. Thus, air pollution negatively influences dwelling values. Chay and Greenstone (2005) studied the reduction of pollution induced by Clean-Air Act amendments on the property values in the US. Findings suggested that the mean value of housing increased by 0.2-0.4 percent due to improved air quality. Considering energy sources, Eichholtz et al. (2018)

and Dr¨oes and Koster (2016) found that nearby wind turbines and gas plants have a negative external price effect on property value.

Moreover, environmental amenities are commonly understood as significant determinants of spatial development and residential choice location (e.g., Wu, 2006; Mendelsohn and Olmstead, 2009; Cho et al., 2011; Freeman et al., 2014; Dr¨oes and Koster, 2016; Chen and Li, 2017). Empirically, quantile regression with spatial components and instrumental variables techniques is being employed to deal with identification issues raised in hedonic models, including parametric assumptions, and the effect of housing characteristics and locations on each point of the distribution of property values (Koenker and Hallock, 2001; Koenker, 2005; McMillen and Thornes, 2006; Zietz et al., 2008; Kostov, 2009; Nicodemo and Raya, 2012; Liao and Wang, 2012; Kim et al. 2015).

For example, Koenker and Hallock (2001) and Koenker (2005) show that hedonic price functions can be modeled using quantile regression, making it possible to empirically examine how housing features are differently valued across the distribution of housing values. Also, by studying the preferences of homebuyers in Hong Kong, McMillen and Thornes (2006) used housing transaction data from Chicago from 1993 to 2005 to show that quantile regression has advantages over conventional mean-based approaches. McMillen and Coulson (2007) found significant variations in the value of physical characteristics across quantiles by studying house price appreciation and constructed quantile house price indexes. Kim et al. (2015) estimated determinants of house prices in Seoul between 2006 and 2012 employing quantile regression. Results suggested that school proximity has the most significant effect on housing prices and the lower quantile has large effects.

This paper aims to study the effects of environmental degradation on residential prices and locations in Rwanda. To the best of the authors' knowledge, no research empirically examines the extensive use of biomass on property values in Rwanda. Therefore, the research question is tested using cross-sectional data by employing bootstrapped quantile regression. The number of individuals, structural, neighborhood characteristics associated with each product is used to determine a set of hedonic prices under the following hypotheses: H_1; average residential prices tend to be decreased because of negative externalities caused by unfriendly environmental sources of energy. H_2; average residential prices increase due to characteristics with better quality. Thus, they illustrate a meaningful correlation between residential prices and a specific characteristic.

Proposition

The divergence among household choices is based on different housing characteristics rather than just the value of different dwelling characteristics. Therefore, the measurement of housing characteristics is not based solely on household socioeconomic features, but also on household preferences, health concerns, and access to information.

3.3 Methodology and Theoretical Framework

Among the different models of estimating the value of environmental degradation, the hedonic housing model is employed to determine household preferences of environmental consumption. We mainly focus on the extensive use of biomass as a source of cooking and lighting energy on households' willingness to pay for the residential location. The hedonic price model typically describes property price as a function of three categories of independent variables: structural, neighborhood, and environmental characteristics, allowing housing spending to be decomposed into values and quantities of individual housing features (Rosen, 1974; Follain and Jimenez,

1985; Epple, 1987; Sheppard 1999; Malpezzi 2003; Ekeland et al., 2004; Sirmans et. la 2005; Palmquist, 2005; Freeman et. la, 2014). Even though demand and supply functions support hedonic price equations, it might be difficult to identify empirically and accurately the market equilibrium. In recent years, this condition is unlikely to be realistic because of the heterogeneity across regions (Freeman, 2003; Kuminoff et al., 2010.) Thus, the estimated marginal willingness to pay suffers from biasedness in estimates if the researcher fails to account for heterogeneity such as spatial correlation.

Hedonic housing price empirically assumes that the original supply function of housing characteristics is vertical, i.e., perfectly inelastic price, where housing attributes are predetermined and fixed in a short period (Rosen, 1974; Epple, 1987; and Bartik, 1987; Ekeland et al., 2004). In other words, the supply of housing characteristics is independent of the implicit price of a specific characteristic and is fixed over time. The implicit price is defined based on the intersection between the downward sloping demand curve and the given vertical supply curve of a specific characteristic, assuming that all consumers are equal. We follow the standard hedonic framework to estimate implicit price as follows:

(1) $$Y_h = f(T_h, \mathrm{N}_h, \mathrm{E}_h;\ \mathrm{e}_h)$$

All variables in bold are vectors, (Y_h) a single house value based on its structural (T_h) and neighborhood (N_h) characteristics, as well as environmental variables (E_h). The error term, (e_h) reflects uncertainty in the measurement of variables and the preferences of individual homebuyers. Housing price is usually affected by its physical characteristics and its location, structural characteristics and sociodemographic factors. One needs to take the partial derivative of derivative of housing price with respect to a specific characteristics to obtain the consumer's marginal willingness to pay for a corresponding characteristic. The individuals' housing

locations and preferences are mainly modeled using a random utility framework. The individual chooses the housing location that yields the highest utility of all locations in the possible set K_n.

In the present paper, the individual will seek better housing locations in Rwanda's provinces. In the random utility framework, overall utility $U_{in} = V_{in} + e_{in}$, where; *i* identifies the location, U_{in}, is the sum of deterministic components, V_{in} can be expressed as an indirect utility function conditional on the multiple arguments, and a random component e_{in} (Rosen, 1974; Ekeland et al., 2004; Palmquist, 2005; Freeman et al., 2014).

In this case, the housing price model assumes a household with income *M* and socio-economic attributes and preferences *a*, which spends its budget choosing a house with $z = (z_1, \dots, z_n)$ which represents a vector of house characteristics other than environmental qualities *E*, other housing features *X*, and household expenditure on other goods *c*. A household will obtain this housing bundle under two assumptions 1) of weak separability in housing characteristics and all other goods and 2) market equilibrium where prices are market-clearing. The former is based on the demand for different housing characteristics independent of the prices of all other goods. A household can consume either housing or a Hicksian composite good (Follain and Jimenez, 1985; Ekeland et al., 2004; Sirmans et al., 2005; Hicks, 1943) cited in Freeman et al., (2014). Therefore, households seek to maximize their utility function *u(X,S)* with respect to budget constraints by choosing houses that will provide them with the best combination of desired characteristics, as follows:

(2) $$V_i = V\ (z_1, \dots, z_n, E_i, X_i', a, c;\ M_i)\ subject\ to$$

$$Budget\ constraint:\ M_i = x + P(z_1, \dots, z_n, E_i)$$

where *Y* represents property price as a function of its characteristics, that is, the hedonic price function to be estimated based on the assumption that the implicit price function is differentiable and continuous. Thus, the functional form is

(3) $$Y_i = p(X'_i;\ \beta_i, \varepsilon)$$

where, β is a vector of parameters to be estimated; ε is a stochastic residual term; and Y_i is the implicit price for the i^{th} characteristic (Rosen, 1974; Ekeland et al., 2004; Freeman et al., 2014), as a measure of household marginal willingness to pay. The implicit marginal price of a specific characteristic, say environmental, can be calculated by taking the first-order condition of equation (3). Thus, the marginal environmental characteristics are $\partial Y_i/\partial E_i = Y_{E_i}(E_i)$. Therefore, the estimation process for environmental externalities, *E*, with hedonic housing price, requires the following assumptions: first, all houses have almost a similar combination of public and private features. Second, the housing market is transparent regarding prices and property characteristics. Third, the price will adapt to change in any housing characteristics, especially environmental quality (Chay and Greenstone, 2005; Mendelsohn and Olmstead, 2009; Kuminoff et al., 2010; Dr ̈oes and Koster, 2016). At the same time, households have the same chance to access market information. Therefore, we assume that market equilibrium will be held on the consumer side, rather than the specific individual producer of these negative externalities, which is a demand-driven decision (Palmquist, 1991; Freeman, 2003.)

3.3.1 Empirical Model Specification

This model assumes that each household chooses from a set of housing characteristics such as individuals, neighborhood, structural, and environmental characteristics, and is expressed by rewriting equation (3) as a linear function:

(4) $$Y_{hi} = \beta_o + \sum_{i=1}^{k} \beta_i X'_{ihk} + u_{hi}; \qquad u_{hi} \sim i.i.d \text{ and } u_{hi} \sim N(0, \delta^2 I)$$

where Y_{hi} is an n×1 vector of the dependent variable and denoted market price of dwelling *h* in the region *i*; X_{ih} is an n×k matrix of explanatory variable and denotes the characteristics k of the dwelling *h;* and β_i are the coefficients estimates and represent the implicit marginal price of characteristic X_i. The error term u_{hi} is an n×1 vector of error terms. We assume the error term $u_{hi} \sim i.i.d \text{ and } u_{hi} \sim N(0, \delta^2 I)$ is an *i.i.d* whereas 0 is the n×1 vector of value 0, σ^2 is the variance of error terms, and *I* is the n×n identity matrix. The error term denotes the component model of the disturbance error $u_{hi} = \mu_h + \nu_{hi}$ which reflects either unobserved attributes of the individual or housing location or deviations in individual n's preference for environmental equality, i.e., unobserved heterogeneity in preferences.

To the extent that μ_h is correlated with observable housing unit characteristics (X_{hj}), employing OLS will lead to biased estimates. Also, failing to control for the unobservable characteristics and omitted attributes can be correlated to environmental quality leading to biased estimates (Ekeland et al., 2004; Mendelsohn and Olmstead, 2009). In practice, many authors have employed a variety of models to estimate the hedonic analysis, such as OLS and quantile regressions model QRM. While OLS models only the conditional mean of a response, quantile regression can be employed to explain the determinants of the outcome variable at any point in the distribution of the dependent variable without assuming a constant variance. QRM are not restricted to explaining the mean value of the outcome variable and can be used to describe the determinants of the outcome variable at any point in the distribution of the dependent variable and uses the entire sample to avoid the truncation issue (Gould, 1992; Gould and Rogers, 1994).

Other significant advantages of quantile regression include its superior capability in handling heteroscedasticity, outliers, and unobserved heterogeneity. Moreover, it is based on the minimization of weighted absolute deviations for estimating conditional quantile functions and

thus reflects changes in coefficient magnitude (Chamberlain, 1994; Koenker and Hallock, 2001; Koenker, 2005; Zietz et al., 2008; Kim et al., 2015). The QRM can be formalized as follows:

(5) $$Q(\tau) = inf\{Y_i : F(Y_i) \geq \tau\}$$

where $0 < \tau < 1$. The variable τ ($0< \tau <1$) is the quantile to be estimated.

Median regression, $Q_{(1/2)}$ refers to a sample fraction of 0.5, known as the least absolute value (LAV) model and minimum absolute deviation (MAD) which models the median of the outcome variable conditional on the value of the covariates. In contrast to OLS, median regression minimizes the sum of the absolute residuals rather than the sum of the squared residuals. Also, the median is particularly convenient to describe a dataset with a significant skew or long tail.

(6) $$\widehat{\beta_\tau} = \underset{\{\beta_\tau\}_{j=0}^{k}}{\operatorname{argmin}}\left[\sum_i \left|Y_i - \sum_{j=0}^{k} x'_{i,j}\beta_j\right| r_i\right]$$

where the weight r_i is defined as $r_i = 2\,\tau$, if the residual for the i^{th} observation is strictly positive or as $r_i = 2\text{-}2\tau$, if the residual for the i^{th} observation is less than or equal zero, $P_{(\tau)}\left(u_{i(\tau)} \leq 0|X\right) = \tau$. Then, we implement the quantile model into the hedonic pricing model by rewriting equation (4) as follows:

(7) $$Q_{(\tau)}(Y_{hi}|X) = \beta_\tau + \sum_{i=1}^{k} \beta_{(\tau),k} X'_k + u_{hi(\tau)}$$

where $Q_{(\tau)}\left(Y_{hj}|X\right)$ is the log housing price in τ^{th} quantile for household h in district i. and X_k denotes a vector of all the housing characteristics.

3.3.2 Identification

Ignoring spatial effects on estimating environmental hedonic evaluation will lead to biased results. To deal with the endogeneity encountered in housing models, we make use of the bootstrapped quantile regression to get bootstrapped standard errors that are significantly less sensitive to heteroscedasticity than a standard analytic error (Rogers, 1992; Gould and Rogers,

1994; McMillen and Thornes, 2006; Zietz et al., 2008; Kostov, 2009; Liao and Wang, 2012; Chernozhukov, 2013; Koenker, 2017a and 2017b; W¨uthrich, 2020). Quantile regression also makes it possible 1) to statistically investigate the extent to which housing characteristics are valued differently across the distribution of housing prices and 20 to examine different reference curves as a function of several variables of interest without imposing strict parametric assumptions (Koenker and Hallock, 2001).

Therefore, we incorporate spatial features and additional instruments based on accessibility to biomass and environmental information and the effect of neighboring areas and adjacent districts. In this study, we construct a spatial lag weight matrix to get a distance-based spatial weight matrix for the dependent variable. To do so, a spatial weight matrix W_{ji} is added to the quantile regression model which reflects the spatial dependence interaction. Each pair of residential locations, district *i* and district *j*, are spatially connected via neighboring and environmental spillovers, Figure 3.1. The neighbor interaction value w_{ij} is assumed as a binary contiguity index and is an element of the spatial exponential weight matrix.

This exponential matrix guarantees fewer influence for farthest distant neighbors. It has two components; *d* denotes the threshold distance, and δ denotes the distance decay parameter (Anselin, 2003; Kondo, 2017). Thus, the matrix takes the following:

(8) $$w_{ij} = \begin{cases} \frac{exp(-\delta d_{ij})}{\sum_{j=1}^{n} exp(-\delta d_{ij})} & , \quad if \quad d_{ij} < d,\ i \neq j,\ \delta > 0, \\ 0, & otherwise \end{cases}$$

Therefore, we incorporate the spatial lag weight matrix in equation (7) and take the matrix form

(9) $$Y = \rho\, WY + X\, \beta + U,$$

where W= (w_{ij}) n×n, ρ is scalar and denotes a spatial dependence parameter, $-1 < \rho < 1$. if $\rho = 0$ the model will be reduced to OLS.

Although the main reason for including the spatial weight matrix is to deal with spatial dependency in our model, both equations (7) and (9) suffer from potential endogeneity. Several authors adopted procedures using instrumental variables with quantile regression (Kim and Muller, 2004; Chernozhukov and Hansen, 2006 and 2008; Chernozhukov, 2013; Koenker, 2017a).

Therefore, we employ two-stage spatial quantile regression. In the first stage, we used the spatial weight matrix as a dependent variable and variables that might influence household preferences, such as whether the household applied for a health insurance plan, the location before moving to the recent district, and other control variables. We, then, obtained the predicted values $\rho_{(\tau)} \sum_{l=1}^{k} \widehat{W_{(\tau),lJ}}\, Y_{(\tau),hJ}$ and plugged it into the second stage equation (9) employing bootstrapped quantile regression model.

Thus, the baseline model is as follows:

(10) $Q_{(\tau)}(Y_{hi}|X,\tau,\rho,\beta\,) = \rho_{(\tau)} \sum_{l=1}^{k} \widehat{W_{(\tau),lJ}}\, Y_{(\tau),hJ} + \beta_{(\tau)} + \sum_{i=1}^{k} \beta_{(\tau),k} X'_k + u_{(\tau)i}$,

where $u \sim IID(0, \delta^2 I)$ and $E\left(u_{(\tau)i} \middle| X'_k\right) = 0$, where ρ denotes the quantile spatial dependence parameter of order τ.

3.4 Data Description

Initially, the survey was released into two files, household and person datasets. We use a secondary dataset extracted from the Statistics Integrated Household Living Conditions Survey, 2013-2014, located in 30 districts, Appendix, Figure 2. The targeted population of the survey consists of all private households in all of Rwanda. We dropped categories with missing values and fewer frequencies. The total number of remaining observations reached 12650.

The dependent variable is the current value of the dwelling in the natural log to reduce high variation, 1000 to 100 million R.W. francs (i.e., about 1.5 to 150 thousand U.S. dollars). The log transformation reduces heteroscedasticity, improves the goodness of fit of the data, and simplifies the interpretation of the coefficients. Figure 3.2 demonstrates the empirical cumulative distribution function of the log current dwelling value, which looks reasonably symmetric at the 10^{th}, 50^{th}, and 90^{th} quantiles. The shape of this graph supports the use of quantile regression along with the theoretical justification of how the effect of housing characteristics might be changed concerning property value distribution.

There are several explanatory variables included in the analysis. The main two environmental characteristics are binary variables. The primary source of cooking fuel is categorized into three categories. The primary source of lighting is categorized into seven categories, see Table 3.1 regarding the high percentage of using the biomass extensively in Rwanda. In this study, we construct two binary variables; the first variable, if the household utilizes at least one of firewood unit, charcoal or and crop wastes as a source of cooking fuel =1, and zero otherwise; the second covariate, we combine these categories in the condition if the household is using firewood as a source of lighting, and zero otherwise.

We also included more variables as controls—for example, socio-economic characteristics. The natural log of aggregated consumption was incorporated as a proxy for household income. Gender: male = one, female = zero. Marital status married = one, zero Otherwise. For housing characteristics, we include the number of rooms ≤ three rooms = one and zero otherwise. Floor material, clay tiles and metal sheets = yes and no otherwise. Location characteristics include Rwanda provinces, i.e., Kigali City, Southern Province, Western

Provinces, Northern Province, and Eastern Province, which contain 30 districts. We use the centroid (latitude and longitude) of these districts to construct the spatial lag matrix.

To limit the consequences of self-selection and omitted bias, we incorporate another binary variable, whether the household is getting any salary or wage from agriculture as a proxy for biomass accessibility. The primary source of information on the environmental issue is five categories: both meetings/training and radio/tv, the most utilized sources by the households. The rubbish and garbage disposal mode contains seven categories; compost heap and thrown into bushes or fields have a higher frequency. Figure 3.3. illustrates the descriptive analysis of the relationship between the log of current dwelling value and both sources of cooking and lighting. Thus, most unfavorable environmental sources cause dwelling value below the overall mean housing value, a horizontal line. We generate a few binary variables out of these energy categorical variables based on the importance of these sources in Rwanda and the highest frequencies recorded.

Since household preferences are vital in residential value and location choice decisions, we include more binary variables. For example, whether the household received any environmental information; the dwelling was affected by environmental destruction in the last 12 months from the interview day; the household always lived in the district; and whether family member had ever been to school and lived in urban = one and zero otherwise. Moreover, additional variables are included in estimating first stage estimates to get the predicted spatial dependence matrix. For example, we incorporate the median value of rent per district to account for surrounding area prices. Finally, we combine the environmental variables of interest together to identify the climate unfriendly energy source.

3.5 Results and Discussion

Using dataset survey data discussed above, we study exposure to environmental risks caused by the extensive use of biomass on housing value in central Africa, we use Rwanda as a case study, and analyze how households choose residential location based on the housing characteristics and socioeconomic features. As an alternative to OLS regression, this study employs two-stage bootstrapped spatial quantile regression that allows for a more comprehensive understanding of the effect of explanatory variables on housing values and how these effects might vary, thus accounting for spatial correlations. Table 3.2 reports the results from estimating equations (10). Coefficients express the added value of the variable in percentages of current value of property. The implicit marginal price of the variable of interest, cooking and lighting sources, is calculated by taking the first-order condition for the hedonic price function concerning the variable of interest. Concerning the estimation, one needs to pay attention to the potential bias caused by omitted variables. This potential bias arises when the covariate is not orthogonal to the error and would be the case if certain variables describing important neighborhood or housing characteristics (e.g., spatial information) are not accessible. However, those variables are correlated with the attribute of interest.

Second stage spatial quantile regression estimates show that the effect on housing values varies across different distributions. Estimating quantile regressions provides an opportunity to measure the relationship of dwelling prices to many housing characteristics. Findings are in support of our hypotheses. Since the estimate for the parameter of spatial dependence ρ is significantly positive across quantiles from the 05^{th} to 95^{th} (ρ = 0.31 and 0.674), there is strong correlation between districts because of neighboring and environmental spillovers.

This result is consistent with Moran's I test (> 0). We reject the null hypothesis that there is spatial randomness. Therefore, OLS estimates are upward biased and inconsistent. Table 3.2, column (1), seems to show clearly that the bias in least-squares is upward. As per this analysis, our findings support the underlying hypotheses of this study. At the same time, results reflect changes in coefficient magnitude of the across models and quantiles. Spatially lagged coefficients are statistically significant for all quantiles, which justifies the importance of including spatial effects in analyzing factors affecting housing values and residential decisions. The results in Table 3.2 column (2)-(12) show bootstrapped quantile regression at various quantiles in the conditional distribution of dwelling values. Standard errors were bootstrapped and are less sensitive to heteroscedasticity. Household willingness to pay for environmental characteristics is likely to be similar across the range of dwelling values, though the magnitudes vary.

Estimated coefficients are relatively sensitive to the distribution of housing values. Therefore, houses located in an area affected by environmental degradation, such as sources of cooking fuel and lighting, tend to negatively affect household willingness to pay across Rwanda across the quantiles, with differences mainly in the coefficient magnitude. Buyers are willing to pay less to stay in houses with negative consumption externalities.

The primary source of cooking fuel has a significant and negative impact on current dwelling value for quantiles 05 and 50, holding others constant, and the property value will drop by 40 and 20 percent, respectively. However, using crop wastes has an insignificant effect on housing price for quantiles between 60 and 95. Using firewood as a source of cooking has a negative impact on property value across quantiles. More precisely, quantiles between 05 and 50 will cause housing price to drop by 18 to 15 percent, respectively, and for quantiles between 60

and 95, prices will drop by 14 to 13 percent, respectively. Our second variable of interest, the use of firewood, will cause housing values to significantly decrease by 9% and 16%. For quantiles 05^{th} and 50^{th}, for quantiles 60^{th} and 95^{th}, and 14% and 13% respectively.

Coefficient estimates of housing characteristics are all reasonable and very robust across the specifications. For instance, an additional bedroom has significant added value across different ranges of current dwelling values. Living in a modern planned area and large floor area will increase the value of the dwelling. For example, floor and wall materials such as beaten earth have a negative effect across quantiles. Using such materials leads to a 9 and 24 percent decrease in housing value.

On the other hand, houses built-out of cement will have a value about 50 percent more across the quintiles. Bricks and clay tile positively impact household's willingness to pay higher for a larger floor area. These findings are almost similar to estimates of the other quantiles, where most of our explanatory variables have a relatively constant effect on property value across different price ranges and consistent with previous literature. Kigali is the capital city and has been Rwanda's economic, cultural, and transport hub in the middle of the country since it became capital. Because individuals are willing to pay less for houses located outside Kigali city, when it comes to location preferences living in provinces other than Kigali has no effects and might leads to decreased housing values.

For socioeconomic characteristics, estimates across the quantiles maintain the expected sign. For example, we use aggregate consumption as a proxy for household income. As we move to a higher quantile, the household is willing to pay a higher price for the property, and estimates range between 21 and 19 for quantiles 05 and 95, respectively. Households that receive income from agriculture negatively affect housing prices. The presence of negative externalities

using specific environmental materials show that dirty energy will cause housing prices to decrease and the willingness to pay for such houses to decline.

3.6 Conclusions

Two independent variables of environmental quality which form the core and basis of the hypotheses of this study are highly determinant in housing prices. In this paper, two-stage bootstrapped quantile regressions are employed. The objective is to examine how the extensive use of biomass influences the choice of house location and whether in this situation the willingness to pay is less. One of the main advantages of analyzing socioeconomics and environmental factors in two-stage spatial quantile regression is controlling for geographical and individual heterogeneity and implicitly reflecting household preferences. Thus, the results are robust and suggest that using cooking and lighting sources with significant negative externalities has a significant adverse effect on the value of residential houses in Rwanda. Furthermore, most of the coefficient estimates of individual and house attributes are consistent with previous literature and have statistically and empirically significant effects on property values across the sample.

For policy recommendation, access to power appears crucial compared to the existence method. Modern types of power will preserve the environment, including the quality of air. Policymakers are required to continue improving environmental management and infrastructural investment and develop regulations to help low-income households afford a better quality of life. According to the findings of this research, directing the sources toward improving the utility supply and transportation is of interest to all households. Encouraging the real estate developers, local workers, and household to use the efficient materials to attract buyers and

renter is recommended. These findings contain some essential lessons for homeowners – private as well as institutional.

Although we provide some intuition on the relation between the size of the energy-efficiency increment and actual energy savings, we are ultimately unable to distinguish between the intangible effects of classification and the economic effects of energy savings per se. There will be a direct financial benefit from lower energy expenses by enhancing energy efficiency by providing and encouraging households to switch to high-quality energy including electricity, solar panels, and natural gas. At the same time, increased energy efficiency is identified by buyers at the time of sale, leading to higher transaction price.

Detailed information on the energy consumption of individual households would allow us to separate these effects further along with the geographical location for each household. Also, having continues panel data allows us to track household decisions over time and employ different panel estimators in order to control for unobservable location heterogeneity and time changes within Rwandan districts on housing prices.

3.7 References

Anselin L. 2003. “Spatial externalities, spatial multipliers, and spatial econometrics.” *International Regional Science Review* 26(2): 153-166.

Batalhone, S. A. et al. 2002. “Economics of Air Pollution: Hedonic Price Model and Smell Consequences of Sewage Treatment Plants in Urban Areas”, *Departamento De Economia Universidade de Brasília.* Texto Para Discussão No 234. Available at http://www.unb.br/face/eco/cpe/TD/234August2002JNogueira.pdf

Bartik, T. J. 1987. “The Estimation of Demand Parameters in Hedonic Price Models.” *Journal of Political Economy* 95:81-88.

Boyle, M., and K. Kiel. 2001. “A survey of House Price Hedonic Studies of the Impact of Environmental Externalities.” *Journal of Estate Literature* 9(2):117-144.

Chamberlain, G. 1994. Quantile regression, censoring, and the structure of wages. In Advances in Economics Sixth World Congress, ed. Christopher A. Sims, 171-209. Cambridge University Press: Cambridge.

Chay, K.Y and M. Greenstone. 2005. “Does air quality matter? Evidence from the housing market.” *Journal of political Economy* 113: 376-424.

Chen, W.Y. and X. Li. 2017. “Cumulative impacts of polluted urban streams on property values: a 3-D spatial hedonic model at the micro-neighborhood level.” *Landscape Urban Planning* 162:1-12.

Chernozhukov, V. 2013. “Quantile Models with Endogeneity.” *Annual Reviews in Economics* (5) 57–81.

Chernozhukov, V.; Hansen, C. 2006. “Instrumental quantile regression inference for structural and treatment effect models.” *Journal of Econometrics* 132:491–525.

_____. 2008. “Instrumental variable quantile regression: A robust inference approach.” *Journal of Econometrics* 142: 379–398.

Chiarazzo V., P. Coppola, L. Dell’Olio, A. Ibeas, and M. Ottomanelli. 2014. “The Effects of Environmental Quality on Residential Choice Location.” *Social and Behavioral Sciences* 162:178 – 187.

Cho, S.H., R.K. Roberts, and S.G. Kim. 2011. “Negative externalities on property values resulting from water impairment: the case of the Pigeon River Watershed.” *Ecological Economics* 70: 2390-2399.

Dr ̈oes, M. L., and H. R. Koster. 2016. “Renewable Energy and Negative Externalities: The Effect of Wind Turbines on House Prices.” *Journal of Urban Economics* 96: 121–141.

Eichholtz, P. M. A. and N. Kok, and M. Langen, and Daan. Van Vulpen. 2018. “Clean Electricity, Dirty Electricity: The Effect on Local House Prices.” SSRN. Available at: https://ssrn.com/abstract=2826508

Ekeland, I., J.J. Heckman, and L. Nesheim. 2004. “Identification and estimation of hedonic models.” *Journal of Political Economics* 112(2): S60–109.

Epple, D. 1987. “Hedonic Prices and Implicit Markets: Estimating Demand and Supply Functions for Differentiated Products.” *Journal of Political Economy* 95:59-80.

Environmental Profile of Rwanda, Republic of Rwanda, European Commission, Kigali, July 2006. http://www.vub.ac.be/klimostoolkit/sites/default/files/documents/rwanda-environmental-profile.pdf (Accessed 12/7/2017).

Freeman A.M., Herriges J A., and Kling, C. L. 2014. “The measurement of environmental and resource values: Theory and methods” (3d ed.). Resources for the Future, RFF Press, New York.

Follain, J.R., Jimenez, E., 1985. “Estimating the demand for housing characteristics: a survey and critique.” *Regional Science and Urban Economics* 15(1) 77-107.

Gould, W. 1992. “Quantile regression with bootstrapped standards.” *Stata Technical Bulletin* 9: 19-21. Reprinted Stata Technical Bulletin 2:137-150.

Gould, W., and W. H. Rogers. 1994. “Quantile regression as an alternative to robust regression.” *Proceeding of the Statistical Computing Section*. Alexandria, VA: American Statistical Association.

Hanna, B.G. 2007. “House Values Income, and Industrial Pollution.” *Journal of Environmental Economics and Management* 54: 100-112.

Hilber, C. A. 2005. “Neighborhood Externality Risk and the Homeownership Status of Properties.” *Journal of Urban Economics* 57(2): 213–241.

Hite, D., W. Chern, F. Hitzhusen, and A. Randell. 2001. “Property-Value Impacts of an Environmental Disamenity: The Case of Landfills.” *Journal of Real Estate Finance and Economics* 22: 185-202.

Kim, T. H., Muller, C., 2004. “Two-stage Quantile Regression When the First Stage is Based on Quantile Regression.” *Econometrics Journal* 7:218–231.

Kim, H., Park, S.W., Lee, S. and Xue, X. 2015. “Determinants of house prices in Seoul: a quantile regression approach.” *Pacific Rim Research Journal* 21(2): 91-114.

Koenker, R. 2005. Quantile Regression. Cambridge University Press.

Koenker, R. 2017a. “Quantile Regression: 40 Years On.” *Journal of Annual Review* 9:155-176.

_____. 2017b. “Computational Methods for Quantile Regression,” in Handbook of Quantile Regression. Chapman-Hall.

Koenker, R., and K. Hallock. 2001. “Quantile regression: An introduction.” *Journal of Economic Perspectives* 15:143–156.

Kondo, K. .2017. “Introduction to spatial econometric analysis: creating spatially lagged variable in Stata.” Mimeo.

Kostov, P. 2009. “A spatial quantile regression hedonic model of agricultural land prices.” *Spatial Economic Analysis* 4(1):53–72.

Kuminoff, N. V., C. F. Parmeter and J. Pope. C. 2010. “Which Hedonic Models Can We Trust to Recover the Marginal Willingness to Pay for Environmental Amenities?” *Journal of Environmental Economics and Management* 60(3):145–160.

Liao, W. C. and Wang, X. 2012. “Hedonic house prices and spatial quantile regression.” *Journal of Housing Economics* 21(1):16–27.

Malpezzi, S. 2003. “Hedonic pricing models: a selective and applied research,” in: O’Sullivan, T., Gibb, K. (Eds.) Housing Economics and Public Policy, Oxford: Blackwell Science.

Mendelsohn, R. and S. Olmstead. 2009. “The Economic Valuation of Environmental Amenities and Disamenities: Method sand Applications,” *Annual Review Environmental Resources* 34:325–47.

McMillen, D. P., and Thornes, P. 2006. “Housing Renovation and The Quantile Repeated-Sales Price Index.” *Real Estate Economics* 34: 567–584.

McMillen, D.P., and Coulson N.E. 2007. “The Dynamics of Intra-urban Quantile House Price Indexes.” *Urban Studies* 44: 1517-1537.

Nicodemo, C.; Raya, J. M. 2012. “Change in the distribution of house prices across Spanish cities.” *Reginal Science Urban Economics* 42:739–748, doi:10.1016/j.regsciurbeco.2012.05.003.

Palmquist, R. B. 1991. “Hedonic Methods.” In *Measuring the Demand for Environmental Improvement*. edited by John B. Braden and Charles D. Kolstad. Amsterdam: Elsevier.

_____. 1992. “Valuing Localized Externalities.” *Journal of Urban Economics* 31(1): 59–68.

_____. 2005. “Property Value Models.” In *Handbook of Environmental Economics.* edited by Karl-Göran Mäler and Jeffery R. Vincent. Amsterdam: Elsevier.

REMA .2011. “Atlas of Rwanda’s Changing Environment: Implications for Climate Change Resilience.” Rwanda Environment Management Authority, 2011, Kigali, Rwanda. https://na.unep.net/siouxfalls/publications/REMA.pdf (Accessed 12/15/2017).

Rosen, S. 1974 “Hedonic prices and implicit markets: Product differentiation in pure competition.” *Journal of Political Economy* 82(1): 34-55.

Rwanda - Integrated Household Living Conditions Survey (EICV4), 2013-2014, Cross-Sectional Sample: June 29, 2016.: http://www.datafirst.uct.ac.za/dataportal/index.php (visited 10/11/2017).

Sheppard, S. 1999. “Hedonic analysis of housing markets. “in Paul C. Chesire and Edwin S. Mills (eds.), *Handbook of Regional and Urban Economics*, volume 3. Elsevier.

Sirmans, S.G., D.A., Macpherson, and E.N., Zietz. 2005. “The composition of hedonic pricing models.” *Journal of Real Estate Literature* 13(1): 1-44.

Wu, J.J., 2006. “Environmental amenities, urban sprawl, and community characteristics.” *Journal of Environmental Economics and Management* 52 (2): 527–547.

W¨uthrich, A. 2020. “Comparison of Two Quantile Models with Endogeneity.” *Journal of Business & Economic Statistics* 38(2): 443-456.

Zietz, J., E. Zietz, and G. Sirmand. 2008. “Determinants of housing prices: A quantile regression approach.” *Journal of Real Estate Finance and Economics* 37 (4): 317–333 doi:10.1007/s11146-007-9053-7.

.

Table 3.1 Data descriptive

Variable	Obs.	Mean	Std. Dev.	Min	Max
Environmental Characteristics:					
Primary source of cooking fuel					
Crop Wastes ==1	12,650	0.008	0.086	0	1
Firewood ==1	12,650	0.915	0.280	0	1
Main source of lighting in home					
Firewood==1	12,650	0.067	0.249	0	1
Combined bad environmental sources	12,650	0.997	0.060	0	1
Received any environmental information in last 12 mths	12,650	0.854	0.353	0	1
Dwelling affected by environmental destruction last 12 mths	12,650	0.225	0.417	0	1
Structural Characteristics:					
Current value of dwelling if were to sell it (Rw Frnc)	11,794	1,891,716	5,159,165	1000	1.00e+08
Current value of dwelling if were to sell it (Rw Frnc)/1000	11,796	1908.351	5314.54	1	100,000
Log of Current value of dwelling if were to sell it	11,796	13.489	1.222	6.908	18.420
Floor area of the dwelling (m^2)	0				
Log of Floor area of the dwelling	12,650	3.566	0.477	1.609	6.418
No. rooms ≤ 3	12,650	0.938	0.241	0	1
Roofing materials					
Clay tiles ==1	12,646	0.462	0.498	0	1
Metal sheets	12,646	0.534	0.498	0	1
Wall materials					
Beaten earth ==1	12,650	0.801	0.400	0	1

Cements ==1	12,650	0.149	0.356	0	1
Metres to main water source	12,009	72.509	50.556	1	169
Socioeconomic Characteristics:					
Place of birth	12,650	18.166	9.924	1	36
Aggregate Consumption (Rw Frnc)	12,650	276528.5	409670.6	7338.551	1.28e+07
Consm	12,650	276.529	409.670	7.339	12809.88
Log of Aggregate Consumption	12,650	5.31791	0.687	1.993	9.458
Main health insurance	12,650	3.345	0.603	1	6
Gender (Male==1)	12,650	0.443	0.498	0	1
Married == Yes	12,650	0.459	0.498	0	1
Income Agricultural work == Yes	12,650	0.309	0.462	0	1
Ever been to school == Yes	12,650	0.822	0.382	0	1
Location Characteristics:					
Duration HH inhabited dwelling (years)	12,650	10.568	10.635	0	71
Always lived in the district == Yes	12,650	0.600	0.490	0	1
Urban==1	12,650	0.102	0.303	0	1
Province	12,650	3.245	1.480	1	5
Districts	12,650	15.530	8.694	1	30
Spatial lag weight matrix	11,796	13.488	0.600	12.790	16.120
Predicted Spatial lag weight matrix	11,201	13.435	0.510	12.793	16.094

Table 3.2 Bootstrapped Spatial Quantile regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	**OLS**	**Q 05**	**Q 10**	**Q 20**	**Q 30**	**Q 40**	**Q 50**
Predicted Spatial lag weight matrix		0.320***	0.374***	0.499***	0.528***	0.553***	0.547***
		(0.076)	(0.048)	(0.038)	(0.030)	(0.027)	(0.030)
Primary source of cooking fuel							
Crop Wastes ==1	-0.239***	-0.403	-0.426***	-0.360***	-0.268**	-0.221*	-0.230
	(0.088)	(0.336)	(0.121)	(0.103)	(0.134)	(0.122)	(0.149)
Firewood ==1	-0.133***	-0.187*	-0.159**	-0.132**	-0.135**	-0.147***	-0.150***
	(0.036)	(0.113)	(0.068)	(0.062)	(0.056)	(0.053)	(0.040)
Main source of lighting in home							
Firewood==1	-0.222***	-0.099	-0.149***	-0.168***	-0.173***	-0.167***	-0.168***
	(0.029)	(0.072)	(0.053)	(0.032)	(0.033)	(0.032)	(0.028)
Log of Floor area of the dwelling (m^2)	0.990***	1.088***	1.091***	1.060***	1.064***	1.056***	1.001***

	(0.018)	(0.048)	(0.026)	(0.021)	(0.029)	(0.018)	(0.022)
No. of rooms <= 3 ==1	-0.227***	-0.238***	-0.158**	-0.191***	-0.204***	-0.185***	-0.256***
	(0.030)	(0.087)	(0.069)	(0.056)	(0.038)	(0.058)	(0.049)
Roofing materials							
Clay tiles ==1	0.053	0.033	-0.035	0.085	0.075	0.035	-0.014
	(0.105)	(0.551)	(0.243)	(0.122)	(0.143)	(0.127)	(0.110)
Metal sheets	0.297***	0.199	0.154	0.259**	0.252*	0.226*	0.176
	(0.104)	(0.529)	(0.239)	(0.125)	(0.148)	(0.129)	(0.112)
Wall materials							
Beaten earth ==1	-0.131***	-0.223***	-0.195***	-0.169***	-0.140***	-0.137***	-0.126***
	(0.032)	(0.079)	(0.048)	(0.025)	(0.032)	(0.039)	(0.022)
Cements ==1	0.454***	0.358***	0.375***	0.428***	0.445***	0.483***	0.497***
	(0.036)	(0.082)	(0.060)	(0.020)	(0.039)	(0.051)	(0.039)
Log of Consumption	0.257***	0.219***	0.210***	0.221***	0.221***	0.231***	0.240***
	(0.012)	(0.031)	(0.021)	(0.016)	(0.018)	(0.017)	(0.018)

Gender Male==1	-0.010	0.009	0.008	0.001	0.011	0.006	0.009
	(0.014)	(0.038)	(0.024)	(0.019)	(0.019)	(0.011)	(0.019)
Married ==1	-0.002	0.079**	0.030	0.021	0.005	0.012	-0.003
	(0.014)	(0.033)	(0.022)	(0.026)	(0.016)	(0.015)	(0.013)
Income Agricultural work == Yes	-0.103***	-0.094***	-0.088***	-0.059***	-0.063***	-0.071***	-0.082***
	(0.016)	(0.036)	(0.023)	(0.017)	(0.020)	(0.018)	(0.016)
Always lived in the district == Yes	0.017	-0.071**	-0.006	0.001	0.011	0.000	0.015
	(0.015)	(0.032)	(0.016)	(0.024)	(0.015)	(0.017)	(0.017)
Ever been to school == Yes	0.070***	0.100**	0.077***	0.046**	0.051**	0.044**	0.055**
	(0.018)	(0.046)	(0.027)	(0.021)	(0.026)	(0.019)	(0.025)
Urban ==1	0.454***	0.381***	0.343***	0.369***	0.395***	0.351***	0.356***
	(0.031)	(0.063)	(0.072)	(0.050)	(0.051)	(0.029)	(0.046)
Constant	8.843***	3.316**	2.945***	1.428***	1.135**	0.949**	1.448***
	(0.158)	(1.334)	(0.730)	(0.523)	(0.450)	(0.441)	(0.434)
Controls							
Provinces	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Water supply Sources	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,794	11,201	11,201	11,201	11,201	11,201	11,201
	0.642						

Notes: The dependent variable is the log of the current value of a dwelling. The table reports the coefficients on the level of all variables. This paper uses microdata of general household survey in 2013/2014 on provinces of Rwanda. The variables were divided into several characteristics based on the hedonic housing prices model, such as environmental characteristics, house characteristics, individual characteristics, location characteristics. The main covariates of interests are Primary source of cooking fuel and Main source of lighting in home. The prefix W indicates spatial lag of the dependent variable. The model is the two-stages simultaneously bootstrapped spatial quantile regression. We control for five Rwanda province and the Water supply sources, the latter has 12 sources, coefficients not reported. Numbers are rounded to three decimals. Numbers in parentheses = standard errors. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.1$, ** $p<0.05$, *** $p<0.001$.

Table 3.2 Cont'd

	(8)	(9)	(10)	(11)	(12)
VARIABLES	**Q 60**	**Q 70**	**Q 80**	**Q 90**	**Q 95**
Predicted Spatial lag weight matrix	0.602***	0.601***	0.633***	0.604***	0.674***
	(0.038)	(0.027)	(0.036)	(0.043)	(0.055)
Primary source of cooking fuel					
Crop Wastes ==1	-0.056	-0.064	-0.178	-0.233	0.012
	(0.120)	(0.065)	(0.127)	(0.180)	(0.205)
Firewood ==1	-0.142***	-0.121***	-0.124*	-0.175***	-0.107
	(0.052)	(0.038)	(0.064)	(0.052)	(0.080)
Main source of lighting in home					
Firewood==1	-0.158***	-0.156***	-0.113**	-0.163***	-0.182***
	(0.043)	(0.042)	(0.050)	(0.035)	(0.059)
Log of Floor area of the dwelling (m^2)	1.001***	0.999***	0.982***	0.925***	0.923***

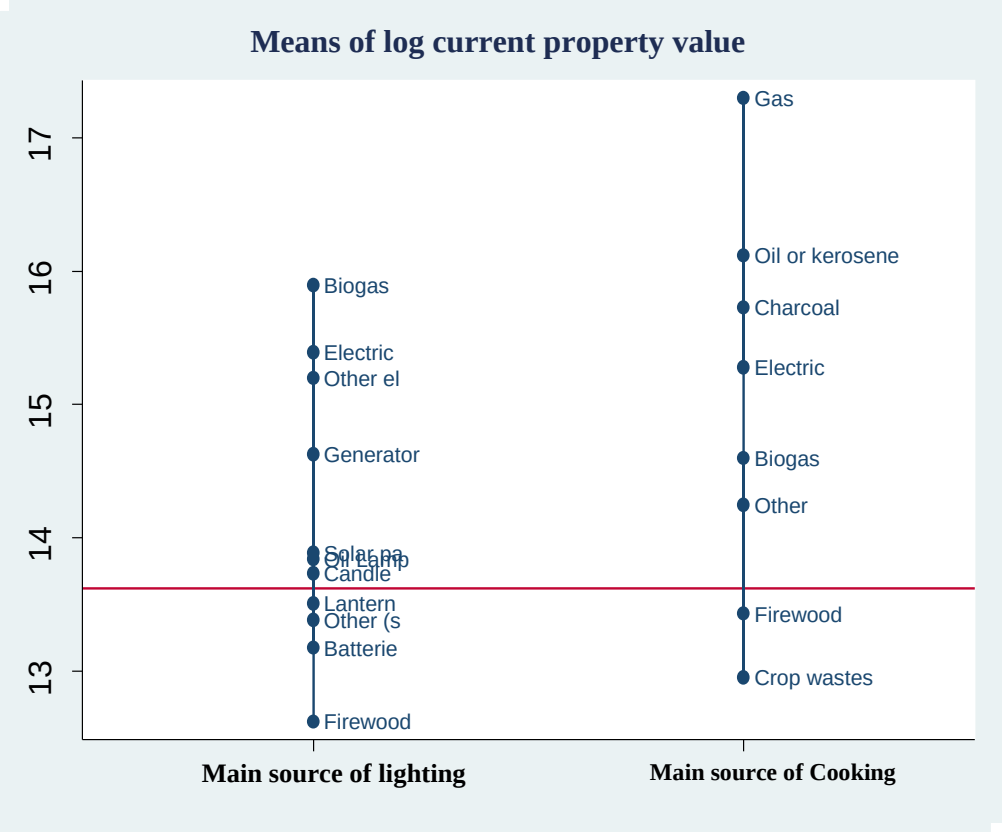
	(0.022)	(0.024)	(0.036)	(0.039)	(0.041)
No. of rooms <= 3 ==1	-0.217***	-0.248***	-0.293***	-0.264***	-0.315***
	(0.030)	(0.040)	(0.030)	(0.050)	(0.060)
Roofing materials					
Clay tiles ==1	0.071*	0.228*	0.212**	0.077	0.222
	(0.042)	(0.117)	(0.107)	(0.180)	(0.162)
Metal sheets ==1	0.255***	0.414***	0.393***	0.271	0.403**
	(0.041)	(0.118)	(0.100)	(0.184)	(0.158)
Wall materials					
Beaten earth ==1	-0.098***	-0.084**	-0.094**	-0.094**	-0.162
	(0.028)	(0.033)	(0.043)	(0.048)	(0.101)
Cements ==1	0.547***	0.529***	0.490***	0.457***	0.320***
	(0.032)	(0.045)	(0.045)	(0.051)	(0.109)
Log of Consumption	0.245***	0.267***	0.275***	0.269***	0.291***
	(0.015)	(0.016)	(0.020)	(0.024)	(0.040)

Gender Male==1	-0.001	-0.020	-0.028	0.004	0.009
	(0.014)	(0.013)	(0.018)	(0.024)	(0.029)
Married ==1	-0.013	-0.006	-0.028	-0.034	-0.066**
	(0.017)	(0.016)	(0.019)	(0.024)	(0.031)
Income Agricultural work == Yes	-0.089***	-0.088***	-0.084***	-0.135***	-0.112***
	(0.011)	(0.018)	(0.022)	(0.025)	(0.038)
Always lived in the district == Yes	0.020	0.008	0.028*	0.047**	0.053
	(0.016)	(0.015)	(0.014)	(0.019)	(0.037)
Ever been to school == Yes	0.044***	0.036	0.039	0.041	0.103**
	(0.016)	(0.028)	(0.025)	(0.034)	(0.042)
Urban ==1	0.357***	0.390***	0.434***	0.504***	0.535***
	(0.052)	(0.035)	(0.060)	(0.049)	(0.069)
Constant	0.693	0.689	0.567	1.719**	0.765
	(0.505)	(0.480)	(0.553)	(0.697)	(0.831)
Controls					
Provinces	Yes	Yes	Yes	Yes	Yes

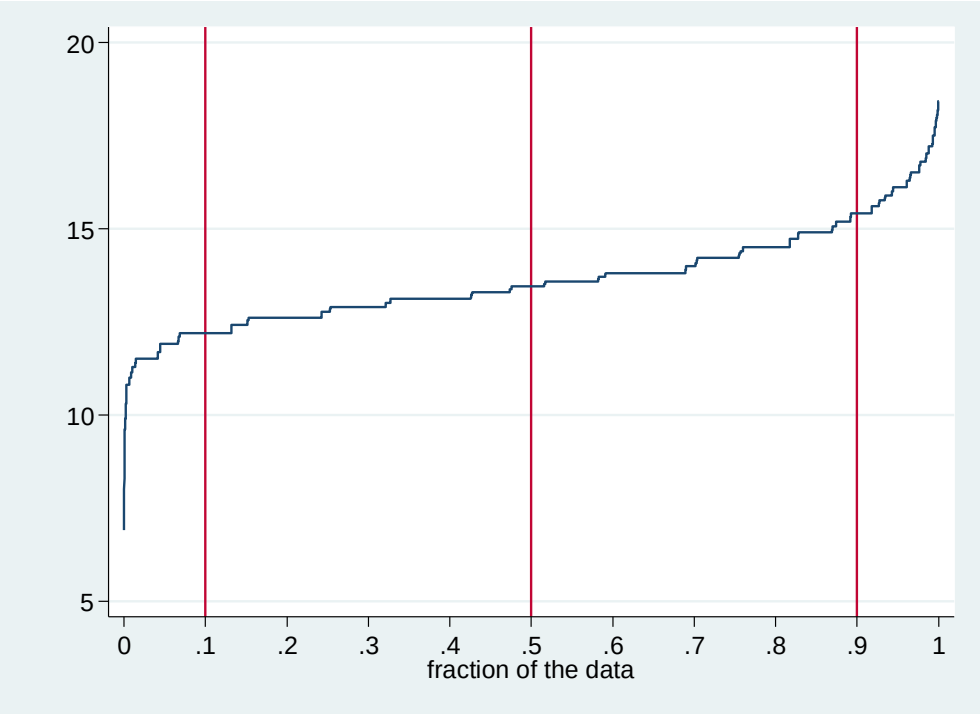
Water supply Sources	Yes	Yes	Yes	Yes	Yes
Observations	11,201	11,201	11,201	11,201	11,201
R-squared					

Notes: The dependent variable is the log of the current value of a dwelling. The table reports the coefficients on the level of all variables. This paper uses microdata of general household survey in 2013/2014 on provinces of Rwanda. The variables were divided into several characteristics based on the hedonic housing prices model, such as environmental characteristics, house characteristics, individual characteristics, location characteristics. The main covariates of interests are Primary source of cooking fuel and Main source of lighting in home. The prefix W indicates spatial lag of the dependent variable. The model is the two-stages simultaneously bootstrapped spatial quantile regression. We control for five Rwanda province and the Water supply sources, the latter has 12 sources, coefficients not reported. Numbers are rounded to three decimals. Numbers in parentheses = standard errors. An asterisk (*) indicates the estimated coefficient is significantly different from zero at the * $p<0.1$, ** $p<0.05$, *** $p<0.001$.

Graph 3.1. Contingency spatial matrix graph between 30 districts



Graph 3.2. illustrates the descriptive analysis of the relationship between log of current dwelling value and both sources of cooking and lighting.



Graph .3.3 the empirical Cumulative Distribution Function of log current dwelling value

Appendix Table 1.3

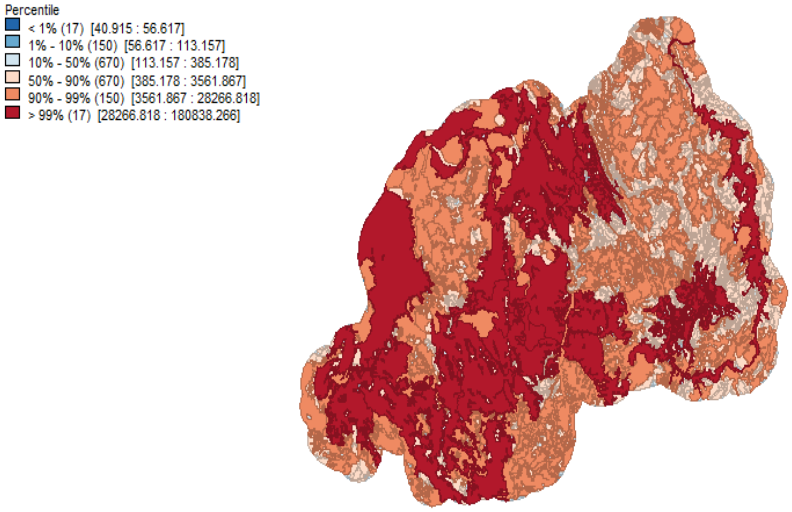
Distance by simplified version of Vincenty formula (unit: mi)

	Obs.	Mean	SD.	Min.	Max.
Distance	186528	47.285	22.690	7.024	115.883

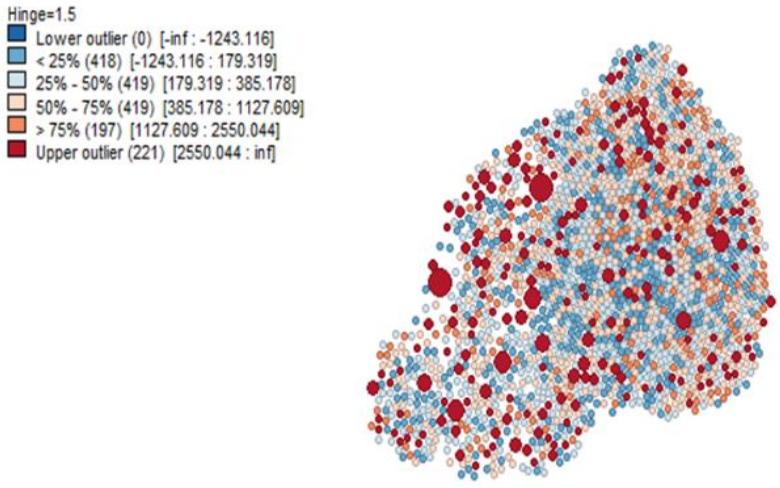
Moran's I Statistic No Obs =11796 Distance threshold (unit: mi):

Variable	Moran's I	E(I)	SE(I)	Z(I)	p-value
Current property value	0.24139	-0.00008	0.00064	376.64941	0.00000

Null Hypothesis: Spatial Randomization



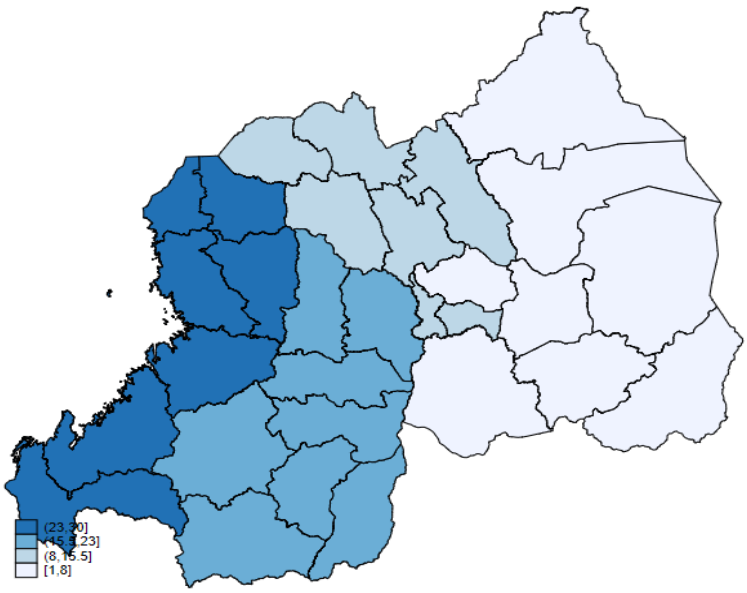
(A) The percentile distribution of land cover



(B) Clustering Rwanda Aggregated Land Cover

Figure 3.1 distribution of land cover for Rwanda

Source: Authors using geographical dataset.



Appendix Figure .3.2: Rwanda 30 districts as of 2012 and shows the five Rwanda provinces, which are Kigali, Southern Province, Western Province, Northern Province, and Eastern Province at are clustered in different shades.

Source: Authors using geographical dataset