ESSAYS ON NATURAL RESOURCES AND ECONOMIC DEVELOPMENT

by

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ABSTRACT

Essays on Natural Resources and Economic Development

by

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The central theme of this dissertation is the political economy of natural resources and how these resources may pose an opportunity or a threat to a country. It provides an overview of an interplay between natural resource endowments and economic development and comprises three essays.

The first essay explores how economic development can impact the consumption behavior of natural resources, with focus on fossil fuels. Analyzing a dataset consisting of 151 countries from 1971 to 2013 and by employing parametric and nonparametric methods, the estimates suggest the existence of an inverted U-shaped relationship between fossil fuel share in the energy mix and economic development, using real income as its proxy. Particularly, the essay illustrates an evidence that fossil fuel’s share in the energy mix increases as a country progresses economically, however, after reaching a real income per capita of around US$16,000, the country reduces the share of fossil fuel in its energy mix.

The second essay presents a general equilibrium theory, providing a theoretical framework, for analyzing the impact of foreign direct investment (FDI) inflows on the risk of violence. The model suggests that FDI inflows into skilled-labor intensive resources sector reduce the risk of violence, while such inflows increase the risk of violence when these are channeled through unskilled-labor intensive resources sector. The empirical analysis in a
dynamic set-up consisting of 34 Sub-Saharan African countries during 1972 to 2013 indeed supports the outcome of the theoretical model.

To understand the donor behavior in aid allocation, the third essay presents a game-theoretic model of aid allocation and geopolitical alignment. The subgame perfect Nash equilibrium of this model suggests that there exists an increasing relationship between aid allocations and solidarity and geopolitical alignment of the recipient countries with the donor. The model also predicts that donors allocate more aid to recipient countries with higher human capital levels. These propositions are empirically tested using a unique dataset of aid allocation by the resource-rich Arab donors covering 147 countries from 1996 to 2015. The results of empirical analysis support the predictions of the theoretical model.
PUBLIC ABSTRACT

Essays on Natural Resources and Economic Development
Ahsan Kibria

This dissertation studies the political economy of natural resources and how these resources may pose an opportunity or a threat to a country and comprises three essays.

The first essay explores how economic development can impact the consumption behavior of natural resources, with focus on fossil fuels. It suggests the existence of an inverted U-shaped relationship between fossil fuel share in the energy mix and economic development. Particularly, the essay illustrates an evidence that fossil fuel’s share in the energy mix increases as a country develops, however, after reaching a real income per capita of around US$16,000, the country reduces the share of fossil fuel in its energy mix. Perhaps this policy shift is due to concerns about air quality from its population.

The second essay analyzes the impact of foreign direct investment (FDI) inflows on the risk of violence both theoretically and empirically. The theoretical model suggests that FDI inflows into skilled-labor intensive resources sector reduce the risk of violence, while such inflows increase the likelihood of violence when these are channeled through the unskilled-labor intensive resources sector. The empirical analysis focusing Sub-Saharan African countries indeed supports the outcome of the theoretical model.

To understand the donor behavior in aid allocation, the third essay presents a theoretical model of aid allocation and political alignment. The equilibrium of this model suggests that geopolitical alignment with the donors increases the aid receipts. The model also suggests that donors allocate more aid to recipient countries with higher human capital levels. These propositions are empirically tested using a unique dataset of aid allocation by the resource-rich Arab donors. The results of empirical analysis support the predictions of the theoretical model.
This dissertation is dedicated to my parents and in loving memory of my grandparents with my deepest appreciation and gratitude for all that they did to benefit the generations that follow.
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ACRONYMS

ACG Arab Coordination Group
ADFD Abu Dhabi Fund for Development
AFESD Arab Fund for Economic and Social Development
AGFD Arab Gulf Programme for Development
AMF Arab Monetary Fund
BADEA Arab Bank for Economic Development in Africa
CO$_2$ carbon dioxide
CV cross-validation
DAC Development Assistance Committee
EIA Energy Information Administration
EKC environmental Kuznets curve
EMKC energy mix Kuznets curve
FDI foreign direct investment
FE fixed effects
GDP gross domestic product
GMM generalized method of moments
HDI human development index
ICIEC Islamic Corporation for the Insurance of Investment and Export Credit
IDA International Development Association
IMF International Monetary Fund
IsDB Islamic Development Bank
KFAED Kuwait Fund for Arab Economic Development
MIGA Multilateral Investment Guarantee Agency
NE Nash equilibrium
NW Nadaraya Watson kernel
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<td>ODA</td>
<td>official development assistance</td>
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<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>OFID</td>
<td>OPEC Fund for International Development</td>
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<td>OIC</td>
<td>Organisation of Islamic Cooperation</td>
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<td>OLS</td>
<td>ordinary least squares</td>
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<td>OPEC</td>
<td>Organization of the Petroleum Exporting Countries</td>
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<td>PCA</td>
<td>principal component analysis</td>
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<td>PPP</td>
<td>public private partnership</td>
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<td>PRIO</td>
<td>Peace Research Institute Oslo</td>
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<td>Qatar Fund for Development</td>
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CHAPTER 1
INTRODUCTION

There is a general belief that the presence of natural resources assists countries in attaining sustainable growth trajectories. However, there is a debate in the economic literature on whether natural resources are a blessing or curse, as well as a dilemma, known as the paradox of plenty. I contribute to this discussion through my three essays addressing key questions related to natural resources and economic development. First, is fossil fuel share in the energy mix of a country has any relationship with its economic development? Second, does foreign direct investment (FDI) in resource-rich and commodity-exporting developing countries increase the risk of civil violence? And third, how can successful natural resource-rich countries, such as the Arab countries, influence other countries in the developing world through aid allocation from their surplus oil revenues? These three interrelated questions motivate the essays presented in the subsequent chapters, which provide an overview of an interplay between natural resource endowments and economic development on one hand; and FDI and civil conflict on the other.

The first essay, Fossil Fuel Share in the Energy Mix and Economic Development, explores how economic development can impact the consumption behavior of natural resources, with focus on fossil fuels. This essay attempts to comprehend the relationship between fossil fuel share in the energy mix and economic development, using real income as its proxy. Fossil fuels, such as petroleum, natural gas, and coal continue to account for the bulk of today’s total global energy consumption. While contributing to global climate change, these fuel sources have shaped the global economy for over a century. During the 2015 climate change negotiations in Paris, known as the Paris Agreement, the world leaders agreed to take necessary steps for limiting global temperature increase to a maximum of 1.5°C in this century. This decision has economic implications, as it would require a reduction of fossil fuel share in the energy mix to achieve this goal. Therefore, it is important
to ascertain the relationship between fossil fuel share in the energy mix and economic development with regard to the implications for environmental and economic policies which may vary depending on the nature of this relationship.

The underlying hypothesis of this essay is that there may exist an inverted U-shaped relationship between fossil fuel share in the energy mix and income. To test this hypothesis, this essay utilizes a panel dataset consisting of 151 countries from 1971 to 2013. Although the parametric analysis in the essay provides evidence in support of this hypothesis, the results are sensitive to polynomial model specification. The results from the nonparametric analysis, which places no restrictions on the functional form, provides a stronger support in favor of the hypothesis.

The second essay, *Foreign Direct Investment and Civil Violence in Sub-Saharan Africa*, seeks to explore the pathways through which natural resources can influence economic development. Natural resource-rich countries often rely on FDI for the development and extraction of its natural wealth. However, whether FDI increases the risk of civil violence in these economies, and thus hurt economic development is a question that has not been researched so far. This essay, for the first time in extant literature, seeks to answer the questions related to FDI and civil violence with a focus on Sub-Saharan African (SSA) countries.

The essay begins by presenting a theoretical model that explains how FDI might influence the risk of civil violence in the context of a natural resource-rich developing country. The model provides a theoretical framework through which FDI affects the likelihood of violence in a resource-rich country. The sector that foreign capital flows in may also be important in this context, which motivates employing a general equilibrium framework. The model suggests that FDI that flows into skilled-labor intensive resource sector reduces the probability of violence, on the other hand, FDI flows into unskilled-labor intensive resource sector increases the likelihood of civil violence. The empirical analysis using a panel dataset of 34 SSA countries from 1972 to 2013 in a dynamic generalized method of moments (GMM) context supports the key predictions of the theoretical model.
The third essay, *Political Economy of Aid Allocation: The Case of Arab Aid*, drives away from the internal influence of natural resources on the host economies to the external opportunities they provide in the form of international political influence. This essay analyzes aid allocation behavior of natural resource-rich Arab countries in the Middle-East to explore this hypothesis. These countries have managed their resources relatively well (when compared to SSA countries) and contribute a portion of their surplus oil revenues as development aid through a group of Arab aid institutions, known as the Arab Coordination Group (ACG). Choosing Arab aid as a testing case provides two value additions. First, it provides a comprehensive account and analysis of the Arab donors’ aid allocation behavior, which is lacking in the existing literature. Second, there has not been any studies covering aid from the ACG institutions and motives underlying it.

To understand the donor behavior in aid allocation, this essay presents a general theory of aid allocation by constructing an aid and geopolitical game-theoretic model between recipient and donor. The subgame perfect Nash equilibrium of this model suggests that there exists an increasing relationship between aid allocation and the solidarity and geopolitical alignment of the recipient countries with the donor. Moreover, donor countries allocate more aid to recipient countries with higher level of human capital. These propositions are empirically tested using a unique dataset of aid allocation by the Arab donors to 147 developing countries from 1996 to 2015. The principal component analysis is employed to construct an index of solidarity and geopolitical alignment. The empirical analysis results using the index score as well as other control variables supports the propositions of the theoretical model.

The rest of the dissertation is organized as follows. Chapter 2, 3, and 4 are the three self-contained essays as discussed. Each essay of this dissertation has a separate introduction, conclusion, and so on. Relevant references are provided after the conclusion of each essay. Chapter 5 summarizes the dissertation and briefly highlights the broader policy implications of this research.
CHAPTER 2

FOSSIL FUEL SHARE IN THE ENERGY MIX AND ECONOMIC DEVELOPMENT

2.1 Abstract

After the Paris Agreement in 2015, fossil fuel share in the energy mix has become a debatable issue within the policy-circles of different countries as they start rolling out their plans to meet the requirements and targets of the agreement. In this essay, we examine the relationship between fossil fuel share in the energy mix and real income using a panel of 151 countries from 1971 to 2013. A cursory examination of the data suggests that there may exist a polynomial relationship between fossil fuel share and income, a phenomenon that we coin as energy mix Kuznets curve (EMKC). Although our parametric estimates provide evidence in support of this hypothesis, the results are sensitive to polynomial model specification. The results from nonparametric analysis, which places no restrictions on the functional form, provide support in favor of the EMKC.

2.2 Introduction

One of the key sources of environmental pollution is carbon dioxide (CO₂) emissions, which result mostly from the combustion of fossil fuels. According to the U.S. Energy Information Administration (2016), the world energy-related CO₂ emissions are projected to increase from 32.3 billion metric tons in 2012 to 35.6 billion metric tons in 2020, and reach 43.2 billion metric tons by 2040. Much of the increase in carbon emissions is attributed to the developing world that relies heavily on fossil fuels to meet their growing energy needs. Emissions by non-OECD countries are expected to be around 29.4 billion metric tons by 2040, which is about 51% higher than the 2012 level; whilst the OECD emissions are expected to be around 13.8 billion metric tons by 2040, which is about 8% higher than the 2012 level (U.S. Energy Information Administration, 2016).
The Paris Agreement has resulted in a commitment from 197 countries and territories to limit the global temperature increase to 1.5°C by the end of this century (UNFCCC, 2016). The reduction of fossil fuel share in the energy mix has to play a key role in achieving this target. As such, energy mix has become a key topic within the policy-circles of different countries as they prepare their plans to meet the guidelines of the agreement. For instance, during the 2017 Bonn negotiations for implementing the Paris Agreement, President Emmanuel Macron of France provided a detailed plan for France, which included closing down all of its coal-fired power plants by 2021 and banning all new explorations of fossil fuel sources in its territories. On the other hand, German Chancellor Angela Merkel voiced her concern that number of jobs had to be taken into account while limiting the use of coal in her country. Therefore, understanding the relationship between fossil fuel share in the energy mix and economic development has important implications for environmental and economic policies as policy recommendations may vary depending on the shape of this relationship.

Figure 2.1 provides an evolving temporal changes in the share of fossil fuel in the energy mix for a sample of countries covered in our analysis for the period between 1980-2013.

It is apparent that the fossil fuel share in the energy mix has seen a considerable increase in several East and South Asian countries (such as China, India, Indonesia, Malaysia, Philippines, and Vietnam) between 1980-1990 and 1990-2013. One can also observe a rise in the fossil fuel share in African countries, including Angola, Egypt, Ghana, Mauritius, Senegal, and Sudan. By contrast, in numerous developed countries, including the North American countries (e.g., United States and Canada) and the Western European countries (e.g., Austria, Denmark, Finland, France, Germany, Spain, Sweden, Switzerland, United Kingdom, etc.), there is a decline in the fossil fuel share in the energy mix over the given period of time. This cursory and anecdotal observation clearly suggests that the attitude of countries towards fossil fuel consumption at various stages of economic development differs. Our conjecture is that there may be an inverted U-shaped relationship between the fossil fuel share in the energy mix and income. Therefore, the purpose of this essay is to empirically
Fig. 2.1. Share of fossil fuel in the energy mix
investigate this hypothesis using a panel of 151 countries from 1971 to 2013.

In order to visualize a functional relationship between the fossil fuel share in the energy mix and income, Figure 2.2 presents the scatter plot for these two variables. In this study, we use the log real GDP per capita as our measure of real income. From the plot, we observe a preliminary evidence for the existence of an inverted U-shaped relationship between the two variables. The figure reveals a few appealing observations: (i) a cluster of very low income countries tend to have a low fossil fuel share in their energy mix; (ii) some very high income countries have a moderate fossil fuel share in their energy mix; and (iii) a cluster of middle income countries has a very large fossil fuel share in their energy mix. For instance, the increase in income in China and India has been accompanied by the increase in the fossil fuel share in the energy mix, as suggested by the phase diagrams. However, in developed countries, including Denmark, France, Germany, Norway, Sweden, and the United States, we observe an opposite scenario: an increase in income has been accompanied by an overall decline in the share of fossil fuel in the energy mix.

These observations seem to preliminarily confirm an inverted U-shaped relationship between fossil fuel share in the energy mix and income. Notice that the behavior of major fossil fuel exporting countries in the Middle East, such as Qatar, Saudi Arabia, and the United Arab Emirates, is an exception as these countries continue to have very high share of fossil fuel in their energy mix regardless of their income.

This relationship is reminiscent of the Environmental Kuznets Curve (EKC) proposed by Grossman and Krueger (1995). Inspired by Kuznets (1955), who first observed an inverted U-shaped relationship between income inequality and economic development, the EKC suggests an inverted U-shaped relationship between the environmental degradation and economic development. The literature on the EKC is relatively rich and has continued to draw an interest to this date (Andreoni and Levinson, 2001, Dasgupta et al., 2002, Stern, 2004, and Neequaye and Oladi, 2015). However, a strand of literature casts doubt

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Footnote: The plot captures the data for a panel of 151 countries from 1971 to 2013. Select countries (in black) are shown in the plot to indicate the position of their 2013 fossil fuel share in the energy mix and log real GDP per capita. The phase diagrams for select countries (in color) indicate the joint evolution of these countries’ fossil fuel share in the energy mix and log real GDP per capita over the given period of time.
Fig. 2.2. Plot of fossil fuel share in the energy mix on log real GDP per capita

on the existence of empirical support for the EKC hypothesis or its shape (Harbaugh et al., 2002, Azomahou et al., 2006, Galeotti et al., 2006, and Nguyen-Van, 2010). Although the previous literature has extensively analyzed the relationship between CO$_2$ emissions and economic growth, the relationship between the share of fossil fuels in the energy mix, which is a key source of CO$_2$ and other greenhouse gases, and economic development has received no attention. Whether or not the EKC holds for greenhouse gases, it is unclear that these empirical results imply the evidence or the lack of evidence for an inverted U-shaped relationship between fossil fuel share in the energy mix and per capita real income, a phenomenon which we coin as energy mix Kuznets curve (EMKC).

Our empirical methodology differs from previous EKC studies, which primarily rely on parametric analysis, in that we implement nonparametric methods to study the EMKC. Nonparametric analysis are known to be more robust compared to parametric analysis since the former does not impose any strict functional form assumptions on the relationship between the dependent and independent variables, and also on the distribution of disturbance

\footnote{Azomahou et al. (2006) and Nguyen-Van (2010) are the exception.}
term. Nonetheless, we also present the results from parametric panel-data methods for completeness and comparisons. Furthermore, similar to the bulk of the literature, in our analysis of the relationship between the share of fossil fuels in the energy mix and income, we do not control rigorously for the possible determinants of fossil fuel share in the energy mix. The main reason for this is, apart from data limitations and the curse of dimensionality in nonparametric studies, we are not necessarily concerned about obtaining the model that can provide best predictions for the fossil fuel share in the next period. Our main interest here is in the shape of the relationship between these two variables (Azomahou et al., 2006).

Our results from parametric methods are mixed and sensitive with respect to the polynomial specification. In particular, the results from the quadratic specification provide significant evidence of an inverted U-shaped relationship between the share of fossil fuel in the energy mix and real income. Both fixed effects, random effects, and pooled OLS methods provide similar parameter estimates and inferences in this setting. However, when the cubic specification is considered, the results become insignificant with incorrect signs. The mixed results within parametric analysis underlie the importance of assumptions imposed on functional form specification, and thus the sensitivity of inferences to such assumptions. On the other hand, the data-driven nonparametric analysis provides empirical support for the existence of a polynomial relationship between the fossil fuel share and the real income.

Several arguments can be put forward to explain the observed relationship between fossil fuel and income. At an early stage of development, a country is typically unable, and perhaps less willing, to make investments in cleaner, non-fossil alternatives. As the country continues to develop and the industrialization speeds up, government policies aim more at economic development rather than at environmental protection, thus resulting in rapid increases in pollutant emissions (e.g., China and India from Figure 2.2). When a country reaches the flatter part of the curve or the turning point for fossil fuel consumption, the state of the economy reaches such a point where people start valuing and demanding cleaner and sustainable environment (e.g., Denmark, France, Germany, Sweden and United States from
Figure 2.2). At this latter stage of development, economies are more inclined to embrace cleaner energy sources, such as solar and wind, and reduce the reliance on fossil fuels. Not only do people demand cleaner energy, they also can afford it thanks to higher real income.

The remaining of the essay proceeds as follows. Section 2.3 presents the data. Section 2.4 presents the empirical analysis of the relationship between the fossil fuel share and real income. In particular, Subsection 2.4.1 provides parametric analysis of the relationship between the fossil fuel share in energy mix and economic growth, while Subsection 2.4.2 presents the nonparametric analysis. Section 2.5 provides some concluding remarks.

2.3 Data

The data used in this study consists of an unbalanced panel of 151 countries for period between 1971 and 2013. The list of countries considered in our analysis is provided after Section 2.5. The time period selected for the study is based on data availability, and is in accordance with previous literature. The data for fossil fuel share in the energy mix is obtained from the World Development Indicator (WDI) database. Fossil fuel comprises coal, oil, petroleum, and natural gas products, and the above variable captures fossil fuel energy consumption as percentage of total energy consumption. Our independent variables are real GDP per capita (in log form) at constant 2011 prices, which is used as a measure of real income, and population density, which are collected from the Penn World Table (PWT) version 9.0 (Feenstra et al., 2015) and the WDI, respectively.

We calculate population density by dividing total population of a country by its area. The limited number of explanatory variables is in line with numerous EKC studies, including Selden and Song (1994), Stern (2002), Dinda (2004), Azomahou et al. (2006), and Nguyen-Van (2010). As discussed in the introduction, our main objective here is the overall relationship between these two variables, and not the model with the best predictive power. On a more technical concern, adding each additional covariate to a nonparametric model, without increasing the sample size, significantly alters the speed of convergence of an estimator, a phenomenon known as the “curse of dimensionality” (Bellman, 1962).

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3See, for example, Suri and Chapman (1998) and Luzzati and Orsini (2009), and references therein.
The summary statistics of the data are reported in Table 2.1. There are a few countries with approximately zero fossil fuel share in their energy mix, i.e., their energy mix consists solely of non-fossil fuels. On the other extreme, there are a few mostly oil exporting countries with fossil fuel share of 100 percent. Furthermore, the highest real per capita income in the data set is recorded for the United Arab Emirates, with US$208,930 in 1980, whilst the lowest is for Mozambique, with US$309 in 1986. The range for the population density is relatively large, which is explained by the presence of very populous countries in the data set as well as countries with large land area and sparse population. We observe some moderate positive correlation (0.63) between real income and fossil fuel share in the energy mix. However, the correlations between population density and fossil fuel share (0.15), and population density and real income (0.13) are relatively low.

Figure 2.2 from the introduction provides the scatter plot of log real GDP per capita and the share of fossil fuel in the energy mix. From an initial visual assessment, we can clearly observe the presence of an inverted U-shaped relationship between the two variables. Interestingly, the phase diagrams for China and India show a monotonic increase of the fossil fuel’s share in the energy mix with an increase in income, while those for the United States and many European countries display a declining trend. Moreover, for members of the Organization of the Petroleum Exporting Countries (OPEC), fossil fuel’s share in the energy mix does not change even with an increase in real income, remaining steady at

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**Table 2.1.** Descriptive statistics

<table>
<thead>
<tr>
<th>Statistics</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil fuel share in the energy mix</td>
<td>4,707</td>
<td>65.59</td>
<td>30.19</td>
<td>0.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Log real GDP per capita</td>
<td>4,707</td>
<td>3.95</td>
<td>0.49</td>
<td>2.49</td>
<td>5.32</td>
</tr>
<tr>
<td>Population density</td>
<td>4,707</td>
<td>194.37</td>
<td>690.62</td>
<td>1.24</td>
<td>7,636.72</td>
</tr>
</tbody>
</table>

---

4 These countries are either very small in size, e.g., Bhutan, Equatorial Guinea, Gambia, Grenada, and Swaziland, or island countries, e.g., Antigua and Barbuda, Bahamas, Barbados, Belize, Cabo Verde, Comoros, Djibouti, Maldives, and Seychelles.

5 Such countries include, for instance, Bahrain, Kuwait, Oman, Qatar, and the United Arab Emirates, among others.
around 100%.

These countries are statistical outliers in our data.

We estimate the densities of the share of fossil fuel in the energy mix and the log real GDP per capita in 1971 and 2013 by the kernel method. In particular, the kernel density of variable $x$ at point $x_0$ is given by

$$\hat{f}(x_0) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x_0 - x_i}{h}\right)$$

(2.1)

where $n$ is the number of observations, $K(\cdot)$ is a kernel function, and $h$ is the bandwidth. We use the univariate Epanechnikov kernel $K(a) = 0.75(1-a^2)I(|a|<1)$, where $I(\cdot)$ is the indicator function, and the optimal bandwidth based on the minimization of the unbiased cross validation criterion (Scott, 1992 and Hastie et al., 2001).

Figure 2.3 depicts the nonparametric kernel density estimates of key variables. The

![Fig. 2.3. Kernel density estimates of key variables in 1971-2013](image)

As of January 2017, OPEC’s members are Algeria, Angola, Ecuador, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
density estimates are obtained using the Epanechnikov kernel and the optimal bandwidth. The distribution of the fossil fuel share in the energy mix shows a multi-modal pattern over the given period. In particular, in 1971, countries with large fossil fuel share in their energy mix (90-100%) accounted for the highest proportion in the sample (mode 1), followed by those with relatively low (20-40%) fossil fuel share (mode 2). In contrast, in 2013, we observe a substantial decline in the upper-tail frequency, which indicates that countries substituted the fossil fuel more with other alternatives compared to 1971. The distribution of the log real GDP per capita generally displays a bell-shaped curve. Since the overall density is shifted rightwards between 1971 and 2013, implying an increase in the real per capita income, this provides a reasonable explanation (through the EMKC lens) for the significant drop in the fossil fuel share in 2013.

2.4 Empirical Analysis

2.4.1 Parametric Analysis

We estimate the relationship between the share of fossil fuel in the energy mix, real income per capita, and the population density within a panel-data framework, similar to Grossman and Krueger (1995).\(^7\) Specifically, we analyze the nonlinear empirical model of the following form

\[
y_{it} = g(x_{it}) + \beta z_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2.2)
\]

where \(y_{it}\) is the fossil fuel share in the energy mix in country \(i\) at time period \(t\), \(x_{it}\) is the log real GDP per capita, \(z_{it}\) is population density, \(\mu_i\) is the country specific effect, \(\lambda_t\) is the time specific effect, and \(\varepsilon_{it}\) is the disturbance term. In equation 2.2, \(g(x_{it})\) is a polynomial function that establishes the relationship between \(y_{it}\) and \(x_{it}\). The EKC literature tends to diverge in terms of the order of the polynomial function \(g(x_{it})\). One strand of literature suggests to use a quadratic form or the second-order polynomial (Selden and Song, 1994, Shafik and Bandyopadhyay (1992), Selden and Song (1995), Holtz and Selden (1995), Suri and Chapman (1998), and Azomahou et al. (2006)).

In order to demonstrate the sensitivity of estimation results to functional form assumptions, we consider the polynomial order at most 3, i.e., $g(x_{it}) = \sum_{j=0}^{k} \alpha_j x_{it}^j$ for $k = 2, 3$. If $k = 2$, the relationship between $y_{it}$ and $x_{it}$ is modeled with a quadratic function; whilst, if $k = 3$, the relationship is of a cubic form. Further, if the coefficient for the squared term has a negative sign, it confirms the existence of an inverted U-shaped relationship between $y_{it}$ and $x_{it}$, i.e., the EMKC. If the coefficient for the cubic term has a positive sign, this provides an evidence that the relationship is N-shaped. Estimation of equation 2.2 is carried out by pooled OLS, fixed effects (FE), and random effects (RE) methods.

The Breusch and Pagan Lagrange multiplier test (Breusch and Pagan, 1980) suggests that there is evidence of significant differences across countries (i.e., random country-specific effects) for both quadratic model ($\chi^2_1 = 48,050, p-value=0.00$) and cubic ($\chi^2_1 = 48,032, p-value=0.00$) models, and therefore the pooled OLS is not appropriate for estimating the above relationship. Moreover, the $F$-test statistic for the null hypothesis of no fixed country-specific effects indicates that fixed country-specific effects do exist for both quadratic ($F_{192, 4511} = 324.50, p-value=0.00$) and cubic ($F_{192, 4510} = 326.42, p-value=0.00$) models, thus further highlighting the importance of unobserved country effects in the analysis. We also perform the $F$-test for the null hypothesis of no fixed year effects in the presence of fixed country effects. The results suggest that fixed year effects exist for both quadratic ($F_{42, 4511} = 1.96, p-value=0.00$) and cubic ($F_{42, 4510} = 2.25, p-value=0.00$) models. Regarding the choice between FE and RE estimation methods, an important issue to consider is whether the country effects $\mu_i$ are correlated with the explanatory variables. In the absence of such correlation, RE estimation is consistent and efficient. However, if there
is such a correlation, there is a potential for omitted variable bias, which necessitates FE estimation (Wooldridge, 2010). We implement the Hausman test (Hausman, 1978) to select between FE and RE models. The results indicate that FE is more appropriate than RE for the analysis of both quadratic ($\chi^2_{44} = 198.84$, p-value=0.00) and cubic ($\chi^2_{45} = 167.90$, p-value=0.00) models.

Table 2.2 presents the estimation results from pooled OLS, FE, and RE methods. We included the results from pooled OLS and RE for comparison purposes. The estimation results for the model with the second-order polynomial are provided in columns (1), (3), and (5); whereas those for the third-order polynomial are reported in columns (2), (4), and (6). In order to control for potential cross-sectional heteroskedasticity and within-panel (serial) correlation of an unknown form, we report cluster robust standard errors for parameter estimates. In order to avoid data manipulation concerns, we did not exclude outliers (OPEC countries) from the estimation sample.  

According to the EMKC hypothesis, the sign of the coefficient for real income should be positive and that for its square negative. The FE estimation results from column (1) of Table 2.2 support this hypothesis since coefficients for real income and its square both have the correct signs and are statistically significant at 1% level. The estimates from RE (column (3)) and pooled OLS (column (5)) models are very close to those from FE model, and also corroborate the EMKC hypothesis at the lowest significance level.

In contrast, when the cubic term of real income is introduced into the model, as seen from column (2), the FE coefficients for the square and the cube of real income come out to be insignificant and have incorrect signs. Importantly, the sign change and lack of significance for the cubic model are in line with the observations of Azomahou et al. (2006). The parameter estimates from the RE model (column (4)) depict similar results as those for FE model. While the pooled OLS produces the estimate of the square term that has the correct sign, it is nevertheless insignificant. Lastly, the coefficient for population density has the correct sign across different specifications, but is statistically significant at 1% level.

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8When we performed the analysis for the sample without these outliers, our standard errors improved significantly, especially for model (2), but our main results did not change qualitatively.
Table 2.2. Parametric estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Real GDP per capita</td>
<td>197.67***</td>
<td>11.45</td>
<td>197.33***</td>
<td>-1.94</td>
<td>219.17***</td>
<td>196.92***</td>
</tr>
<tr>
<td></td>
<td>(37.57)</td>
<td>(250.75)</td>
<td>(37.04)</td>
<td>(246.85)</td>
<td>(7.64)</td>
<td>(68.99)</td>
</tr>
<tr>
<td>Square of Log of GDP per capita</td>
<td>-23.47***</td>
<td>24.90</td>
<td>-23.14***</td>
<td>28.61</td>
<td>-23.08***</td>
<td>-17.34</td>
</tr>
<tr>
<td></td>
<td>(4.68)</td>
<td>(63.53)</td>
<td>(4.61)</td>
<td>(62.45)</td>
<td>(0.97)</td>
<td>(17.58)</td>
</tr>
<tr>
<td>Cubic of Log of GDP per capita</td>
<td>-4.11</td>
<td>-4.39</td>
<td>-4.91</td>
<td>-5.15</td>
<td>-4.84</td>
<td>-4.79</td>
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<tr>
<td></td>
<td>(5.30)</td>
<td>(5.52)</td>
<td>(5.36)</td>
<td>(5.37)</td>
<td>(1.47)</td>
<td>(1.47)</td>
</tr>
<tr>
<td>Population Density</td>
<td>0.0026</td>
<td>0.0026</td>
<td>0.0025</td>
<td>0.0025</td>
<td>0.0034***</td>
<td>0.0034***</td>
</tr>
<tr>
<td></td>
<td>(0.0018)</td>
<td>(0.0018)</td>
<td>(0.0017)</td>
<td>(0.0017)</td>
<td>(0.0002)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>Constant</td>
<td>-553.86***</td>
<td>-102.45</td>
<td>-435.18***</td>
<td>-406.87***</td>
<td>-406.87***</td>
<td>-406.87***</td>
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<tr>
<td></td>
<td>(74.31)</td>
<td>(321.35)</td>
<td>(14.81)</td>
<td>(89.14)</td>
<td>(14.81)</td>
<td>(89.14)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time Effects</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>Yes</th>
<th>No</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-squared</td>
<td>0.236</td>
<td>0.241</td>
<td>0.217</td>
<td>0.221</td>
<td>0.454</td>
<td>0.454</td>
</tr>
<tr>
<td>Number of Countries</td>
<td>151</td>
<td>151</td>
<td>151</td>
<td>151</td>
<td>151</td>
<td>151</td>
</tr>
<tr>
<td>Observations</td>
<td>4,707</td>
<td>4,707</td>
<td>4,707</td>
<td>4,707</td>
<td>4,707</td>
<td>4,707</td>
</tr>
</tbody>
</table>

Note: Cluster robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

only in the pooled OLS models.

Figure 2.4 illustrates the fit of the preferred FE model to the data. The regression fits under pooled OLS and FE models are obtained for the median population density. For FE model, fixed country effects are evaluated at their mean values. We also included the fit of pooled OLS for comparison purposes. It is clear that FE model displays a stronger evidence of an inverted U-shaped relationship between share of fossil fuel in the energy mix and real income than pooled OLS. This can be attributed to the fact that FE model controls for country- and year-specific effects. Though the introduction of the third-order polynomial of income variable in the FE model (also in RE and pooled OLS) yields insignificant results and causes sign reversal, the regression fit still confirms the existence of the inverted U-shaped relationship. This indicates that the inverted U-shape is probably the best parametric fit that can be obtained for the given data set using polynomial functions. Although the third-order polynomial helps us increase the nonlinearity of the model, from Figure 2.4 it seems to be redundant as the observations do not support N-shaped relationship. In fact, the inclusion of an additional variable (i.e., cubic term) in the model is not sufficiently reducing the model mean squared error, hence costing us in terms of inflated standard errors of the model parameters. This may be a plausible explanation for parameters becoming highly insignificant when we switch from quadratic (parsimonious model) to cubic model.

It is evident from the analysis provided above that the inferences from parametric
methods can be highly sensitive to the functional form specification. In order to complement parametric analysis and shed further light on the relationship between the fossil fuel share and income, we next present the analysis from the data-driven, nonparametric methods.

### 2.4.2 Nonparametric Analysis

Parametric analysis can be vulnerable to model misspecification issues if the functional form imposed on the regression equation or the distribution of disturbance term is not appropriately characterized. We noted this problem in the preceding section as parametric results were sensitive to functional form specification. Nonparametric regression, on the other hand, provides a versatile method for exploring a general relationship between variables without reference to a fixed parametric model. In particular, the main advantage of nonparametric analysis is that it does not impose any strict parametric functional form assumptions on the model (e.g., linear, quadratic, or cubic polynomial functions), and thereby mitigates potential model misspecification issues. Therefore, in this section, we implement

---

**Fig. 2.4.** Parametric estimation of the relationship between the share of fossil fuel in the energy mix and the log real GDP per capita.
nonparametric methods for a more robust analysis of the relationship between the fossil fuel share in the energy mix and the real income per capita.

The nonparametric regression function takes the following general form

\[ y_{it} = f(x_{it}) + \varepsilon_{it} \quad (2.3) \]

where \( y_{it} \) is the fossil fuel share in the energy mix in country \( i \) at time period \( t \); \( x_{it} \) is the log real income per capita; \( f(x_{it}) = E(y_{it}|X_{it} = x_{it}) \) is the unknown function that establishes the relationship between \( y_{it} \) and \( x_{it} \); and \( \varepsilon_{it} \) is the error term. The goal is to estimate the conditional mean function \( f(x_{it}) \) with minimal assumptions about the form of \( f(x_{it}) \) and the distribution of the error component \( \varepsilon_{it} \). In this study, we implement two distinct types of nonparametric methods to estimate equation (2.3): (i) the Nadaraya-Watson (NW) kernel regression (Nadaraya, 1964 and Watson (1964)) and (ii) the local linear regression (Fan, 1992). The NW kernel regression (i.e., local constant estimator) is a special case of the local linear regression (i.e., local line estimator) (Fan, 1993). The advantage of the local linear regression over the NW kernel regression is that the former reduces the design bias and the boundary bias of the later (Fan and Gijbels, 1992 and Fan, 1993).

Since the main interest in this section is the aggregate shape of the relationship between the share of fossil fuel in energy mix and the per capita real income, and not the best predictions for the share of fossil fuel, we pool the data across time periods similar to Millimet et al. (2003) and Halkos and Tzeremes (2013), treating fixed effects as nuisance parameters. Thus, in the following analysis, we drop the subscript \( t \) from model variables. Although controlling explicitly for individual country effects (i.e., 151 country-specific intercept terms) is desirable, such endeavor is limited due to the sample size relative to the number of parameters to be estimated. Moreover, Racine and Li (2004) notes that, “when contemplating the nonparametric estimation of panel data models, one issue that immediately arises is that the standard (parametric) approaches that are often used for panel data models (such as first-differencing to remove the presence of so-called ‘fixed effects’) are no longer valid unless one is willing to presume additively separable effects, which for many
defeats the purpose of using nonparametric methods in the first place.”

The Nadaraya-Watson Kernel Regression. The NW kernel estimator used in the present study to estimate the conditional mean function is specified as

\[
\hat{f}(x_0) = \frac{\sum_{i=1}^{N} K \left( \frac{x_0 - x_i}{h} \right) y_i}{\sum_{i=1}^{N} K \left( \frac{x_0 - x_i}{h} \right)}
\]  

(2.4)

where \( K(\cdot) \) is a kernel function, \( h \) is the bandwidth (smoothing parameter), \( x_0 \) is the evaluation point; and \( N \) is the sample size of the entire data. Intuitively, the estimate of the conditional mean \( \hat{f}(x_0) \) is simply a weighted average of \( x_i \)'s around the point of evaluation \( x_0 \), where the weights are supplied by the kernel function \( K(\cdot) \) and the neighborhood around \( x_0 \) is identified by the bandwidth \( h \).

In empirical applications the choice of the kernel function is not important as different kernel functions yield numerically similar estimates. Nevertheless, we use the Epanechnikov kernel which is commonly used in the literature and is treated as the optimal kernel (Cameron and Trivedi, 2005). Bandwidth choice, on the other hand, is much more important than kernel choice as it directly influences the trade-off between the estimation bias and the estimation variance. In our analysis, the bandwidth choice is based on the least squares cross-validation approach of Racine and Li (2004), where the optimal bandwidth \( h \) minimizes an overall measure of fit given by

\[
CV(h) = N^{-1} \sum_{i=1}^{N} \left( y_i - \hat{f}_{-i}(x_i) \right)^2 M(x_i)
\]  

(2.5)

where \( \hat{f}_{-i}(x_i) = \frac{\sum_{j \neq i}^{N} K \left( \frac{x_i - x_j}{h} \right) y_j}{\sum_{j \neq i}^{N} K \left( \frac{x_i - x_j}{h} \right)} \) is the leave-one-out kernel estimator of \( f(x_i) \) and \( 0 < M(\cdot) < 1 \) is a weighting function that adjusts the boundary observations, which otherwise may receive too much importance (Cameron and Trivedi, 2005).
**The Local Linear Regression.** The local linear regression involves fitting a weighted linear model

\[
\min_{\beta_0, \beta_1} \sum_{i=1}^{n} K\left(\frac{x_0 - x_i}{h}\right) (y_i - \beta_0 - \beta_1(x_i - x_0))^2
\] (2.6)

within a sliding window, where the size of the window is determined by the bandwidth \(h\) and the weights are provided by the kernel function \(K(\cdot)\). Similar to the NW kernel regression, we use the Epanechnikov kernel in our analysis. For the bandwidth selection, we implement the generalized cross validation technique (Craven and Wahba, 1979 and Fan and Gijbels, 1992), where the optimal bandwidth \(h\) minimizes

\[
\text{GCV}(h) = \frac{1}{N(1 - \frac{v}{N})^2} \sum_{i=1}^{N} (y_i - \hat{f}(x_i))^2
\] (2.7)

where \(v = \text{trace}(W) = \sum_{i=1}^{N} W_{ii}\) and \(W_{ii} = w_i(x_i) = \frac{K\left(\frac{x_i - x_0}{h}\right)}{\sum_{j=1}^{N} K\left(\frac{x_j - x_0}{h}\right)}\).

We estimate the relationship between fossil fuel share in the energy mix and the log real income per capita nonparametrically using a panel of 151 countries for the period between 1971 to 2013. Figure 2.5 plots the fits of the NW kernel regression and the local linear regression along with the 95% confidence interval and the original data.\(^9\) For both estimators, the asymptotic 95% pointwise confidence levels are reported. The common bandwidth \(h\) derived from cross-validation method is 0.026 for the NW kernel regression and 0.071 for the local linear regression.

energy mix that pulls the entire curve upwards, especially for log real income per capita of 4.5 and above.\(^{10}\) In fact, from a close examination of the upper tail of the curve, and the way the observations are positioned, we can also vaguely notice an N-shaped curve.

**Multivariate Nonparametric Kernel Regression.** In order to demonstrate the robustness of the results from both the NW kernel regression and the local linear regression

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\(^9\)The solid curves in the figure represent \(\hat{f}(x_i)\), while the dashed lines denote the 95% asymptotic confidence bounds.

\(^{10}\)Similar to the parametric analysis, we did not exclude outliers (i.e., OPEC and other major fossil fuel producing countries) from the estimation sample in order to avoid data manipulation concerns. An analysis for the sample without these outliers produced a discernible inverted U-shaped curve.
Fig. 2.5. Nonparametric estimation (a) Nadaraya-Watson kernel regression fit; (b) Local linear regression fit
suggest that the shape of \( \hat{f}(x_i) \) is nonlinear, consisting of a discernible inverted U-shaped part. In particular, starting from low levels of log real income per capita, share of fossil fuel in energy mix increases. But, after a certain level of log real income per capita (\( \approx 4.2 \)), the share of fossil fuel noticeably diminishes. The reason one of the legs of the inverted U-shape does not extend further down is because there is a cluster of countries (our statistical outliers, i.e., members of OPEC) where fossil fuel contributes to almost 100% of previous results, we also consider nonparametric multiple regression by extending kernel smoothing to higher dimensions. Specifically, we estimate the regression function of the following form

\[
y_{it} = f(x_{1,it}, x_{2,it}) + \varepsilon_{it}
\]  

In equation 2.8, the fossil fuel share in the energy mix \( (y_{it}) \) is modeled as a function of the log real income per capita \( (x_{1,it}) \) and the population density \( (x_{2,it}) \). Though the addition of a richer set of explanatory variables is desirable to obtain more powerful predictive model, such endeavor is limited (more so with nonparametric methods) if the sample size remains unaltered. The problem stems from the “curse of dimensionality”: as the number of explanatory variables increases, the number of observations in the local neighborhood of a focal point tends to decline rapidly, hence necessitating exponentially larger samples (Bellman, 1962 and Hastie et al., 2001). Intuitively, in higher dimensions, the observations are sparsely distributed even for large sample sizes, and consequently estimators based on local averaging perform unsatisfactorily. Therefore, similar to a large body of EKC studies, we limit the analysis to the above two predictors.

The interest is in estimating \( f(x_{1,it}, x_{2,it}) = E(y_{it}|X_{1,it} = x_{1,it}, X_{2,it} = x_{2,it}) \), which is the unknown function that establishes the relationship between the dependent and independent variables. In order to explore the aggregate relationship between the dependent and independent variables, we pool the data across time periods, similar to the univariate nonparametric analysis, and thus drop the subscript \( t \) in the analysis to follow.
The multivariate NW kernel estimator is specified as

\[
\hat{f}(x_0) = \sum_{i=1}^{N} \frac{K(H^{-1}(x_0 - x_i)) y_i}{\sum_{i=1}^{N} K(H^{-1}(x_0 - x_i))}
\]

(2.9)

where \(K(\cdot)\) is a bivariate kernel function; \(H = \text{diag}(h_1, h_2)\) is a bandwidth matrix; \(x_0 = (x_{1,0}, x_{2,0})'\) is the evaluation vector; and \(x_i = (x_{1,i}, x_{2,i})'\) is the data vector. We use the Epanechnikov kernel and the optimal bandwidth based on the least squares cross-validation approach (Racine and Li, 2004 and Li and Racine, 2004). The common bandwidth obtained from the cross-validation method is \(h_1 = 0.039\) for the log real income per capita \((x_{1,i})\) and \(h_2 = 59.658\) for the population density \((x_{2,i})\).

The results for the multivariate NW regression fit of the conditional expectation are provided in Figure 2.6. The nonparametric regression plane, \(\hat{f}(x_{1,it}, x_{2,it})\), in Figure 2.6(a) displays a curvilinear response surface, with a visible dome-shaped structure between log real income per capita of 2.5-4.4. Fixing the level of population density, we can obtain a cross-section of the regression plane parallel to the log real income per capita. Figure 2.6(b) illustrates such a cross-section evaluated at the sample median of population density.\(^{11}\) It is apparent that controlling for population density results in a more distinguished inverted U-shaped relationship between the share of fossil fuel in the energy mix and the log real income per capita, especially at the apex (log real income per capita of 4-4.3). Similar to Figure 2.5, the gravity of the upper-tail cluster of oil rich Middle Eastern countries pulls the regression curve upwards (at log real income per capita of 4.5 and above), thereby somewhat distorting the otherwise clear inverted U-shaped curve.

2.5 Concluding Remarks

As the global economies have grown, and so has the demand for fossil fuels. However, greater consumption of fossil fuels has had many adverse effects on the environment. It is well established that one of the main sources of global carbon dioxide (CO\(_2\)) emissions is

\(^{11}\)Given a small sample size and the presence of several extreme observations in the population density, the sample mean is not a good measure of central tendency. The sample median, on the other hand, is better measure as it is not prone to outliers.
Fig. 2.6. Multivariate nonparametric estimation: (a) Multivariate kernel regression fit; (b) A slice of the multivariate fit along the log real GDP per capita axis, with population density evaluated at its median.
burning fossil fuel to generate energy. Energy related CO₂ emissions are expected to grow by about 10% and 34% from 2012 level to 2020 and 2040, respectively, based on estimates of the U.S. Energy Information Administration (2016). Although there is a rich literature on CO₂ emissions and economic growth, little attention has been paid to the relationship between fossil fuel share in energy mix, which is the driving force behind energy related CO₂ emissions, and economic growth. Moreover, it is not clear whether the existence of an EKC-type relationship between CO₂ emissions and income implies the existence of an analogous relationship between fossil fuel share and income.

This essay examines a relationship between the fossil fuel share in the energy mix and income using an unbalanced panel consisting of 151 countries from 1971 to 2013. A close observation of the data suggests that fossil fuel share and real income may exhibit an inverted U-shaped relationship. Our parametric estimates, using panel-data methods, provide mixed results that are sensitive to model specification. This motivates us to use more robust nonparametric kernel regression and local linear regression, which are immune to model misspecification issues. We find evidence of an inverted U-shaped relationship between fossil fuel share in the energy mix and real income.

Several arguments can be put forward to explain the observed relationship between fossil fuel and income. At an early stage of development, a country is typically unable, and perhaps less willing, to make investments in cleaner, non-fossil alternatives. As the country develops, government policies aim more at economic development than at environmental protection until the development reaches a certain stage when people start valuing and demanding cleaner environment. At this latter development stage, economies are more inclined towards embracing cleaner energy sources, such as solar and wind. Not only do people demand cleaner energy, they also can afford it thanks to rising real incomes. People also believe that this source of energy is safer, environmentally friendly and therefore sustainable.
List of countries covered in the analysis of chapter 2

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3.1 Abstract

This essay considers the effect of foreign direct investment (FDI) on civil violence in Sub-Saharan Africa (SSA). We first present a new general equilibrium theory of FDI and violence. Our theoretical results suggest that resource-directed FDI inflow to countries where the resource sector is skilled-labor intensive reduces the risk of violence and where the resource sector is unskilled-labor intensive increases the risk of violence. Using a panel dataset consisting 34 SSA countries during 1972-2013, our dynamic panel estimates suggest that FDI flows into skilled-labor intensive fuel-resource rich countries reduce the risk of violence. However, FDI is less effective in reducing the likelihood of violence when it flows into countries that are rich in unskilled-labor intensive non-fuel ore and other mineral resources.

3.2 Introduction

After decades of development planning and efforts by various international organizations, such as the United Nations, Sub-Saharan Africa (SSA) still faces intractable developmental challenges including extreme poverty, illiteracy, and above all violence (Easterly and Levine, 1997).\(^1\) The future development needs of SSA are shaped by the “Agenda 2063 - the Africa We Want” by the African Union, which aspire to transform the continent socially and economically by implementing strategic initiatives, including the universally adopted Sustainable Development Goals (SDGs) of the United Nation’s “2030 Agenda for Sustainable Development”. This development agenda calls for substantial financial resources at this critical juncture when the global development finance landscape is rapidly changing from

\(^1\) Throughout the essay, we refer to civil violence as “violence.”
an aid-based model towards foreign direct investment (FDI) and public-private partnership (PPP) models. The required investment to finance the SDGs in Africa could amount to 65.5% of its annual GDP, translating into $600 billion to $1.2 trillion per annum (Kedir et al., 2017). Therefore, alongside its own domestic resources and foreign aid, SSA would have to attract a significant amount of FDI as SSA’s public budgetary resources are inadequate to address the region’s major and urgent development financing needs.

Aside from financial requirements highlighted by SDGs and other policy-circles, the positive effects of FDI on economic growth is well documented (see, for instance, Borensztein et al., 1998). Being a resource-rich region, much of foreign investment flows into the natural resources sector in SSA (Asiedu, 2006). Notwithstanding sizable investments flowing into this part of the world, SSA countries face substantial risks of violence and social conflicts. Observing these anecdotes, some critics of FDI as well as political activists claim that inflow of FDI (much of which is by multinational corporations) may cause civil unrest and violence in countries of SSA. In this study, we address the validity of this claim by providing a theoretical and empirical analysis of the effect of FDI inflow on the risk of violence. To our knowledge, this crucial issue has not been explored, nor has it been quantified, in the economics literature. This essay hence is a first attempt to fill this important gap.

The possible relationship between risk of violence and FDI inflow in SSA as suggested by the anecdotal evidence is quite controversial and, at the same time, intriguing. To shed some light on this puzzling relationship, Figure 3.1 plots the counts of violence and average net FDI inflow as a percentage of GDP for SSA countries covered in this study for 1971-2013. These scatter plots seems to suggest a pattern, with a likely positive relationship. This cursory observation may be conforming the view held by critics that FDI causes violence in SSA, particularly in its resource-rich areas. This hypothesis questions the multi-faceted role of FDI in SSA, with its resolution having important implications for the future development of SSA.

Bannon and Collier (2003) suggest that SSA countries face substantial risks of violence, social conflict, and poor governance if they are highly dependent on natural resources. See Bernard (2012) for business and violence.
Many countries in SSA with high FDI inflow have seen high violence rate. Figure 3.2 maps number of violence and FDI as a percentage of GDP for SSA countries. A few interesting observations can be noted: (i) some SSA countries, such as South Africa and Mauritania, receive a sizable FDI but have low violence rate; (ii) some countries, including Somalia and Ethiopia, receive almost no FDI but have very high violence rate; and (iii) some countries, such as Angola, Congo, Kenya, Niger, Nigeria, Sudan, and Zambia, receive a relatively higher amount of FDI but at the same time report a significant number of violence incidents. It is thus imperative to investigate the relationship between FDI and violence after controlling for economic and political factors. Such analysis offers a unique perspective that, aside from its significant contribution to the literature, is important for policymakers and international investors.

We first present a novel general equilibrium model of FDI and violence. Our model consists of three-sectors: two production sectors (one of which is a resource sector) and an enforcement (security) sector. Each of the two production sectors uses either skilled or unskilled labor, hence one of the sectors is skilled-labor intensive, while the other is
unskilled-labor intensive. Foreign capital flows in the resource sector. We consider two alternative models: the resource sector is skilled-labor intensive in one alternative model, while the resource sector is unskilled-labor intensive in the other. These formulations are meant to mimic the SSA economies and the nature of their economies vis-a-vis the types natural resources they are endowed with. More specifically, fuel-related natural resource sector is more skilled-labor intensive, as more specialized workers need to operate oil rigs and gas fields. On the other hand, non-fuel (non-oil and gas minerals, e.g., ores) natural resource sector is unskilled-labor intensive, as excavation work for diamond, for instance, requires relatively little skill and expertise (Ross, 2003). We show how FDI can affect the risk of violence through our theory. Our theoretical results suggest that if FDI flows into skilled-labor intensive resource sector, it reduces the risk of violence. In contrast, if FDI flows into unskilled-labor intensive sector, it increases the risk of violence. The novelty of our theory is due to the fact that it is the first of its kind that uses general equilibrium framework to measure the risk of violence, providing significant contributions to literature.
on political economy of violence.

We test our theoretical predictions empirically using data on 34 SSA countries for the period between 1972 and 2013, as per data availability. To account for both unobserved heterogeneity, lagged dependent variable effects, and the endogeneity, we use the system generalized method of moments (GMM) estimator in a dynamic panel data framework (Blundell and Bond, 1998). The results from empirical analysis show that FDI inflow overall reduces the risk of violence. Most importantly, our findings suggest that FDI inflow reduces the risk of violence for countries that are rich in skilled-labor intensive resources, whereas FDI inflow increases the risk of violence for countries that are rich in unskilled-labor intensive non-fuel resources. These findings are consistent across different specifications of the model and are in line with our theoretical predictions.

The literature on economics of violence is relatively rich and, at the same time, ambiguous. In an influential work, Collier and Hoeffler (1998) provide a political economic theory of civil war, and empirically study economic causes of violence and its implications for policy (see also Collier and Hoeffler, 2004). More recently, Besley and Persson (2011) offer a novel game-theoretic approach for studying political violence, and, in particular, political and economic factors that drive repression and civil war. A larger body of this growing literature focuses on the relationship between the occurrence of violence and endowment of natural resources. This essay contributes, both in theory and empirics, to this line of work but also opens a new avenue. In particular, we explicitly explore the effects of FDI on the risk of violence, and show how the effect of FDI varies in association with natural resource endowments/production (i.e., skilled-labor intensive fuel sector versus unskilled-labor intensive non-fuel resource sector).

The remainder of the essay is organized as follows. In Section 3.3, we present our theoretical model and derive testable hypothesis. Section 3.4 discusses our data, empirical strategy, and presents empirical results. Finally, Section 3.5 provides some concluding remarks.

---

3For example, see Collier and Hoeffler (1998), Bannon and Collier (2003), Fearon and Laitin (2003), and Brunschwiler and Bulte (2009) for natural resources and violence; Ross (2012) and Lei and Michaels (2014) for oil and violence; Lujala et al. (2005) for diamond and violence; among others.
3.3 Theoretical Analysis

In this section, we present our theoretical framework that explains how FDI might influence the risk of violence. While there may be a number of alternative ways that one can formulate the association between FDI and risk of violence, our objective here is to construct a simple and elegant formulation that provides a theoretical channel through which FDI affects the likelihood of violence. The sector that foreign capital flows in may be also important in this context, which motivates us to employ a general equilibrium framework. We consider two alternative economies, both with a resource sector and a composite good sector. The resource sector is skilled-labor intensive in our first economy. In the second economy (i.e., our alternative formulation), the resource sector is unskilled-labor intensive. These alternative assumptions are considered to mimic the nature of SSA economies in our study. In both case, foreign capital flows into the resource sector.

3.3.1 Skilled-labor Intensive Resource-based Economy

Consider a small open economy with three sectors, two production sectors that produce goods \( X \) and \( Y \) and an enforcement (security) sector. Suppose sector \( X \) is a natural resource sector, such as crude oil, that uses skilled labor and foreign capital to extract the resource. Sector \( Y \) uses unskilled labor in its production. The enforcement or security sector, such as law enforcement, uses unskilled labor to restrict violence. Production technologies for these three sectors are represented by following production functions:

\[
\begin{align*}
    x &= X(S, K) \\
    y &= Y(U_y) \\
    \pi &= \frac{U_{\pi}}{U}
\end{align*}
\]  

where \( x \) and \( y \) are production quantities for sectors \( X \) and \( Y \), respectively, and \( \pi \) is the enforcement level.\(^4\) Moreover, \( K \) and \( S \) denote foreign capital and skilled labor usage in

\(^4\)We abstract away from the dynamics of resource extraction and depletion as our static setup sufficiently makes our points. In addition, one can assume that these sectors also use specific domestic capital, which has little consequence on our model, but raises its dimension.
production of $X$ while $U_y$ and $U_\pi$ are unskilled labor usage in production of good $Y$ and enforcement sector, respectively. $\bar{U}$ is the fixed endowment of unskilled labor. We impose all neoclassical assumptions on production functions (4.1) and (4.2), and in particular $X_{SK} > 0$. $\gamma$ is production parameter in enforcement sector and we assume that $0 < \gamma < 1$, i.e., diminishing marginal productivity of labor in this sector. Note that enforcement (or contest) function (4.3) is of logistic form and implies that $0 \leq \pi \leq 1$ since $U_\pi \leq \bar{U}$. Our interpretation of this contest function is that $\pi$ is viewed as the portion of unskilled labor contesting the order and been taken out (i.e., incarcerated, taken refuge to underground, economically disabled, etc.). That is, it represents the percentage of unskilled workers, who may contest the ruling authority, that have been driven out of employed pool unskilled labor. Thus, $\pi$ works in our model like the unemployment rate. Hence, we refer to $\pi$ as unemployment rate although its nature is different. Notably, the higher the fixed population of unskilled labor, the lower is marginal productivity of enforcement. We denote by $p(\pi)$ the probability of enforcement (peace). Thus, the probability of violence is $\nu(\pi) = 1 - p(\pi)$. Assume that $p(\pi)$ follows the beta distribution with its cumulative distribution function (CDF) given by:

$$p(\pi) = \frac{\pi^\alpha (1 - \pi)^\beta}{\mathbb{B}(\alpha, \beta)}$$

(3.4)

where $\alpha, \beta \geq 0$ and $\mathbb{B}$ is the beta function.

We assume full employment of skilled labor, but allow for unemployment of unskilled labor. That is:

$$S = \bar{S}$$

(3.5)

$$U_y + U_\pi + U_n = \bar{U}$$

(3.6)

where $S$ is the fixed supply of skilled labor and $U_n$ is the unemployment level for unskilled labor (i.e., number of people taken out of labor force to control the population). We further
assume that all markets are competitive, which implies that:

\[ W_s = X_S(S, K) \]  
\[ W_u = Y_U \]  

where \( W_s \) and \( W_u \) denote skilled-labor wage and unskilled-labor wage, respectively. We maintain that unskilled workers that are employed in enforcement sector (a sort of public sector) are paid a premium wage compared to their likes employed in production sector 2. In particular, we assume:

\[ W_\pi = W_s \]  
\[ W_u = (1 - \pi)W_\pi \]  

That is, the enforcement sector and its high wage creates a distortion in this economy similar to Harris and Todaro (1970). The enforcement sector is financed by payroll taxes. Specifically, we assume:

\[ W_sU_\pi = \tau[W_sS + W_uU_y] \]  

where \( \tau \) is the uniform tax rate on wages of production sectors. Use equation (4.3) and our definition of unemployment rate to re-write equation (4.6) as:

\[ U_y + U_\pi + U_{\pi}^{\gamma} = \bar{U} \]  

Moreover, use equation (4.3) and (3.9) to re-write equation (3.10) as:

\[ W_u - W_s \left( 1 - \frac{U_{\pi}^{\gamma}}{\bar{U}} \right) = 0 \]  

Equations (4.1)-(4.5), (3.7)-(3.9), and (3.11)-(3.13) constitute a system of equations with our eleven endogenous variables \( x, y, \pi, S, U_y, U_\pi, W_s, W_u, W_\pi, \tau \) and \( p \).
Now, we turn to the effects of foreign capital inflow on this economy. By differentiating equations (3.7)-(3.8) and (3.11)-(3.13), we obtain:

\[
\frac{dW_s}{dK} = X_{SK} > 0 \quad (3.14)
\]

\[
\frac{dW_u}{dK} - Y_{UU} \frac{dU_y}{dK} = 0 \quad (3.15)
\]

\[
\frac{dW_u}{dK} + \gamma W_s U_{\pi}^{\gamma - 1} \frac{dU_{\pi}}{dK} = (1 - \pi) \frac{dW_s}{dK} \quad (3.16)
\]

\[
\frac{dU_y}{dK} + (1 + \gamma U_{\pi}^{\gamma - 1}) \frac{dU_{\pi}}{dK} = 0 \quad (3.17)
\]

\[
W_s \frac{dU_{\pi}}{dK} - \tau U_y \frac{dW_u}{dK} - \tau W_u \frac{dU_y}{dK} - (W_s S + W_u U_y) \frac{d\tau}{dK} = \tau S \frac{dW_s}{dK} \quad (3.18)
\]

where \(dW_s/dK > 0\) follows directly from our assumptions. By solving the remainder of our system, i.e., equations (3.15)-(3.18) simultaneously, we obtain:

\[
\frac{dW_u}{dK} = -\frac{(1 - \pi)Y_{UU}}{\Delta} \left(1 + \gamma U_{\pi}^{\gamma - 1}\right) \frac{dW_s}{dK} \quad (3.19)
\]

\[
\frac{dU_y}{dK} = -\frac{1 - \pi}{\Delta} \frac{1}{(1 + \gamma U_{\pi}^{\gamma - 1})} \frac{dW_s}{dK} \quad (3.20)
\]

\[
\frac{dU_{\pi}}{dK} = -\frac{(1 - \pi) dW_s}{\Delta} \frac{dW_s}{dK} \quad (3.21)
\]

where \(\Delta \equiv \left(\gamma W_s U_{\pi}^{\gamma - 1}/\bar{U} - Y_{UU} \left(1 + \gamma U_{\pi}^{\gamma - 1}\right)\right) > 0\). It follows from (3.19)-(3.21) and our assumption on production functions that \(dW_u/dK > 0\), \(dU_y/dK < 0\) and \(dU_{\pi}/dK > 0\). This, in turn, implies that \(d\pi/dK > 0\). Therefore, we conclude from the probability distribution function that \(dp/dK > 0\) and \(d\nu/dK < 0\). Thus, we have the following result.

**Proposition 3.3.1** *Foreign direct investment flow into skilled-labor intensive resource sector reduces the probability of violence.*

### 3.3.2 Unskilled-labor Intensive Resource-based Economy

Now, consider an economy with a resource sector, denoted by \(Y\), which is unskilled-labor intensive. Assume that FDI flows into this sector. Equations (4.1) and (4.2) need to
be changed to:

\[
x = X(S) \quad (3.22)
\]

\[
y = Y(U_y, K) \quad (3.23)
\]

Again, all neoclassical assumptions are imposed on these production functions. In particular, we assume \( Y_{UK} > 0 \). All other equations of the preceding subsection remain unchanged except for:

\[
W_s = X_s(S) \quad (3.24)
\]

\[
W_u = Y_U(U_y, K) \quad (3.25)
\]

By differentiating equations (3.24)-(3.25) and (3.11)-(3.13), we obtain:

\[
\frac{dW_s}{dK} - Y_{UK} = 0 \quad (3.26)
\]

\[
\frac{dW_u}{dK} + \frac{\gamma W_s U_{\pi}^{\gamma - 1}}{U} \frac{dU_{\pi}}{dK} = 0 \quad (3.27)
\]

\[
\frac{dW_u}{dK} + \frac{\gamma W_s U_{\pi}^{\gamma - 1}}{U} \frac{dU_{\pi}}{dK} = 0 \quad (3.28)
\]

where we used \( dW_s/dK = 0 \) to simplify equations (3.28)-(3.30). By solving this system, we obtain:

\[
\frac{dW_u}{dK} = \frac{\gamma W_s U_{\pi}^{\gamma - 1} Y_{UK}}{U \Delta} \quad (3.31)
\]

\[
\frac{dU_y}{dK} = \frac{Y_{UK}}{\Delta} (1 + \gamma U_{\pi}^{\gamma - 1}) \quad (3.32)
\]

\[
\frac{dU_x}{dK} = -\frac{Y_{UK}}{\Delta} \quad (3.33)
\]

where \( \Delta \) is defined as in the preceding subsection. It follows from equations (3.31)-(3.33)
that $dW_u/dK > 0$, $dU_y/dK > 0$ and $dU_\pi/dK < 0$. This latter result implies that $d\pi/dK < 0$, which in turn implies from equation (4.4) that $dp/dK < 0$. Thus, $d\nu/dK > 0$. Therefore, we have the following proposition.

**Proposition 3.3.2** Foreign direct investment that flows into unskilled-labor intensive resource sector increases the likelihood of civil violence.

### 3.4 Empirical Analysis

#### 3.4.1 Data

This essay uses an unbalanced panel data of 34 SSA countries over the period 1972-2013. The number of SSA countries included in our dataset is largely determined by data availability. The list of countries considered in our analysis is provided after Section 3.5. Our dependent variable is the occurrence of violence (Violence), which is a binary variable that takes value 1 if there is violence in a given year in a given SSA country and 0 otherwise. The violence data is obtained from the Armed Conflict Database developed jointly by the Peace Research Institute Oslo (PRIo) and the University of Uppsala, hereafter referred to as the PRIo/Uppsala dataset. This dataset is used widely in the literature since it was first made available in the early 2000’s. The PRIo/Uppsala dataset defines violence as an armed conflict which results in at least twenty-five battle-related deaths. In our dataset, 12.6% or 49 out of 388 observations are reported of having violence.

The list of independent variables considered in our analysis is based on the literature (Asiedu and Lien, 2011) and also data availability. The descriptive statistics for the variables are reported in Table 3.1, while the correlation between the variables are presented in Figure 3.3. It is apparent that there is generally mild correlation between the variables, with some moderate positive correlation between log real GDP per capita and inequality (0.37), fossil fuel exporter dummy and log population (0.42), fossil fuel exporter dummy and natural resource exporter dummy (0.32), and FDI net inflow and real oil price (0.32). More importantly, the correlation coefficient between Violence and FDI net inflow is 0.02,
which seems to corroborate findings from Figure 3.1, but it is statistically not different from zero (p-value = 0.74).

In what follows, we briefly describe the explanatory variables used in the analysis by grouping them into three distinct categories: main, economic, and political.

**Table 3.1. Descriptive statistics**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violence</td>
<td>0.13</td>
<td>0.33</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>FDI net inflow (% of GDP)</td>
<td>2.27</td>
<td>2.54</td>
<td>-2.94</td>
<td>19.28</td>
</tr>
<tr>
<td>Fossil fuel exporter</td>
<td>0.48</td>
<td>0.50</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Non-fuel non-renewable resource exporter</td>
<td>0.66</td>
<td>0.47</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Natural resource export (% of merchandise export)</td>
<td>27.28</td>
<td>29.81</td>
<td>0.00</td>
<td>99.67</td>
</tr>
<tr>
<td>Inequality (SWIID)</td>
<td>41.85</td>
<td>7.50</td>
<td>26.44</td>
<td>63.26</td>
</tr>
<tr>
<td>Log real GDP per capita</td>
<td>7.57</td>
<td>0.86</td>
<td>6.02</td>
<td>9.77</td>
</tr>
<tr>
<td>Real oil price</td>
<td>49.73</td>
<td>25.85</td>
<td>18.11</td>
<td>111.59</td>
</tr>
<tr>
<td>Inflation</td>
<td>81.09</td>
<td>1,266.36</td>
<td>-8.24</td>
<td>24,411.03</td>
</tr>
<tr>
<td>Log population</td>
<td>7.07</td>
<td>0.51</td>
<td>5.81</td>
<td>8.21</td>
</tr>
<tr>
<td>Polity (regime authority)</td>
<td>1.40</td>
<td>5.58</td>
<td>-9.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Cold War</td>
<td>0.04</td>
<td>0.19</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Fig. 3.3. Sample correlation coefficients between variables**
Main Variables

*FDI net inflow* (% of GDP) is a key variable of interest. The data on this variable is collected from the UNCTAD database, which is used by a number of studies related to FDI in SSA, including Asiedu (2006) and Asiedu and Lien (2011). FDI net inflow is defined as net inflows of investment to acquire a lasting management interest (ten percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. Negative values of FDI net inflows indicate that the value of disinvestment by foreign investors was more than the value of capital newly invested in the reporting economy. In our data, Togo is reported as having received the largest FDI inflows in 2011 and Swaziland the lowest in 2003, with FDI inflows representing 19.28 and -2.94 percents of GDP, respectively. In Figure 3.4, we show kernel densities for *FDI net inflow* in SSA over study period by *Violence*. For most of the range, the two distributions are relatively similar, except for the middle range (between 3-12), which receives somewhat larger weight under no violence than under violence. This suggests that violence might potentially be inhibiting the inflows of FDI into SSA, which makes intuitive sense.

*Fossil fuel exporter* is a dummy variable that takes value 1 if a country is fossil fuel exporting country and 0 otherwise. If a country’s fossil fuel export is 1% or above of its total export in a specific year, the country is classified as fossil fuel exporter for that year.

Fig. 3.4. Empirical distribution of FDI net inflows in SSA countries, 1972-2013
The data for fossil fuel export as percentage of total export is collected from the World Development Indicators (WDI) of the World Bank. In our data, 25 out of 34 SSA countries were fossil fuel exporting countries at different points in time.

*Non-fuel non-renewable resource exporter* is a dummy variable which takes value 1 if a country is non-fuel non-renewable resource (e.g., ore and metal) exporting country and 0 otherwise. It is determined using similar approach and data as explained above for fossil fuel exporter dummy. In our data set, 25 out of 34 SSA countries were non-fuel natural resource exporting countries at different time periods. In addition, 18 countries were exporters of both fossil fuel and non-fuel natural resource, while 13 countries exported neither of these products at different points in time.

To empirically verify the effect of FDI inflows on violence based on host countries natural resource endowments, ideally one has to obtain an FDI data that is disaggregated by the recipient country’s natural resources sectors. However, such data is not available for the SSA countries, which admittedly represents the limitation of our study, and we have to rely on aggregate FDI inflows. To identify the impact of resource-focused FDI on violence, in this study we interact the aggregate FDI inflows (*FDI net inflow*) with the two natural resource exporter dummies (*Fossil fuel exporter* and *Non-fuel non-renewable resource exporter*). Our identification strategy is as follows. If a country is a fuel-resource exporter (e.g., *Fossil fuel exporter*=1), this implicitly implies that the country has a necessary infrastructure in place for the production, processing, and exporting that resource. Importantly, establishing, and maintaining, the capacity to produce and export the resource requires capital that may be obtained from both/either internal and/or external sources. As a result, when we interact *FDI net inflow* with, for instance, *Fossil fuel exporter* dummy, we capture the joint effect of FDI inflows and endowment/production of fossil fuel resources on violence. Analogous intuition applies to the interaction effect between *FDI net inflow* and *Non-fuel non-renewable resource exporter*.

**Economic Variables**

*Natural resource export* (% of merchandise exports) represents the share of fossil fuel
and minerals in total merchandise exports, and thus reflects the importance of natural resources to the host country. This variable, which is obtained from the WDI database, allows us to examine whether the likelihood of violence changes with the level of natural-resources exported. In our data, Gambia exported no natural resources in 2000 and 2001, similarly Guinea-Bissau had no natural resource exports in 1995; whilst Nigeria topped the list with 99.67 percent in 2001. On average, natural resources contributed to 27.28 percent of total merchandise exports in SSA countries during the study period.

*Inequality* is measured by the Gini, a metric calculated and published by the Standardized World Income Inequality Database (SWIID) (Solt, 2016). This variable is widely used in empirical studies as a proxy for income inequality (see, for instance, Hakura et al., 2016). The main advantage of the SWIID is that it provides broadest country coverage by incorporating a number of data sources to maximize the comparability over time. The higher the SWIID score, the more prevalent is inequality. The highest value of the SWIID score within the data set is observed for Namibia in 2005 with 63.26, while the lowest for Ethiopia in 2004 with 63.26.

*Log real GDP per capita* is obtained by log transforming the real GDP per capita data collected from the Penn World Table (PWT) version 9.0 (Feenstra et al., 2015). In our data, Gabon has the highest log real GDP per capita of 9.77 (corresponding to $17,526.38) in 2005, while Nigeria has the lowest with 6.02 (corresponding to $412.79) in 1996.

*Real oil price*, collected from the U.S. Energy Information Administration (EIA), represents an annual average of imported crude oil price per barrel in real terms. We introduce this variable in the model to control for the global fuel price movement. The lowest oil price (in real terms) recorded in our dataset is $18.11/barrel in 1998, while the highest is $111.59/barrel in 2011.

*Inflation* is measured by the consumer price index and is also obtained from the WDI. This variable is included to control for the potential impact of annual percentage change in the cost of a basket of goods and services on violence.

*Log population* is obtained by log transforming population data collected from the WDI.
This variable controls for the potential impact of population size on the onset of violence. In our data set, the lowest population is reported for Gabon in 1975 (649,719), while the highest for Nigeria in 2011 (163,770,670).

**Political Variables**

*Polity* measures the level of regime authority, and reflects the openness and competitiveness of the political processes in a country and the presence of institutions that foster political participation. This variable comes from the Polity IV Project of the Center for Systemic Peace (CSP) and the Integrated Network for Societal Conflict Research (INSCR).

The values of *Polity* range from negative 10 (autocracy) to positive 10 (democracy). According to the CSP (data source), the values between -10 and 5 correspond to “non-democracy”, which essentially includes “autocracy” and “anocracy”; those between -5 and 5 to “anocracy”; and 6 to 10 correspond to “democracy”. The lowest value for *Polity* within the data set is -9 and it is recorded for Cote d’Ivoire (1985), Gabon (1975, 1977), Malawi (1985-1988, 1990-1991), Swaziland (2000-2007), and Zambia (1972, 1976). In contrast, the highest *Polity* score of 10 is recorded for Mauritius (1991-2006). Figure 3.5 plots the empirical distribution of *Polity* for the SSA countries over the study period by violence status. It is clear that when SSA countries experience violence, their regime authorities tend to be characterized as anocracy, with most of the weight falling between -6 and 1. However, in the absence of violence, the outcomes of *Polity* tend to be more evenly distributed, with the upper tail (5-10) receiving noticeably larger weight than that of the case when violence is present. This seemingly negative relationship between *Polity* and *Violence* is in line with the sample correlation coefficient (-0.08) from Figure 3.3.

*Cold War* is a dummy variable that takes value 1 for the final years of cold war period (1985-1991). This variable is introduced in the analysis to control for the potential confounding effects of cold war (e.g., geopolitical situation) on the likelihood of violence in SSA countries.

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5A detailed description of the constructed index is available at [http://www.systemicpeace.org/inscrdata.html](http://www.systemicpeace.org/inscrdata.html).
3.4.2 Empirical Strategy

We estimate the relationship between the likelihood of violence and FDI inflows using a dynamic panel data (DPD) model. As the occurrence of violence in the past may potentially increase the likelihood of violence in the subsequent period (i.e., spillover to the next period), the DPD model allows to explicitly capture the effect of past (lagged) violence on the likelihood of current violence. With the DPD model, unobserved panel-level effects are correlated with the lagged dependent variable (i.e., dynamic panel bias), and thus the standard panel data estimators (e.g., fixed and random effects) are inconsistent (Nickell, 1981). Moreover, as FDI inflows may be conditioned on the recipient country’s economic and political stability, which in turn depends on the level of civil violence, the FDI-civil violence relationship is likely subject to a simultaneity bias. In particular, Li (2006), studying the dynamics of FDI inflows in 129 countries from 1976 to 1996, shows that political violence can have a negative ex-post effect on investment as multinational executives consider civil violence as a significant risk when making investment decisions. Consequently, FDI inflow is potentially endogenous to violence and correlated with the error term.
The presence of both unobserved heterogeneity, lagged dependent variable effects, and endogeneity (due to lags of the endogenous dependent variable and endogenous independent variable) renders the conventional nonlinear panel data models (e.g., probit or logit) unsuitable for sound statistical inferences as these methods at the moment cannot accommodate all of these estimation issues simultaneously. As a result, in line with a voluminous literature, the linear probability model (LPM) cast in DPD framework is implemented to address the above estimation issues. Although LPM has its known disadvantages, as Angrist and Pischke (2009) note, “While a nonlinear model may fit the CEF (conditional expectation function) for LDVs (limited dependent variable models) more closely than a linear model when it comes to marginal effects, this probably matters little.” In addition, Wooldridge (2010), addressing the limitation of LPM, states that, “If the main purpose is to estimate the partial effect of [the independent variable] on the response probability, averaged across the distribution of [the independent variable], then the fact that some predicted values are outside the unit interval may not be very important.”

The main equation of interest is:

\[
Violence_{i,t} = \rho Violence_{i,t-1} + \beta FDI_{i,t} + \gamma_1 FDI_{i,t} \ast FuelExp_{i,t} \\
+ \gamma_2 FDI_{i,t} \ast NonFuelNRExp_{i,t} + \sum_{k=1}^{K} \lambda_k x_{k,i,t} + \alpha_i + \varepsilon_{i,t} \tag{3.34}
\]

In (3.34), \(Violence_{i,t}\) is a binary variable that takes value 1 if there is a violence incident in country \(i\) at time \(t\), and 0 otherwise. \(Violence_{i,t-1}\) is one-period lagged value of the dependent variable. \(FDI_{i,t}\) is the FDI inflow into country \(i\) at time \(t\). \(FDI_{i,t} \ast FuelExp_{i,t}\) is the interaction between FDI inflows and a dummy for fuel exporting country, while \(FDI_{i,t} \ast NonFuelNRExp_{i,t}\) is the interaction between FDI inflows and a dummy for non-fuel natural resource exporting country. \(x_{k,i,t}\), for \(k = 1, \ldots, K\), is control variables, which include economic and political variables discussed Section 3.4.1. Lastly, \(\alpha_i\) is the fixed country effects and \(\varepsilon_{i,t}\) is the idiosyncratic disturbance term. We consider various specifications

---

\(^6\)See Honoré and Kyriazidou (2000), and the references therein, for panel data discrete choice models.

\(^7\)See, for instance, Asiedu and Lien (2011).
of equation \((3.34)\), by varying the list of covariates given in \(x_{k,i,t}\) (e.g., economic variables, political variables, all covariates) and time periods, to demonstrate the robustness of parameter estimates of interest to the inclusion of various control variables and subsets of data.

Based on our testable hypotheses derived from the theoretical model presented in Section 3.3, the effect of FDI inflows on violence varies depending on the sector where the investment is channeled to. In particular, it is expected that FDI in skilled-labor intensive natural resources sector (e.g., fossil fuel) has a negative effect on the likelihood of violence (i.e., \(\gamma_1 < 0\)) and FDI in unskilled-labor intensive natural resource sector (e.g., minerals and precious metals) has a positive effect on the occurrence of violence (i.e., \(\gamma_2 > 0\)).

We use the Arellano-Bond generalized method of moments (GMM) estimator (Arellano and Bond, 1991) to obtain consistent estimates for the DPD model in \((3.34)\). The original, two-step GMM estimator (also known as the difference-GMM estimator) has been shown to suffer some inefficiencies due to lagged levels of endogenous regressor being potentially poor instruments for the first differences (Arellano and Bover, 1995). Therefore, we adopt a more efficient estimator, the system-GMM estimator, proposed by (Blundell and Bond, 1998) to mitigate the weak instrument problem. Specifically, the lags of the endogenous variables are used as instruments for the difference equation and the lagged differences of the endogenous variables are used as instruments for the level equation (Arellano and Bover, 1995; Blundell and Bond, 1998). Our empirical analysis relies entirely on internal instruments, as we do not include any external instruments.

To check for the validity of model instruments, we perform the Hansen/Sargan test of over-identifying restrictions. Furthermore, to avoid the “too many” instruments problem associated with the system-GMM estimator,\(^8\) we control the number of instruments used in empirical analysis such that it is never large relative to the number of countries (cross

---

\(^8\)In particular, the Hansen/Sargan test for over-identifying restrictions loses power when the number of instruments is larger than the cross section sample size (Roodman, 2009). As a rule of thumb, when the ratio of cross section sample size (in our case, number of countries) to the number of instruments is lower than one, the estimates become more susceptible to Type I error and thus tend to be statistically significant even if there is no underlying statistical association between the variables.
section sample size). The Arellano-Bond method assumes that there is no second- or higher-order autocorrelation in the idiosyncratic error terms. Hence, for each regression, we also run the Arellano-Bond autocorrelation test to select an appropriate list of instruments. Finally, to address the potential heteroskedasticity imposed by the linear model in the case of a binary response variable, we use heteroskedasticity-consistent robust standard error estimates, which is a common approach in the literature.

3.4.3 Main Results

In this section, we present the main results from fitting the linear DPD model in (3.34) with the system-GMM estimator. Table 3.2 reports the estimation results. To illustrate the robustness of key parameter estimates to control variables included in the analysis, we consider four different specifications of the main model: (1) model with the main variables only; (2) model with main and economic variables; (3) model with main and political variables; and (4) model with all the explanatory variables. For all four specifications, the number of instruments used in the estimation is either equal or almost equal to the number of countries (i.e., cross section sample size). Moreover, the Sargan test of over-identifying restrictions (for which p-values are all greater than conventional significance levels) suggests that the set of instruments used in the analysis are jointly valid (exogenous) in all four cases. Last but not least, the Arellano-Bond autocorrelation test shows that the serial correlation in the idiosyncratic disturbance term is limited to a first-order lag for all four specifications.

Our findings suggest that the occurrence of violence is statistically related to lagged Violence across all four specifications. This indicates that past violence incident does influence the likelihood of violence in the current period, thus justifying the DPD framework. Moreover, the parameter estimate on the lag of Violence is clearly less than one, which implies a stable growth process. The results for FDI net inflow suggest that the main effect of FDI on violence is negative and statistically significant across all specifications. Furthermore, the joint effect between FDI net inflow and Fossil fuel exporter dummy is also negative and statistically significant across all models; while the interaction between FDI net inflow and Non-fuel non-renewable resource exporter dummy is positive and statistically
Table 3.2. Estimation results from system-GMM under different specifications

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag of violence</td>
<td>0.382***</td>
<td>0.692***</td>
<td>0.691***</td>
<td>0.613***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
<td>(0.042)</td>
<td>(0.009)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>FDI net inflow (% of GDP)</td>
<td>-0.027***</td>
<td>-0.061***</td>
<td>-0.064***</td>
<td>-0.037*</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.015)</td>
<td>(0.008)</td>
<td>(0.021)</td>
</tr>
<tr>
<td>FDI net inflow*fossil fuel exporter</td>
<td>-0.034***</td>
<td>-0.031***</td>
<td>-0.024***</td>
<td>-0.027**</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.008)</td>
<td>(0.002)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>FDI net inflow*non-fuel NR exporter</td>
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<td>0.056***</td>
<td>0.065***</td>
<td>0.039*</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.012)</td>
<td>(0.007)</td>
<td>(0.022)</td>
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<tr>
<td>Natural resource export</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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</tr>
<tr>
<td>Inequality</td>
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<td>-0.004**</td>
<td>-0.004**</td>
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</tr>
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<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Log real GDP per capita</td>
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<td>-0.012</td>
<td>-0.012</td>
<td>-0.012</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Real oil price</td>
<td>0.001***</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.000***</td>
<td>-0.000</td>
<td>-0.000</td>
<td>-0.000</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Log population</td>
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<td>0.042**</td>
<td>0.042**</td>
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<td>(0.014)</td>
<td>(0.018)</td>
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<td>Cold War</td>
<td>-0.077***</td>
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<td>-0.007</td>
<td>-0.007</td>
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<td></td>
<td>(0.014)</td>
<td>(0.039)</td>
<td>(0.039)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>Polity (regime authority)</td>
<td>0.001</td>
<td>0.002</td>
<td>0.002</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.131***</td>
<td>0.600</td>
<td>0.083***</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.098)</td>
<td>(0.010)</td>
<td>(0.137)</td>
</tr>
<tr>
<td>Observations</td>
<td>315</td>
<td>304</td>
<td>315</td>
<td>304</td>
</tr>
<tr>
<td>Number of countries</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Number of instruments</td>
<td>29</td>
<td>30</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>Sargan test (p-value)</td>
<td>0.07</td>
<td>0.72</td>
<td>0.66</td>
<td>0.58</td>
</tr>
<tr>
<td>First order (p-value)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Second order (p-value)</td>
<td>0.72</td>
<td>0.14</td>
<td>0.27</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

significant across all models. Therefore, the overall effect of $FDI$ net inflow depends on a country’s natural resources. Figure 3.6 compactly summarizes the overall effect of $FDI$ net inflow on Violence under different model specifications, which we discuss in detail below.

First, if an SSA country is not fossil fuel exporter ($Fossil fuel exporter=0$), nor non-fuel non-renewable resource exporter ($Non-fuel non-renewable resource exporter=0$), then for every one percentage point increase in $FDI$ net inflow (% of GDP), ceteris paribus, the likelihood of violence in the country decreases by anywhere between 0.027 to 0.064 (depending on specification). Second, if an SSA country is fossil fuel exporter ($Fossil fuel
Fig. 3.6. Estimated overall effect of FDI net inflow on the likelihood of violence by type of natural resource endowments (exports)

exporter=1), but not non-fuel non-renewable resource exporter (Non-fuel non-renewable resource exporter=0), the probability of violence declines by anywhere between 0.061 to 0.092 (depending on specification) for every one percentage point increase in FDI net inflow (% of GDP), ceteris paribus. Consequently, being fossil fuel exporter reduces the risk of violence more relative to the previous case. This result is in line with the theoretical prediction from Proposition 3.3.1.

The above two findings support the strong-held position of proponents of FDI inflows into the SSA countries, which is that FDI helps rebuild and stabilize economic and political environment in this part of the world. This message, however, is not reflected clearly in Figure 3.1, nor by the sample correlation between FDI net inflow and Violence. As a result, we need to carefully examine the remaining two cases to shed further light on the effect of FDI net inflow.

Third, and importantly, if an SSA country is not fossil fuel exporter (Fossil fuel exporter=0), but non-fuel non-renewable resource exporter instead (Non-fuel non-renewable resource exporter=1), our results suggest that every one percentage point increase in FDI
net inflow (% of GDP), all else constant, changes the likelihood of violence by anywhere between -0.007 to 0.002 (depending on specification). The positive overall effect of FDI net inflow, especially in the full model (0.002), supports our theoretical prediction from Proposition 3.3.2 and also provides a plausible explanation for the relationship between Violence and FDI net inflow observed in Figure 3.1. Finally, if an SSA country is both fossil fuel exporter (Fossil fuel exporter = 1) and non-fuel non-renewable resource exporter (Non-fuel non-renewable resource exporter = 1), then, similar to the first and second cases, the likelihood of violence drops by anywhere between 0.025 to 0.041 (depending on specification) for every one percentage point increase in FDI net inflow, all else constant.

In summary, from Figure 3.6 it is evident that the inflow of FDI reduces the risk of violence the most if an SSA country has fossil fuel endowments that solely constitute its natural resource exports. By contrast, if an SSA country has non-fuel non-renewable natural resource endowments that solely comprise its natural resource exports, then FDI inflows potentially increase the likelihood of violence. These results can be rationalized based on labor skill requirements needed for the production of these two types of resources, as discussed in the introduction.

Focusing on the effect of the remaining explanatory variables, we can observe that the magnitude and the sign of parameter estimates remain consistent across different specifications, which lends support for the robustness of observed results. According to our findings, Inequality has a statistically significant, small negative effect on violence across different specifications. In particular, for one unit increase in income inequality (SWIID score), which implies the worsening of inequality, the likelihood of violence goes down by about 0.004. This somewhat counter-intuitive result can be explained by two observations inherent to the SSA. First, most of the SSA countries are hard-stricken by inequality, among other issues. The sheer inequality, however, is part of the reason why foreign aid and investment (e.g., in the form of micro-credits or micro-loans) is channeled to the SSA, so as to enable individual households to become self-subsistent, and thereby gradually alleviate inequality and poverty. In fact, from Figure 3.3 we observe a mild positive correlation
between *Inequality* and *FDI net inflow* (0.05). As a result, inequality might be attracting some FDI into the SSA countries, which, in turn, can reduce the risk of violence based on our previous discussions. Second, SSA countries with stronger institutional structures (i.e., higher *Polity* score) often have more inequality than those with weaker institutional structures.\(^9\) This is also apparent from a mild positive correlation between *Inequality* and *Polity* (0.06) from Figure 3.3. Since stronger institutional structures have been shown to reduce the risk of violence (Asiedu, 2006), the negative sign can then be justified considering such observation.

Further, we find that population is statistically significant and has the positive sign across different models, which is line with Figure 3.3. Specifically, the full model suggests that one unit increase in *Log population* raises the probability of violence by 0.042. The remaining control variables are mostly significant in models (2) and (3), but not in the full model. For instance, *Log real GDP per capita* has the correct sign across different specifications, but it is not found to be statistically significant predictor of violence. Similarly, *Natural resource export* (% of merchandise export) and *Polity* remain statistical insignificant across different specifications. Since *Polity* had some visible association with *Violence* from Figure 3.5, we provide a more detailed analysis for this variable in Section 3.4.5. On the other hand, *Real oil price* and *Inflation* have a small significant effect on violence in model (2). These effects, however, disappear once we control for the regime authority (*Polity*) in model (4).

### 3.4.4 Analysis by Time Period

To demonstrate the sensitivity of our main findings from the previous section to time periods, and potentially control for the effect of business cycles, we next fit the linear DPD...
model to different subsets of years. Specifically, we consider five different periods: (1) 1972-2013, (2) 1985-2013, (3) 1990-2013, (4) 1995-2013, and (5) 2000-2013. Notice that 1972-2013 correspond to model (4) in Table 3.2, and we include it here for comparison purposes. The estimation results are provided in Table 3.3. Again, for all the models: (i) the number of instruments used is equal or approximately equal to the number of countries; (ii) the set of instruments used in the analysis are jointly valid (exogenous); and (iii) the serial correlation in the idiosyncratic disturbance term is limited to a first-order lag.

Table 3.3. Estimation results from system-GMM for different subsets of years

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag of violence</td>
<td>0.613***</td>
<td>0.614***</td>
<td>0.611***</td>
<td>0.600***</td>
<td>0.095***</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.023)</td>
<td>(0.024)</td>
<td>(0.010)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>FDI net inflow (% of GDP)</td>
<td>-0.037*</td>
<td>-0.037*</td>
<td>-0.036*</td>
<td>0.005</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.020)</td>
<td>(0.015)</td>
<td>(0.027)</td>
</tr>
<tr>
<td>FDI net inflow*fossil fuel exporter</td>
<td>-0.027**</td>
<td>-0.026**</td>
<td>-0.028**</td>
<td>-0.037***</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.010)</td>
<td>(0.010)</td>
<td>(0.013)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>FDI net inflow*non-fuel NR exporter</td>
<td>0.039*</td>
<td>0.039*</td>
<td>0.040*</td>
<td>0.031</td>
<td>-0.001</td>
</tr>
<tr>
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<td>(0.022)</td>
<td>(0.021)</td>
<td>(0.022)</td>
<td>(0.019)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Natural resource export</td>
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<td>0.000</td>
<td>0.000</td>
<td>-0.000</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Inequality</td>
<td>-0.004**</td>
<td>-0.004**</td>
<td>-0.004**</td>
<td>-0.005***</td>
<td>-0.009***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.001)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Log real GDP per capita</td>
<td>-0.012</td>
<td>-0.012</td>
<td>-0.012</td>
<td>0.002</td>
<td>-0.033</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.010)</td>
<td>(0.006)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Real oil price</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.000</td>
<td>0.002***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.000</td>
<td>-0.000</td>
<td>-0.000</td>
<td>-0.000</td>
<td>-0.000**</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Log population</td>
<td>0.042**</td>
<td>0.042**</td>
<td>0.045**</td>
<td>0.070***</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.019)</td>
<td>(0.019)</td>
<td>(0.022)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>Cold War</td>
<td>-0.007</td>
<td>-0.005</td>
<td>-0.013</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.039)</td>
<td>(0.037)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Polity (regime authority)</td>
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<td>0.002</td>
<td>0.002*</td>
<td>-0.001</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.002</td>
<td>0.013</td>
<td>0.004</td>
<td>-0.261*</td>
<td>0.383</td>
</tr>
<tr>
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<td>(0.137)</td>
<td>(0.141)</td>
<td>(0.145)</td>
<td>(0.137)</td>
<td>(0.266)</td>
</tr>
<tr>
<td>Observations</td>
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<td>303</td>
<td>298</td>
<td>277</td>
<td>199</td>
</tr>
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<td>Number of countries</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Number of instruments</td>
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<td>29</td>
<td>29</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Sargan test (p-value)</td>
<td>0.58</td>
<td>0.58</td>
<td>0.60</td>
<td>0.14</td>
<td>0.08</td>
</tr>
<tr>
<td>First order (p-value)</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Second order (p-value)</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.31</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.
It is apparent that the estimation results from different specifications are generally comparable to model (1). Despite the magnitude and the sign of key parameter estimates (main and joint effects of *FDI net inflow*) remaining largely consistent across different models, the toll of decreasing sample size is more and more evident with each successive model, culminating in models (4) and (5), whereby the sign and significance of some of the parameter coefficients start to deviate from those in model (1). Overall, analysis by time period emphasize the robustness of our main findings.

### 3.4.5 Analysis by Regime Authority

While we do not find a strong evidence for the effect of regime authority (*Polity*) on *Violence* from our main analysis, our observations from Figures 3.3 and 3.5 seem to point to the contrary. Therefore, in this section we further investigate the effect of *Polity* on *Violence* by zeroing in on specific sub-groups of regime authority. In particular, we build three sub-groups: (1) *Polity* score between -10 and 10 (all observations); (2) *Polity* score between -10 and 5 (non-democracy); and (3) *Polity* score between -5 and 5 (anocracy). Notice that *Polity* score between -10 and 10 (all observations) correspond to model (4) in Table 3.2, and it is included here for comparison purposes. Moreover, we also considered a sub-group for *Polity* score between 6 and 10, which represents “democracy”. However, due to limited number of observations falling into this group, the econometric analyses were weakened which questioned the reliability of empirical results. Hence we omitted this analysis from our results presented in this section.

Table 3.4 provides the estimation results. For all the models: (i) the number of instruments used is equal or approximately equal to the number of countries; (ii) the set of instruments used in the analysis are jointly valid (exogenous); and (iii) the serial correlation in the idiosyncratic disturbance term is limited to a first-order lag.

It is clear that the estimation results from different specifications are largely similar, and also consistent with previous findings. *FDI net flow* has a negative sign across the models, but it is statistically significant only in model (1), when all observations are considered. The joint effects of *FDI net flow* have the expected signs across different specifications, but
Table 3.4. Estimation results from system-GMM under different levels of regime authority

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) All (Polity -10 to 10)</th>
<th>(2) Non-democracy (Polity -10 to 5)</th>
<th>(3) Anocracy (Polity -5 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lag of violence</td>
<td>0.613*** (0.024)</td>
<td>0.747*** (0.059)</td>
<td>-0.346 (0.218)</td>
</tr>
<tr>
<td>FDI net inflow (% of GDP)</td>
<td>-0.037* (0.021)</td>
<td>-0.034 (0.030)</td>
<td>-0.221 (0.229)</td>
</tr>
<tr>
<td>FDI net inflow*fossil fuel exporter</td>
<td>-0.027** (0.010)</td>
<td>-0.008 (0.011)</td>
<td>-0.204** (0.074)</td>
</tr>
<tr>
<td>FDI net inflow*non-fuel NR exporter</td>
<td>0.039* (0.022)</td>
<td>0.032 (0.036)</td>
<td>0.397* (0.218)</td>
</tr>
<tr>
<td>Natural resource export</td>
<td>0.000 (0.000)</td>
<td>-0.000 (0.001)</td>
<td>0.001 (0.002)</td>
</tr>
<tr>
<td>Inequality</td>
<td>-0.004** (0.001)</td>
<td>0.001 (0.002)</td>
<td>-0.008 (0.017)</td>
</tr>
<tr>
<td>Log real GDP per capita</td>
<td>-0.012 (0.009)</td>
<td>0.019 (0.031)</td>
<td>-0.025 (0.164)</td>
</tr>
<tr>
<td>Real oil price</td>
<td>0.000 (0.000)</td>
<td>0.000 (0.001)</td>
<td>-0.008** (0.004)</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.000 (0.000)</td>
<td>-0.000 (0.000)</td>
<td>-0.000 (0.000)</td>
</tr>
<tr>
<td>Log population</td>
<td>0.042** (0.018)</td>
<td>0.048* (0.025)</td>
<td>0.880*** (0.271)</td>
</tr>
<tr>
<td>Cold War</td>
<td>-0.007 (0.039)</td>
<td>-0.017 (0.052)</td>
<td>0.000 (0.000)</td>
</tr>
<tr>
<td>Polity (regime authority)</td>
<td>0.002 (0.001)</td>
<td>0.005 (0.004)</td>
<td>-0.038 (0.042)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.002 (0.137)</td>
<td>-0.474 (0.294)</td>
<td>-5.306** (2.339)</td>
</tr>
</tbody>
</table>

Observations | 304 | 189 | 113
Number of countries | 30 | 22 | 17
Number of instruments | 29 | 21 | 16
Sargan test (p-value) | 0.58 | 0.15 | 0.18
First order (p-value) | 0.03 | 0.10 | 0.08
Second order (p-value) | 0.15 | 0.18 | 0.93

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

are statistically significant for models (1) and (3) only. Two important observations can be noted by observing the main and joint effects of FDI net flow from the three models. First, Polity, and more specifically, sub-groups of Polity, do play a role in determining the likelihood of violence. In particular, regime authorities characterized as “anocracy” are found to experience the joint effects of FDI net flow and natural resource exports. However, when regime authorities are characterized more broadly as “non-democratic”, the above effects disappear. This can be attributed to the fact that states with anocracy usually
have larger spectrum of governing authorities (falling just below democracy) compared to those in non-democracy, which includes autocracy as well. Second, observing the magnitude of parameter estimates on the main and joint effects of FDI net flow in models (2) and (3), one concludes that as the regime authority/institutional structures improve (i.e., moving from non-democracy to anocracy), the effect of FDI net flow on Violence enlarges. This observation is line with Figure 3.5.

3.5 Concluding Remarks

This essay studies the effects of FDI on the risk of violence in SSA. Economics literature on exploring factors that affect civil violence in developing countries is scant. While in some policy-circles and political activists have criticized that FDI may increase violence in developing countries, this issue has been overlooked in the economic literature. This essay attempts to fill this gap by providing both theoretical and empirical analysis.

On the theoretical front, we develop a general equilibrium theory of FDI and violence, consisting of three sectors: two production sectors and an enforcement (security) sector. We focus on two types of resource-based developing economies, one with skilled-labor intensive resource sectors and the other with unskilled-labor intensive resources. We show that an increase in resource-directed FDI inflow decreases (increases) the risk of violence in the former (latter) type of developing countries.

We empirically test our theory by utilizing a dataset of 34 countries in SSA between 1972 and 2013 in a dynamic panel setup. Our empirical results provides support for our theoretical findings and are robust to different specifications. In particular, our econometric estimates suggest that an increase in FDI reduces the risk of violence in SSA economies if they are fuel-based resource rich countries. However, according to our estimates, the likelihood of violence is increasing in such a type of FDI flow if SSA countries are rich in non-fuel resources. These results are in-line with our theoretical findings.

As a caveat, studies such as ours, due to their nature, have limitations, especially pertaining to data availability. Despite its limitation, our study provides a new perspective to resolve the paradox surrounding the effect of FDI on violence. This essay also provides
important policy implications. It supports policymakers in SSA countries, such as Ghana, Kenya, Mozambique, Tanzania, and Uganda, who are making policy shifts by encouraging FDI in their newly found oil and gas sector. However, accountability and good governance is the key to accrue the benefits from the vast natural resources of SSA to its people, as it is extensively explained in the literature on FDI and economic growth. Nevertheless, FDI will continue to be an important tool for policymakers of SSA in preventing future violence as well as contributing towards the journey for achieving the “Sustainable Development Goals” by 2030.
List of SSA countries covered in the analysis of chapter 3

<table>
<thead>
<tr>
<th>Angola</th>
<th>Guinea</th>
<th>Rwanda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>Guinea-Bissau</td>
<td>Senegal</td>
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<td>Kenya</td>
<td>South Africa</td>
</tr>
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<td>Burkina Faso</td>
<td>Lesotho</td>
<td>Sudan</td>
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<tr>
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<td>Malawi</td>
<td>Swaziland</td>
</tr>
<tr>
<td>Cameroon</td>
<td>Mali</td>
<td>Tanzania</td>
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<td>Central African Republic</td>
<td>Mauritania</td>
<td>Togo</td>
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<td>Cote d’Ivoire</td>
<td>Mauritius</td>
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<td>Gabon</td>
<td>Namibia</td>
<td>Zimbabwe</td>
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<td>Gambia</td>
<td>Niger</td>
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<tr>
<td>Ghana</td>
<td>Nigeria</td>
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REFERENCES


CHAPTER 4

POLITICAL ECONOMY OF AID ALLOCATION: THE CASE OF ARAB AID

4.1 Abstract

We develop a new theory of aid allocation, whereby a representative donor country’s payoff depends on both the well-being of the representative recipient country as well as its political alignment with the donor. Our theoretical model suggests that there exists an increasing relationship between donor’s aid allocation and the solidarity and geopolitical alignment of the recipient country. The model also predicts that donor’s allocate more aid to recipient countries with higher levels of human capital. We test these predictions using a unique dataset on aid allocation by major Arab donors. After constructing a new measure of solidarity and geopolitical alignment for recipient countries by using principal component analysis, we employ this measure as well as other control variables in our empirical analysis. The results suggest that solidarity and geopolitical alignment, as well as the human capital of a recipient country, are the key determinants of aid allocation from the Arab donors.

4.2 Introduction

Although the economic development of recipient countries is typically the stated objective of foreign aid, there is a perception that foreign aid may also be politically motivated. These motives may be overt. For example, US aid to both Israel and Egypt since the Camp David were designed to keep peace between these two countries. More often however, political motives for aid are likely to be covert or without clearly stated political objectives. To what extent are foreign aid allocations due to the political alignment of recipient countries with donors relative to recipients’ development needs? This essay is intended to provide a theoretical framework to address this question and to empirically assess the predictions of this model.
Foreign aid allocation in response to a recipient’s position on a particular political issue, such as voting behavior at the United Nations (UN), has empirically been addressed in the literature (see Alesina and Dollar, 2000, Kuziemko and Werker, 2006, and Dreher et al., 2009, among others).\(^1\) We define a more general measure of solidarity and political alignment that takes into account geographic, political, and cultural attributes of recipient countries with donors. We then construct a novel game theoretic model of aid allocation and political alignment.

Although the literature on the theory of foreign aid is rich (see Jones, 1970, Srinivaasan and Bhagwati, 1984, Easterly and Easterly, 2006, and Beladi and Oladi, 2006, among others), to our knowledge our approach is new. Our theory formulates both political and developmental motives of aid and shows how strategic alignment by the recipient countries may affect aid allocation. In our model, donors respond to socio-political-cultural positioning, while remaining benevolent in caring for development in recipient countries. We characterize the sub-game perfect equilibrium of this game. Two testable hypotheses emerge from the sub-game perfect Nash equilibrium of this game. First, there exists a positive relationship between aid allocation and the solidarity and geopolitical alignment of the recipient countries with donors. Second, at equilibrium, donor countries allocate more aid to recipient countries with higher levels of human capital.

We test these propositions by applying them to a unique dataset of aid allocation by Arab donors in 147 developing countries\(^2\) during the time period 1996 to 2015. The benefits of applying our theory to aid allocation by the Arab donor block, referred to as the Arab Coordination Group (ACG), are twofold. While the empirical literature on aid and international development is extensive and rich, little attention has been paid to Arab aid. This is despite the fact that the ACG is the largest donor among non-OECD donors. Another advantage of our application to aid allocation by ACG is the unique dataset we possess. While the very few studies on Arab aid took on a major challenge, they all face data limitation due to lack of access. Their common source of data was limited to OECD database

---

\(^1\)Empirical literature on foreign aid is extensive and certainly deserves an extensive review. However, such a review is beyond the scope this essay.

\(^2\)As per UN classification.
and, as a result, they were not able to cover a full time-series for all the ACG institutions (see Neumayer, 2003, Villanger, 2007, Dreher et al., 2011). Clearly, inaccessibility to data imposes a limit on the reliability of empirical results.

Indeed, the publicly available source of data on Arab aid commitments or disbursements is OECD database. However, this is incomplete and contains missing values for many years for the key Arab donors, such as Kuwait, Saudi Arabia, and the United Arab Emirates (UAE). As an example, Dreher et al. (2011) faced this challenge and could only account for US$4.3 billion aid flow from Kuwait, Saudi Arabia, and UAE during 2001-2008. However, this amount understates the level of aid reported in our dataset which is obtained directly from the ACG Secretariat that covers the historical aid allocation by the ACG institutions. Therefore, this essay can be viewed as the first comprehensive study on Arab aid channeled through the ACG institutions. Nonetheless, we do not have additional data on (other) direct aid from Arab donors. For example, the aid that a major Arab donor may provide to a recipient country when the head of state of the donor country visits the recipient country is not included in our dataset. In fact, such aid may not be recorded in any database. However, we believe that this sort of direct aid is strongly correlated to the aid channeled through the ACG institutions.

Yet another important feature of our empirical study is that it focuses on South-South aid, in contrast to North-South direction of the most of foreign aid (i.e., official development assistance (ODA) of OECD). Notably, the Arab donors block leads amongst the non-OECD donors (Nielson et al., 2009). The genesis of Arab aid can be traced back to the 1960s when several Arab aid institutions were established. The prime objective of developing these institutions was to support Arab and other developing countries in their socio-economic development. The Arab aid institutions formed ACG as a donor block in 1974. ACG institutions have made remarkable contributions in socio-economic development in many Arab and non-Arab developing countries. Since 1962, they have provided funding of over US$164 billion (ACG Secretariat). Furthermore, over the past twenty years, these institutions witnessed a tremendous evolution in scale and scope of their activities compared
to the levels attained during the early nineties and earlier decades. As an example, the average yearly commitment between 1990 and 1995 was only US$2.2 billion, while the annual average during the period we cover in this study (i.e., 1996-2015) was US$6.1 billion. This nearly threefold increase is primarily due to the awareness of these institutions of the need to cope with the increasing financing requirements of the beneficiary countries, as well as the imperatives of the changing economic environment.\textsuperscript{3}

Our empirical study consists of two types of statistical analysis. We first employ principal component analysis to construct a composite index for solidarity and geopolitical alignment of recipients with major Arab donor countries. Our construction of this composite in itself contributes to the political economy literature. Second, we use our index to econometrically assess the effects of solidarity and political alignment on aid allocation.

The remainder of the essay is organized as follows. In Section 4.3, we review some stylized facts about Arab aid. We present our political economy theory of aid allocation in Section 4.4. Section 4.5 highlights the econometric analysis including data, development of our political alignment index, econometric methodology, and followed by a discussion on econometric results. Section 4.6 provides some concluding remarks.

4.3 Stylized Facts

The ACG comprises ten bilateral and multilateral institutions. The bilateral institutions include the Saudi Fund for Development (SFD), the Kuwait Fund for Arab Economic Development (KFAED), the Abu Dhabi Fund for Development (ADFD) and the Qatar Fund for Development (QFD). On the other hand, multilateral institutions are the Arab Fund for Economic and Social Development (AFESD), the Islamic Development Bank (IsDB), the OPEC Fund for International Development (OFID), the Arab Monetary Fund (AMF), the Arab Gulf Program for Development (AGFD), and the Arab Bank for Economic Development in Africa (BADEA). Many of these multilateral institutions provide funding to only their member countries. As an example, IsDB extends its funding to its 57 member countries. The largest contributor of funding commitments among the ACG members is

\textsuperscript{3}Details of the ACG Institutions shall be presented in section 2.
the IsDB (40.2%), followed by the AFESD (18.3%) and KFAED (12.7%). The contribution of the other members of the group is in single digits. In terms of amount, IsDB’s contribution is over US$66 billion out of the total ACG commitments, which stands at US$265 billion from 1962 to 2015. It should be noted that IsDB and OFID are not strictly Arab owned institutions as there are other non-Arab shareholders in their membership. However, the largest shareholders of these institutions are Arab countries and therefore are considered as Arab institutions. Figure 4.1 shows the ACG commitments from 1962 to 2015 (by institutions and in million US$).

Figure 4.2 depicts annual commitments of the ACG members. Since the late 1990s, there has been a tremendous increase in commitments of ACG funding. Between 1996 and 2015, the total commitment was US$121 billion, which is about 73% of the total ACGs commitment of US$164 billion since inception. Moreover, the annual commitment has drastically increased from just above US$2 billion in 1996 to over US$17 billion in 2015. The figure also suggests that non-oil producing Arab countries are the largest beneficiaries of the funding with 55% of the total commitment, followed by Asia (25%), Latin America (18%) and Africa (17%). There is also a small percentage of commitment (3%) for regional organizations. In terms of regional allocation, there is a notable change in the scale of funding for Asia during the 2000s, which substantially increased from US$386 million in 1996 to US$5.9 billion in 2015.
Several studies have suggested the price of oil is a key driving force for Arab aid (for example, see Werker et al., 2009). Figure 4.3 plots the cumulative Aid commitments from the Arab institutions (left) and real oil price per barrel (right) for the period between 1996 and 2015. The figure suggests a moderate correlation between the two. However, a higher oil price may not always lead to an increase in aid commitments from the Arab institutions or vice versa. As an example, when oil price increased in 2004, 2006 and 2011, we observe a decrease in the commitments from the Arab institutions when compared to the previous year. Likewise, when oil price was on a declining path from 2013 to 2015, we observe an increase of the aid commitments from the Arab institutions. This may be due to the fact that the citizens of oil-producing Arab countries enjoy heavy subsidies from their central governments. It is often the case that years of budgetary shortfalls (as a result of low oil prices) are followed by years of massive capital expenditure, subsidies and other social benefits across the board (when oil prices start to take an upward trend) to make up for the “lost years” and to appease the always expectant public. Besides, the institutions within the ACG have a set financial structure based on subscribed capital and have own policies on commitment growth, which may not be correlated with oil price volatilities.
Figure 4.3. The ACG commitments and real oil price movements, 1996-2015

Figure 4.4 provides an overview of Arab aid’s global allocation. A clear concentration of Arab aid in South Asian and North African Muslim majority countries is quite visible. During 1962 to 2015, the top five beneficiaries of the ACG funding include three North African countries of Egypt, Morocco, and Tunisia, and two South Asian countries of Bangladesh and Pakistan. One may argue that the three North African Arab countries are in fact relatively better off in terms of poverty situation and general welfare compared with their Sub-Saharan African neighbors. Further, during the last two decades between 1996 and 2015, top five beneficiaries include Egypt, Morocco, Bangladesh, Sudan, and Tunisia, four of which are considered Arab countries. This anecdotal evidence suggests that although the scale of the ACG funding has increased over the last two decades, there seems to be little change in policy regarding aid allocation.

These stylized facts may raise the question why a significant portion of the Arab aid has been allocated to countries such as Egypt, Morocco, and Tunisia rather than to less developed countries of the Muslim world. This may be because major donors have proximity to the Arab region, have a common religion, common language, and are politically aligned. Despite this argument, it is not clear why countries like Indonesia is not benefiting as much from the ACG as Bangladesh and Pakistan, though Indonesia is the largest Muslim country in terms of population and aligned with the major Arab donors in international issues.
4.4 Theoretical Analysis

In this section, we develop a general theory of aid allocation by constructing an aid and geopolitical game. Consider a foreign aid recipient representative country and a donor, denoted by \( r \) and \( d \), respectively. Let the base position of the recipient and the donor be given by \( \beta_i \in [0,1], i = d, r \). That is, the recipient and the donor’s ideal position located on geopolitical spectrum bonded by zero and one. Without lose of generality, let \( \beta_r \leq \beta_d \). The recipient country takes an actual geopolitical position \( p \) on geopolitical spectrum, i.e., \( p \in [0,1] \). The payoff function for the recipient country is given by:

\[
W_r = u(C) \left[ 1 - g(\delta_r) \right]
\]  

(4.1)

where \( C \) denotes the aggregate consumption level in the recipient country and \( \delta_r \) is the Euclidean distance between its location on geopolitical spectrum and the position it take, i.e., \( \delta_r = |p - \beta_r| \). Note that \( u \) is the utility of consumption and \( g : [0,1] \rightarrow [0,1] \) is the cost (dis-utility factor) for deviating from ideal geopolitical position.\(^4\) We maintain that \( u_C > 0, u_{CC} < 0, g(0) = 0, g' > 0 \) and \( g'' > 0 \). This economy also produces an aggregate

\(^4\)Our formulation of cost is similar to iceberg-type trade cost in international trade literature as in Beladi and Oladi (2011).
good using production technology \( Y = Hf(K) \) where \( H \) denotes human capital, \( K = \bar{K} + A \) is the capital stock, \( \bar{K} \) is the fixed stock of domestic capital and \( A \) is foreign aid. We further assume that \( f' > 0 \) and \( f'' < 0 \). In this simply autarkic economy \( C = Y \).

In addition to providing aid, the payoff of the donor depends on the consumption level in the recipient country (i.e., the development factor) and on the utility of proximity of the recipient’s geopolitical position to its own base position. Thus, we define the donor’s payoff function as:

\[
W_d = C - \nu(\delta_d, A) \tag{4.2}
\]

where \( \delta_d = |p - \beta_d| \) is the distance of the recipient’s geopolitical position from the donor’s location on geopolitical spectrum. The first term, consumption in the recipient country, is the benefits of aid, while the second term is the cost of aid, both in terms of dis-utility of recipient distancing itself from the donor’s ideal position on geopolitical spectrum and in terms of the opportunity cost of providing the loan itself. Assume the standard assumptions on \( \nu \), i.e., \( \nu_{\delta_d} > 0, \nu_{\delta_d\delta_d} > 0, \nu_A > 0, \nu_{AA} > 0 \) and \( \nu_{A\delta_d} > 0 \). Marginal cost of aid is higher the more geopolitical distant a recipient country is from the donor.

The game played by the recipient and the donor is sequential. It is reasonable to assume that the recipient country moves first, followed by the donor country. The rationale is simple. In the real world, recipient countries often leave a long list of policy records over time, such as voting behavior at the United Nations General Assembly (UNGA), having a friendly relationship with donor countries, encourage and promote cultural affinity with that of donors, etc. Having observed these political and cultural aspects (or what we call geopolitical position), the donor countries decide on their aid allocation.

To find the sub-game perfect equilibrium of this game, we derive the implicit best response function for the donor as:

\[
Hf'(\cdot) - \nu_A(\cdot) = 0 \tag{4.3}
\]

Denote this best response function in its explicit form by \( A = \tau(p) \). Notably, \( \tau \) is not
monotonic in general, it is monotonically increasing for all $p < \beta_d$. To see this, note that we can obtain from (4.3) that $d\tau/dp = [\nu_A\delta_d/(Hf''(\cdot) - \nu_{AA})]\delta_d/dp$. Since $d\delta_d/dp < 0$ for all $p < \beta_d$, it follows from our assumptions on $f$, and $\nu$ that $dA/dp > 0$ if $p < \beta_d$. The converse is true if $p > \beta_d$.

The recipient country chooses its geopolitical position, knowing how the donor will react in its aid allocation. Thus, the optimization that the recipient faces is given by $\max_{p \in [0,1]} W_r(\cdot)$ subject to $a = \tau(p)$. Thus, at an equilibrium, we have:

$$Hu'(\cdot)f'(\cdot)[1 - g(\cdot)]\frac{d\tau}{dp} - u(\cdot)g'(\cdot)\frac{d\delta_r}{dp} = 0$$

(4.4)

That is, at sub-game perfect equilibrium we have $d\tau/dp = u(\cdot)g'(\cdot)/H[u'(\cdot)f'(\cdot)[-g(\cdot)]]$. The right hand side of this expression is the slope of the iso-payoff curve for the recipient country and the left hand side is the slope of best response function for the donor country. Note that $p < \beta_r$ is never a best response to $a = \tau(p)$ since there exists a higher $p$ at which both $\delta_r$ is lower and $a$ is higher (along $\tau$). This, along with equation (4.4) and the sign of $d\tau/dp$, implies that at sub-game perfect equilibrium $p > \beta_r$. We depict our sub-game perfect equilibrium (SPE) and our Nash equilibrium (NE) in Figure 4.5, where the associated quantities are denoted by $(\hat{p}, \hat{A})$.

Next, consider the effects of a change in human capital in the recipient country on sub-game perfect equilibrium. By totally differentiation equation (4.3), we get $d\tau/dH = -f'(\cdot)/Hf''(\cdot) > 0$. It then follows that a higher level of human capital in a recipient country will lead to a higher aid level. This is indicated by an upward shift in $\tau$ to $\tau'$, where its associated sub-game perfect equilibrium is denoted by $SPE'$. Two testable propositions emerge from our general theory of aid allocation:

**Proposition 4.4.1**

*There exists an increasing relationship between foreign aid allocation and the geopolitical alignment of the recipient countries with the donors.*

---

5The best response function of an alternative simultaneous-move game (not analyzed here) for the recipient country is denoted by $\phi$. 
Proposition 4.4.2

*Donor countries allocate more aid to recipient countries with higher level of human capital.*

We shall take our general theory of aid allocation to the data and test our proposition by applying them to Arab aid in the remainder of this essay.

4.5 Empirical Analysis

4.5.1 Data

Our analysis is highly data demanding and consists of a large unbalanced panel containing nineteen variables for 147 developing countries (based on UN classification) during 1996-2015. The list of countries considered in our analysis is provided after Section 4.6. 121 countries (82%) in the dataset are the recipient of Arab development funding (ADF), while 26 countries are not. We also drop the funding provided to the private sector (mainly for public-private partnership type of projects) in Saudi Arabia, Kuwait, and UAE by the ACG institutions. Overall, our dataset covers about 95% ADF receipts. We will use nine of
Table 4.1. Descriptive statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arab Development Funding ($millions)</td>
<td>41.41</td>
<td>138.1</td>
<td>0</td>
<td>2,990</td>
</tr>
<tr>
<td><strong>Solidarity and Geopolitical Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voting in UNGA with Saudi Arabia (%)</td>
<td>0.721</td>
<td>0.222</td>
<td>0</td>
<td>0.987</td>
</tr>
<tr>
<td>Arab</td>
<td>0.116</td>
<td>0.321</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Africa</td>
<td>0.364</td>
<td>0.481</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.178</td>
<td>0.383</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Member of OIC</td>
<td>0.349</td>
<td>0.477</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Israel (recognition)</td>
<td>0.164</td>
<td>0.370</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Muslim Majority (MM)</td>
<td>0.280</td>
<td>0.449</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Shia Majority (SM)</td>
<td>0.034</td>
<td>0.182</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Baseline Economic Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log GDP, (PPP constant 2011 international $)</td>
<td>10.20</td>
<td>2.346</td>
<td>3.149</td>
<td>16.74</td>
</tr>
<tr>
<td>Human Development Index Score</td>
<td>0.599</td>
<td>0.147</td>
<td>0.237</td>
<td>0.925</td>
</tr>
<tr>
<td><strong>Other Baseline Economic Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log (population)</td>
<td>0.696</td>
<td>0.988</td>
<td>-2.034</td>
<td>3.137</td>
</tr>
<tr>
<td>Real oil price</td>
<td>61.15</td>
<td>30.64</td>
<td>18.11</td>
<td>111.6</td>
</tr>
<tr>
<td>Trade with Arab (Saudi, Kuwait, &amp; UAE)</td>
<td>1,815</td>
<td>8,984</td>
<td>0</td>
<td>142,573</td>
</tr>
<tr>
<td><strong>Economic Stability Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>21.21</td>
<td>490.7</td>
<td>-35.84</td>
<td>24,411</td>
</tr>
<tr>
<td>Current Account Balance</td>
<td>-4.518</td>
<td>11.36</td>
<td>-148.0</td>
<td>48.21</td>
</tr>
<tr>
<td><strong>Institutional Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freedom House Political Rights Index</td>
<td>3.968</td>
<td>2.056</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Freedom House Civil Rights Index</td>
<td>3.874</td>
<td>1.686</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

Our variables to construct our measure of solidarity and geopolitical alignment in this section. Summary statistics for all of our variables are provided in Table 4.1, where we classify our covariates into solidarity and geopolitical variables, main baseline economic variables, other baseline economic variables, those variables that deal with economic stability, and institutional variables.

Our dependent variable, ADF, is the development funding receipts in millions of USD. We have obtained our data on ADF directly from ACG Secretariat. As highlighted earlier in this essay, this direct access makes our dataset unique as it provides a significantly broader coverage compared with a few earlier studies of Arab aid that relied on publicly available data, mainly the OECD database. Another important key variable needed to test our general theory of aid is an index score for measuring solidarity and geopolitical alignment (SPGA), which we shall construct shortly in the subsequent subsection. As will be discussed shortly, nine variables are used in our construction of this index. Regional classification,
such as Arab, Asia, etc. are also collected from the ACG Secretariat. UNGA voting records are obtained from UN database. According to our analysis, major Arab donors, such as Saudi Arabia, Kuwait, and UAE votes very similarly (about 97% of times) at the UNGA. Hence, we compare recipient country’s UNGA voting position with the lead Arab donor, Saudi Arabia. Data on other geopolitical variables, such as diplomatic relations with Israel is from the Ministry of Foreign Affairs of Israel, Muslim and Shia majority (over 50%) is collected from Pew Research Center database, and Organization of Islamic Cooperation (OIC) membership is collected from the OIC website.

Data on human development index (HDI) is collected from the UN database. We obtained our data on real income (in purchasing power Parity), population, inflation, and current account balance (as a percentage of income) from the World Bank database, while trade with Arab donors Saudi Arabia, Kuwait, and UAE (in millions of USD) are collected from the IMF database. Real oil price is collected from the U.S Energy Information Administration (EIA). Institutional variables, such as political rights and civil liberties are collected from Freedom House database.

4.5.2 SGPA Index Development Employing Principle Component Analysis

In the aid literature, the problem of measuring aid motives is difficult. Many variables have been used since the pioneering work of Alesina and Dollar (2000). The variables used in different combination include votes of the recipient countries at the UNGA, religion and ethnicity, language, colonial past, etc. These variables are possibly correlated and individually may be viewed as imperfect measures of aid motives while a composite measure provides more information due to their correlations. Thus, we provide correlation matrix amongst the SGPA variables in Table 4.2. Notably, SGPA variables are strongly correlated. As an example, the percentage of voting at the UNGA with Saudi Arabia is highly correlated being Arab, member of the OIC, not recognizing Israel, and Muslim majority country. Similarly, not recognizing Israel for Muslim majority country and being a member of the OIC is strongly correlated.

Such multi-collinearity issues may lead to incorrect inferences if each of the SGPA
related variables are employed as a stand-alone independent variables in the econometric analysis (Johnston and DiNardo, 1997). Therefore, we resolve this issue by constructing an index score using principle component analysis (PCA). Apart from multicollinearity issue, this index also contains all the information relating to geopolitical and solidarity variables. PCA is a well-known statistical tool that summarizes the information accessible in a multivariate system into fewer dimensions. While the interpretation of estimated principal components (PCs) is speculative, the coefficients obtained from the analysis shows the importance of each of the factors in the composite measure. PCA techniques help us analyze many variables and provide us with a more compact measure by exploiting the pattern of dependence among the variables. Generally, in PCA, the coefficient of all the variables in the composite measure is determined by maximizing the variation among the related variables. This allows extracting the maximum information relating to interdependence among the variables in a multivariate system, which subject to the constraint that the sum of the square of coefficients equals one.

We utilize PCA to calculate the PCs of nine solidarity and geopolitical variables. Since donor interest and solidarity is one of the central interest in this essay, PCA helps us to develop an index that provides us with a single score for all solidarity and geopolitical variables. We call this SGPA index. Similar to previous studies, we could have separately added the SGPA variables in the regression, however, in doing so, we would have lost the impact of interactions (additional information) between all these variables. Further, the overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy statistics is 0.67, which suggests that undertaking PCA is well justified as the correlation among the SGPA variables

Table 4.2. Correlations for SGPA variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>UN</th>
<th>Arab</th>
<th>Africa</th>
<th>Asia</th>
<th>L. America</th>
<th>OIC</th>
<th>Israel (recognition)</th>
<th>MM</th>
<th>SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arab</td>
<td>0.190***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>0.00268</td>
<td>0.169***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asia</td>
<td>0.159***</td>
<td>0.106***</td>
<td>-0.472***</td>
<td>1</td>
<td>-0.291***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>0.108***</td>
<td>-0.169***</td>
<td>-0.252***</td>
<td></td>
<td>-0.246***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OIC</td>
<td>0.179***</td>
<td>0.496***</td>
<td>0.222***</td>
<td>0.246***</td>
<td>-0.264***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Israel (recognition)</td>
<td>0.195***</td>
<td>0.646***</td>
<td>0.0868***</td>
<td>0.258***</td>
<td>-0.206***</td>
<td>0.606***</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Muslim Majority (MM)</td>
<td>0.190***</td>
<td>0.581***</td>
<td>0.0972***</td>
<td>0.356***</td>
<td>-0.289***</td>
<td>0.821***</td>
<td>0.719***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Shia Majority (SM)</td>
<td>0.0683***</td>
<td>0.283***</td>
<td>-0.142***</td>
<td>0.301***</td>
<td>-0.0876***</td>
<td>0.257***</td>
<td>0.523***</td>
<td>0.301***</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: *** p<0.01, ** p<0.05, * p<0.1
PCA results of SGPA variables shows that the cumulative proportion of the variance explained by the first three PCs is 69%. Each of the PCs from 4 to 9 adds less than 10% to the explanation of the variance within the variables. Therefore, these PCs can be classified as relatively unimportant, the significant portion of the useful information about SGPA is contained in the first three PCs. In general, we take the PCs up to Eigenvalue greater than one, apply factor loadings in predicting SGPA score for the dataset, and use it as an independent variable in the subsequent econometric analysis.

4.5.3 Empirical Model and Strategy

The determinants of Arab aid can be described as follows:

\[ ADF_{i,t}^* = x'_{i,t} \beta + \epsilon_{i,t} \]  

(4.5)

where, \( ADF_{i,t}^* \) is the desired level of Arab development funding from the ACG institutions (referred as Arab aid or ADF hereafter), \( x'_{i,t} \) is a vector of covariates, which include SGPA and human capital (among other covariates), and \( \epsilon_{i,t} \) is the usual random disturbance. The desired Arab aid by the recipient country is not observable, rather we observe its actual level (\( ADF_{i,t} \)), i.e. what the recipient actually receives from the donor.

Intuitively, the recipient country has some desired level of funding and recognizes that the funding agency makes decisions based on a number of different variables. Some of these variables the potential recipient country has influence over. For example, the recipient country may be able to signal political alignment through voting behavior in international organizations. This idea suggests the potential for feedback between the actual level of funding and the observed level of the covariates. We can capture this feedback effect through change in alignment and human capital by adding the legged term of the dependent variable, ADF, in equation (4.5). Therefore, we employ a dynamic panel model to estimate the effects of SGPA, as well as human capital (HDI as its proxy), on received Arab aid in line

---

6As a rule of thumb, KMO of 0.5 or higher is acceptable. A formal mathematical analysis of PCA, as well as the result of the PCA, for SGPA variables are available on request.
with Proposition 4.4.1 and Proposition 4.4.2 of our theoretical analysis. Hence, our prime econometric model can be:

\[
ADF_{i,t} = \rho ADF_{i,t-1} + \alpha SGPA_{i,t} + \beta HDI_{i,t} + \sum_{k=1}^{K} \lambda_k x_{k,i,t} + \theta_i + \varepsilon_{i,t} \quad (4.6)
\]

In equation (4.6), \( ADF_{i,t} \) is the amount of Arab Aid received by the recipient country \( i \) at time \( t \). \( ADF_{i,t-1} \) is one-period lagged value of the dependent variable. \( SGPA_{i,t} \) and \( HDI_{i,t} \) is the geopolitical alignment and human capital (that proxies a recipient’s capacity) of recipient country \( i \) at time \( t \) respectively. \( x_{k,i,t} \), for \( k = 1, \ldots, K \), is control variables, which include other variables discussed in Section 4.5.1. Lastly, \( \theta_i \) is the fixed country effects and \( \varepsilon_{i,t} \) is the idiosyncratic disturbance term. We consider various specifications of equation (4.6) in Section 4.5.4, by varying the list of covariates given in \( x_{k,i,t} \) (e.g., baseline variables, other economic variables, Institutional variables, and all covariates) and time periods, to demonstrate the robustness of parameter estimates of interest to the inclusion of various control variables and subsets of data.

If there is a positive feedback effect, the coefficient of the lagged dependent variable \( \rho \) should be positive (i.e., past change in alignment and human capital impacts Arab aid receipts). Based on Proposition 3.3.1 and Proposition 3.3.2 derived from the theoretical analysis presented in Section 4.4, we expect that the more a country is aligned geopolitically and culturally with the major Arab donors, the higher is the likelihood of ADF receipt. Further, the higher a country’s capacity (measured by human development index, HDI), the more ADF it may receive. Since the sources of funds from major Arab donors are their oil revenues, oil prices might explain the variation in ADF. All the other control variables are standard covariates that are commonly used in the literature including income and measures of internal and external economic stability, mainly inflation rate and current account balance as a percentage of income.

As a starting point of our empirical analysis, we estimate equation (4.5) using OLS. While this approach does not account for potentially endogenous effects, it illustrates the general pattern of correlations among our variables of interest. In addition to OLS, we also
use the system-generalized method of moments (GMM) estimator to estimate our dynamic panel model (Arellano and Bover, 1995, and Blundell and Bond, 1998). This estimator yields consistent and efficient estimates by addressing two important econometric problems. First, this approach allows us to control for possible bias due to unobserved country heterogeneity on estimated coefficients when compared with fixed effects estimators. Second, some of our covariates, including some factors in estimating our composite measure of SGPA, are likely to be endogenous. While it seems difficult to find a good instrument for many of these variables, the system GMM estimator helps to solve the endogeneity problem by using a series of internal instrumental variables based on lagged values of the dependent and independent variables that are potentially endogenous (Blundell and Bond, 1998).

In particular, independent variables such as GDP and trade with major Arab donors may be endogenous. The other independent variables are treated as strictly exogenous. Moreover, the system GMM estimator performs better as it uses additional moment conditions when it is compared with the “difference” GMM estimator. This method is much more efficient in small T and large N, which is the case in our dataset where N=147 countries and T=20 years (Roodman, 2009). System GMM also assumes that there is no first-order and second-order autocorrelation in the error terms. Thus, we test for autocorrelation and the validity of instruments using Sargan/Hansen test for over-identifying restrictions. For second-order serial correlation of the differenced error terms, the statistics always indicate that there is no second-order serial correlation and that instruments are not correlated with residuals. Therefore, Hansen J test for over-identifying restrictions loses power when the number of instruments exceeds the cross-section sample size (Roodman, 2009). When the ratio of countries to instruments is lower than one, the estimation procedure may be biased and coefficients may be significant even if there is no statistical association. To overcome this type of possible bias in the results, we control for the relative number of instruments so that this number is never large relative to the number of countries.

Note that in system GMM analysis, the lags of endogenous variables are used as instruments for the difference equation and the lagged differences of the endogenous variables are used as instruments for the level equation. As such, we do not include additional (external) instruments in the analysis.
Finally, we implement two-step system-GMM estimator instead of one-step as it provides asymptotically efficient, robust and reliable results when facing endogeneity, dynamic issue, and heteroscedasticity (Windmeijer, 2005). These measures ensure that the estimated coefficients are not biased by reverse causality and only measures the direct effect of the independent variables on ADF.

## 4.5.4 Main Results

In this section, we present the main empirical results of our analysis. As explained in Section 4.5.3, we first present the results of our analysis using OLS in Table 4.3. For all models in this table, we report robust standard errors as well as results with and without time dummies. Our results for the baseline model, with and without time effects, are in columns one and two, respectively. We take a similar approach when we add the control variables in columns three and four. In columns five and six, we add economic stability variables and provide results with and without controlling for time effects as well.

<table>
<thead>
<tr>
<th>Table 4.3. Results of the OLS estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>Solidarity and geopolitical alignment (SGPA)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Country capacity (HDI)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Log (GDP)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Log (Population)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Trade with Arab donors</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Real oil price</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Inflation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Current account balance</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Time dummies</td>
</tr>
<tr>
<td>Observations</td>
</tr>
<tr>
<td>R-squared</td>
</tr>
<tr>
<td>VIF (Multicollinearity test)</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.
In the first and second columns of Table 4.3, baseline model results are presented. When we control for time effects, our three variables of interest, namely, SGPA, HDI, and log of GDP (income) are statistically significant. In columns three and four, we add control variables, such as population, trade with Arab donors, and real oil price. The coefficients for population and real oil price are significant at the 1% level here. The signs suggest that countries with larger population receives more ADF and allocation of ADF is positively correlated with the real oil price. Furthermore, the coefficient for trade relationship with Arab donors is insignificant throughout, suggesting ADF allocation is not associated with a trade relationship between Arab donors and recipient countries. In columns five and six, we added economic stability variables, such as inflation and current account balance. In these models, while SGPA and HDI are significant, income and population are statistically insignificant, trade with Arab donors continued to be insignificant while real oil price is significant. Besides, the coefficient on inflation is not statistically significant and current account balance is significant at the 1% level and has the expected negative sign. This suggests that the Arab donors may try to assist countries with challenging current account balance positions.

We present our principal results using system-GMM in Table 4.4. In contrast to the OLS models previously reported, these models include the lag of ADF as an independent variable to capture the dynamic impact of the lag of ADF on current year ADF. Moreover, the model also accommodates an endogenous relationship between the dependent variable and SGPA, trade with Arab donors, and income.

Our primary hypothesis, predicted by the theoretical model in Proposition 4.4.1, that ADF is increasing in SGPA index is supported by our empirical results. We observe that the SGPA is statistically significant almost in all our specifications. The relationship between ADF allocation and the human development index, HDI, as a proxy for recipient country, is the second prime variable of interest in this study. Proposition 4.4.2 of our general theory of aid allocation suggests that, for a given level of income, donor countries will allocate more aid to countries with a higher level of human capital. Intuitively, this is because higher levels
Table 4.4. Results of the dynamic system-GMM estimates

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) Baseline</th>
<th>(2) Baseline</th>
<th>(3) Control</th>
<th>(4) Control</th>
<th>(5) Benchmark</th>
<th>(6) Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.ADF</td>
<td>0.89***</td>
<td>0.92***</td>
<td>0.87***</td>
<td>0.89***</td>
<td>0.93***</td>
<td>0.95***</td>
</tr>
<tr>
<td>(0.10)</td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.11)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>Solidarity and geopolitical alignment (SGPA)</td>
<td>47.38*</td>
<td>34.27</td>
<td>52.81**</td>
<td>43.24**</td>
<td>51.64**</td>
<td>37.89*</td>
</tr>
<tr>
<td>(24.88)</td>
<td>(23.23)</td>
<td>(22.93)</td>
<td>(21.11)</td>
<td>(20.64)</td>
<td>(20.60)</td>
<td></td>
</tr>
<tr>
<td>Country capacity (HDI)</td>
<td>470.80</td>
<td>298.87**</td>
<td>877.65</td>
<td>588.01*</td>
<td>2,280.87***</td>
<td>964.51*</td>
</tr>
<tr>
<td>(360.76)</td>
<td>(87.90)</td>
<td>(613.93)</td>
<td>(320.24)</td>
<td>(1,132.39)</td>
<td>(536.25)</td>
<td></td>
</tr>
<tr>
<td>Log (GDP)</td>
<td>-0.56</td>
<td>0.63</td>
<td>-52.65</td>
<td>-32.02</td>
<td>-255.44*</td>
<td>-87.67</td>
</tr>
<tr>
<td>(10.14)</td>
<td>(10.03)</td>
<td>(67.39)</td>
<td>(50.91)</td>
<td>(145.40)</td>
<td>(79.37)</td>
<td></td>
</tr>
<tr>
<td>Log (Population)</td>
<td>125.77</td>
<td>74.50</td>
<td>596.85*</td>
<td>312.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(160.28)</td>
<td>(117.20)</td>
<td>(330.99)</td>
<td>(181.80)</td>
<td>(1.91)</td>
<td>(1.37)</td>
<td></td>
</tr>
<tr>
<td>Trade with Arab donors</td>
<td>-0.00</td>
<td>-0.00</td>
<td>0.00</td>
<td>-0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real oil price</td>
<td>-0.89</td>
<td>-0.23</td>
<td>7.65</td>
<td>-0.35*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3.28)</td>
<td>(0.15)</td>
<td>(5.75)</td>
<td>(0.19)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>0.51</td>
<td>0.31</td>
<td></td>
<td></td>
<td>(0.49)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>Current account balance</td>
<td>0.33</td>
<td>-0.96</td>
<td>(1.91)</td>
<td>(1.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-265.81</td>
<td>-123.05</td>
<td>0.00</td>
<td>-54.62</td>
<td>0.00</td>
<td>182.04</td>
</tr>
<tr>
<td>(190.65)</td>
<td>(82.12)</td>
<td>(291.81)</td>
<td>(396.89)</td>
<td>(1.37)</td>
<td>(1.37)</td>
<td></td>
</tr>
<tr>
<td>Time dummies</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>2,173</td>
<td>2,173</td>
<td>2,173</td>
<td>2,137</td>
<td>1,859</td>
<td>1,859</td>
</tr>
<tr>
<td>Number of countries</td>
<td>125</td>
<td>125</td>
<td>125</td>
<td>125</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td>Number of instruments</td>
<td>74</td>
<td>74</td>
<td>111</td>
<td>94</td>
<td>113</td>
<td>96</td>
</tr>
<tr>
<td>First order (p-value)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Second order (p-value)</td>
<td>0.41</td>
<td>0.39</td>
<td>0.42</td>
<td>0.40</td>
<td>0.44</td>
<td>0.43</td>
</tr>
<tr>
<td>Sargan test (chisquare)</td>
<td>248.94</td>
<td>264.56</td>
<td>263.13</td>
<td>279.14</td>
<td>239.34</td>
<td>267.28</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

of human capital allow each aid dollar to be used more effectively in development projects. Although HDI is not a perfect proxy for human capital, the HDI does correlate strongly with education levels (UN Human Development Report, 2016) and is indicative of an economy where human capital can work effectively with aid to improve development outcomes. In line with our theoretical prediction, the sign for the coefficient of HDI is consistently positive in all our specifications and it is statistically significant in most. Furthermore, the coefficient for HDI variable is also large in magnitude. The coefficient for HDI suggests that a one-point increase in HDI score, increases ADF receipts by about US$878 million, keeping all else constant.

We now present a short discussion on the results for other control variables. Many authors have suggested that development aid should be decreasing in the level of economic development, measured by income (for example, see Easterly, 2003). This implies that in our setup, ADF should be decreasing in log of income and increasing in log of population. While
these expected signs hold in almost all our specifications, they are statistically insignificant, except for model (5). Furthermore, one may expect that trade with donors may have a positive impact on aid receipts. This hypothesis is not supported in the case of ADF in our results. This may be due to the fact that Arab donors are mainly exporting petroleum and poorer countries are not traditionally large buyers of petroleum. This finding is similar to that of Neumayer (2003) in case of Arab donors. However, the effect of this variable may vary amongst donors as Younas (2008) finds that Western donors significantly value trade relationship when it comes to aid allocation.

We also control for real oil price as it the main source of revenue for the major Arab donors. We find the coefficients for real oil price is insignificant and has different signs depending on model specification. However, it is statistically insignificant in most specifications. Therefore, our analysis does not support the hypothesis that a higher price of oil leads to a higher allocation of ADF since the availability of these funds might be correlated the price of oil. However, this result contrasts with the current literature (see Werker et al., 2009).

Turning now to the economic stability variables, namely inflation and current account balance, it may be expected that countries suffering from economic instability are more in need of foreign aid. That is, developing countries that face higher inflation and lower current account balance may receive more aid. The foreign funds that Greece recently received from IMF and Eurozone countries is a good example. In our results, while the economic stability variables have signs consistent with this hypothesis, they are not significant. This is partly consistent with Dreher et al. (2009).

4.5.5 Robustness Analysis

The combined results presented in Section 4.5.4, which is robust in different methodologies and specifications, provide strong support for the predictions from our general theory of aid allocation. In particular, we observe that development funding is targeted towards recipient countries that are (i) aligned geopolitically, culturally, and stand in solidarity with donor countries and (ii) have the required capacity for implementing development projects.
Table 4.5. Results of the dynamic system-GMM estimates with inclusion of institutional variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) Benchmark</th>
<th>Benchmark</th>
<th>(2) Institutional</th>
<th>(3) Institutional</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.ADF</td>
<td>0.93***</td>
<td>0.95***</td>
<td>0.93***</td>
<td>0.95***</td>
</tr>
<tr>
<td>Solidarity and geopolitical alignment (SGPA)</td>
<td>51.64**</td>
<td>37.89*</td>
<td>49.34*</td>
<td>36.95</td>
</tr>
<tr>
<td>Country capacity (HDI)</td>
<td>2,280.87**</td>
<td>964.51*</td>
<td>2,280.20**</td>
<td>1,026.92**</td>
</tr>
<tr>
<td>Log (GDP)</td>
<td>-256.09*</td>
<td>-256.09*</td>
<td>-94.64</td>
<td></td>
</tr>
<tr>
<td>Log (Population)</td>
<td>595.42*</td>
<td>228.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade with Arab donors</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Real oil price</td>
<td>7.65</td>
<td>6.89</td>
<td></td>
<td>-0.35*</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.51</td>
<td>0.47</td>
<td></td>
<td>0.34</td>
</tr>
<tr>
<td>Current account balance</td>
<td>0.33</td>
<td>0.35</td>
<td></td>
<td>-0.84</td>
</tr>
<tr>
<td>Freedom House Political rights</td>
<td>-7.85</td>
<td>-6.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freedom House Civil liberties</td>
<td>11.57</td>
<td>6.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.00</td>
<td>0.00</td>
<td>226.76</td>
<td></td>
</tr>
<tr>
<td>Time dummies</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>1,859</td>
<td>1,859</td>
<td>1,859</td>
<td>1,859</td>
</tr>
<tr>
<td>Number of countries</td>
<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td>Number of instruments</td>
<td>113</td>
<td>96</td>
<td>115</td>
<td>98</td>
</tr>
<tr>
<td>First order (p-value)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Second order (p-value)</td>
<td>0.44</td>
<td>0.43</td>
<td>0.45</td>
<td>0.43</td>
</tr>
<tr>
<td>Sargan test (chi²)</td>
<td>239.34</td>
<td>267.28</td>
<td>240.00</td>
<td>266.84</td>
</tr>
</tbody>
</table>

Note: Robust standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.1.

To ensure that our conclusion with respect to SGPA and HDI holds and to further check the robustness of our econometric results presented in the preceding section, we also provide results of alternative model specifications. We do this by including two institutional quality variables, political rights, and civil liberty, in our benchmark dynamic panel models presented in column (5) and (6) of Table 4.4. The civil liberties score includes considerations, such as fair electoral process, political pluralism and participation, and function of government. The political rights score includes considerations, such as freedom of expression and belief, association and organizational rights, rule of law, personal autonomy, and individual rights. The results of this extension are presented in Table 4.5.

The first two columns provide results from our benchmark columns in Table 4.4 (for comparison purposes) and the second two columns provide results with institutional variables using system-GMM approach. As before, we provide the results with and without controlling for time effects. The results suggest that adding these two institutional quality variables does not change any signs or significance level for the variables discussed in the
earlier section. Nonetheless, this provides alternative evidence that SGPA and HDI are significant in different specifications. Moreover, civil liberties and political rights are not statistically significant.\footnote{We also included these variables in our OLS results (not presented here) and our results of Table 4.5 did not change.}

In terms of the robustness of our econometric models, the system-GMM estimator checks for the validity of the moment conditions through performing the Sargan/Hansen test for over-identification. This is the test for serial correlation of the differenced error term. As can be seen from the corresponding p-values of these tests, reported at the bottom of Table 4.4, the null hypothesis of the validity of instruments cannot be rejected. Furthermore, the first- and second-order serial correlation tests suggest existence of negative first-order serial correlations and no evidence of second-order serial correlation in the differenced error terms.

4.6 Concluding Remarks

Despite substantial political change in the Arab and Muslim world during the past decades, Arab donors have shown consistent support for the Arab world and for other Muslim nations. In this essay, we highlight several stylized facts about the contribution of the Arab donors block in development and develop a game theoretic model of aid allocation consistent with these stylized facts. Our empirical analysis shows results consistent with this model. We find a statistically significant relationship between aid allocations and solidarity or geopolitical alignment using a unique dataset from the ACG. Furthermore, our measure of human capital is found to be an important factor in aid allocation. This result may be due (at least in part) to the fact that most aid funds are given as concessional loans channeled through the ACG institutions (Roui, 2010).

In order to assess whether aid is driven by developmental need or by solidarity and geopolitical alignment (SGPA) (or both), we construct a composite score that measures SGPA using principal component analysis. Then, we show empirically that, in fact, solidarity and geopolitical alignment play a positive and statistically significant role in aid
allocation by the Arab donors. Our econometric analysis also shows that development needs have limited explanatory power. Moreover, our analysis suggests that human capital (country capacity) is an important determinant of aid allocation.

While several studies find trade relationships to be a key determinant of aid from OECD donors, we find little evidence to suggest that Arab donors employ aid as a tool for advancing commercial self-interests. Another interesting finding is that the aid allocation is not affected by volatility in the price of oil. This result stands in contrast to earlier studies, such as Werker et al. (2009).

Our results contribute to the growing literature showing that there is no single factor that drives development aid; there are political, strategic, and other interests at play. All in all, our study suggests that Arab aid from the ACG institutions has three distinctive features: First, it is South-South in nature, as both donors and the recipients are from the developing countries of the South. Second, it is solidarity and geopolitical alignment based. Last but not least, aid is given more to countries having better capacity to implement projects. This latter feature has the potential to make the development interventions impactful.

It is important to highlight several caveats of this study. First, our dataset only captures the Arab aid that is channeled through the ACG institutions. Second, we do not have the breakdown of the amount of aid that is given by the bilateral and the multilateral Arab institutions. Third, we are unable to qualify the funding in terms of funding modality, i.e. grant and concessional loan, which is similar to the concessional terms of IDA-type funding provided by the World Bank. An analysis based on the nature of the institutions and funding modality could be a fruitful avenue for future research.
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<td>Cabo Verde</td>
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REFERENCES


Easterly, W. and Easterly, W.R. (2006). *The white man’s burden: why the West’s efforts to aid the rest have done so much ill and so little good*. Penguin.


CHAPTER 5
SUMMARY AND CONCLUSIONS

This dissertation contributes to a better understanding of the political economy of natural resources and economic development in the form of political influence either on the host country or externally on another country, in the form of political influence.

The first essay analyzes the relationship between fossil fuel share in the energy mix and economic development using an unbalanced panel consisting of 151 countries from 1971 to 2013. Although there is a rich literature on CO\textsubscript{2} emissions and economic growth, little attention has been paid to study the relationship between fossil fuel share in the energy mix, which is the driving force behind energy-related CO\textsubscript{2} emissions, and economic development.

The central contribution of this essay is to illustrate an inverted U-shaped relationship between fossil fuel share in the energy mix and economic development, using real income as its proxy. While parametric estimates, such as fixed and random effect methods, provide mixed results that are sensitive to model specification, more robust nonparametric kernel regression and local linear regression, which are immune to model misspecification issues, supports the existence of such a relationship.

As Paris Agreement is being implemented to counter the challenges of climate change by putting an emphasis on reducing fossil fuel consumption globally, this essay contributes to the discussion related to country-level reduction targets. Particularly, it provides evidence that historically, there is a reduction of fossil fuel share in the energy mix when real income per capita of a country reaches around US$16,000. China, the leading country in terms of CO\textsubscript{2} emissions, has already reached this level of economic development. India, the other major polluter, has only real income per capita of US$6,000 far from reaching that threshold. In the global policy context, the results of this essay’s analysis calls for a discussion on phasing out the use of fossil fuel in countries like China. The analysis also suggests that a number of fossil fuel producing countries, such as Australia, Canada, Germany, and Saudi
Arabia already have surpassed the said economic development threshold, and may need to take appropriate policy decisions to reformulate their energy mix with more sustainable sources like wind and solar.

The second essay of this dissertation presents a theoretical and empirical analysis of the foreign direct investment’s (FDI) effect on the risk of violence in Sub-Saharan Africa (SSA). Being a resource-rich region, SSA receives much of its FDI inflows into the natural resources sector. On the other hand, this region also faces substantial risks of violence and social conflicts.

This essay makes a significant contribution to the economics of violence by addressing the validity of the claim that FDI may cause civil unrest and violence through providing both theoretical and empirical analysis. By presenting a new general equilibrium theory of FDI, this essay demonstrates how FDI may influence the risk of violence in resource-rich countries. Particularly, if FDI inflow is used in skilled-labor intensive natural resources sector (i.e. fuel), it reduces the risk of violence. In contrast, an inflow of FDI into unskilled-labor intensive sector (i.e. mining) may increase the risk of violence. For empirical evidence, this essay utilizes a dataset of 34 countries in SSA during 1972 to 2013 in a dynamic panel setup. The empirical results, using system generalized method of moments estimation, are in-line with the theoretical model’s findings.

The correlation between FDI and violence has far-reaching policy implications, including the following three. First, the results of our analysis support policymakers in SSA countries, such as Ghana, Kenya, Mozambique, Tanzania, and Uganda, who are making policy shifts by encouraging FDI in their newly found oil and gas sector. Second, our results encourage development partners and foreign investors to extend additional funding for developing the much-needed infrastructures of SSA, particularly the ones supporting oil and gas sector. Third, specialized institutions that provide investment insurance to the foreign investors and multinationals, such as the Multilateral Investment Guarantee Agency (MIGA) of the World Bank and the Islamic Corporation for Insurance of Investment and Export Credit (ICIEC) of the Islamic Development Bank Group, may find the results of our
analysis supportive for providing foreign investors, particularly in oil and gas sector of SSA, investment insurance (which includes political risk insurance) at a lower premium. Such initiatives would make a contribution in supporting the UN 2030 Development Agenda for SSA, as well as the much longer-term development framework for Africa (Agenda 2063) by the African Union.

Lastly, the third essay of this dissertation explores the political economy of aid allocation by the Arab donors. This study aims to assess whether aid allocation is driven by developmental needs or by solidarity and geopolitical alignment or both. In doing so, the essay first presents a theoretical model, which suggests that there exists an increasing relationship between donor’s aid allocation and the solidarity and geopolitical alignment of the recipient country. The model also predicts that donors allocate more aid to recipient countries with higher levels of human capital. These predictions are empirically tested using a unique dataset on aid allocation by major Arab donors. The results of the empirical analysis strongly support the theoretical model’s predictions. Furthermore, the analysis suggests that the major Arab donors do not employ aid as a tool for advancing commercial self-interests. Another interesting finding is that the aid allocation is not affected by volatility in the oil price, suggesting the consistency of Arab donors’ support to the developing countries.

This study makes a compelling contribution to the foreign aid literature by drawing some important insights from analyzing Arab aid allocation. First, Arab donors have been persistent in their support for the Arab world and other Muslim nations, as well as other developing nations. Second, they provided a larger aid envelope to the countries who are geopolitically aligned and has a higher level of project implementation capacity. This is a very important feature of the Arab aid as it renounces the arguments of the critics that Arab aid is politically-motivated.

To conclude, the advent of Arab (and other non-OECD DAC) donor countries is changing the entire aid landscape. These new donors are providing additional financial resources that are funding urgent and emerging binding constraints faced by the neediest develop-
ing countries. Prime concerns of recipient countries have traditionally been aid volume, predictability, and easiness in the administration (utilization) of aid. New donors, such as the Arab block, appear to be strongly aligned to both. Another policy implication is country ownership. There is no denying of the fact that conditionalities by the traditional donors of the “North” have at times undermined a recipient country’s sovereignty in terms of not having the leeway to determine its own financing requirements and priorities. Non-traditional donors do not impose such conditionalities, though they have not been spared of criticism either. Ironically, the criticisms have come mainly from the very traditional donors and their attendant institutions. Furthermore, technology and expertise provided by non-OECD DAC countries appear to be more relevant and adaptable, given the similarities in socioeconomic conditions.
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Education
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I joined the IsDB as a Young Professional and served in different capacities including Country Economist and most recently, as Senior Country Programs Manager overseeing IsDB’s interventions in South Asia. My key responsibilities included managing IsDB’s Field Offices in the region, implementing country strategies and development project portfolio, and undertaking meaningful policy dialogues with competent Government authorities, such as Cabinet Ministers, Director Generals, Central Bank Governors, and Senior Bureaucrats.

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