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THREE ESSAYS ON ECONOMIC DEVELOPMENT AND ECONOMIC GROWTH

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Abstract

My dissertation chapters focus on economic development and economic growth. Chapter 1 investigates the effects of bilateral FDI flows on host countries' productivity growth as well as on the productivity gap between host countries and the frontier country - USA. Using bilateral FDI flows data from 240 countries over 1990-2012, and employing fixed effects, 2-step GMM, and instrumental variable estimation methods, the empirical results show that there is no significant effect of bilateral FDI flows on either host countries' productivity growth or on the productivity gap between host countries and the frontier country. There tends to be no significant effects of FDI on either host countries' productivity growth or the productivity gap between host countries and the frontier. After decomposing the effects of FDI, we find FDI tends to promote host countries' human capital growth, but only for South-South countries. No evidence shows FDI has any impact on either labor productivity or TFP by sector.

Chapter 2 uses spatial analytical skills to investigate aid effectiveness and aid spillovers at the sub-national level in Sub-Saharan Africa over the period 1995-2013. The previous literature examines aid-growth relationship and gets mixed results. One reason of the conflicting conclusions is that it suffers from the so-called "aggregation bias". By using geocoded aid dataset and night lights data as proxy for economic activities, I am able to reveal more detailed pictures of aid effectiveness at different aggregate levels. Overcoming the potential simultaneity problem, I find that aid targeted at the local level tends to promote local economic growth, while aid received at more aggregate levels depresses local economic activities. One possibility is that more specifically targeted aid tends to be less fungible compared to "general" aid, while aid

generally given to a more aggregated level is more likely to be misappropriated for other purposes, thus creating rent-seeking opportunities to cause corruption and hurt institutional environment. There exist positive spillovers of aid effectiveness across adjacent neighbors at the local level, probably due to total factor productivity improvement, technology and knowledge dissemination, and income effect. Aid at the local level promotes total economic flourish and slows down population growth, while aid at more aggregate levels depresses total economic activities but stimulates population growth. Aid directly received at all levels exhibits diminishing returns, which is consistent with the theory that aid directly stimulates investment and adds capital accumulation. While aid spillovers show weak increasing returns, which suggests the spillover effects partly function through technology and knowledge dissemination. As to the conditional aid effectiveness, no systematic story is found that aid is effective conditional on policy or institutions, probably due to data limitations that local policy and institutions data are unavailable in Sub-Saharan Africa. The findings have very profound policy implications that to promote local economic growth, we should focus more on specifically targeted and less-fungible aid projects rather than aid generally given to governments at more aggregate levels; also we should reduce barriers to resource movements and knowledge dissemination within the country to promote positive spillover effects.

Chapter 3 uses geographic information systems (GIS) skills to test the effects of foreign aid on conflict occurrences and fatalities at local level in Sub-Saharan Africa. Using lagged aid variables as the instruments for current aid, negative relationship between current aid and future conflict is detected. Aid is effective to deter conflict when conflict events happening in short period or particular types of conflict events are under way. Income per capita, with night lights per capita as proxy, has non-linear impacts on conflict occurrences. Foreign aid can alleviate conflict and help Sub-Saharan countries to jump out of the low-income-conflict trap.

Chapter 1: Bilateral FDI, Productivity Spillovers and Growth Decomposition

1.1. Introduction

There have been numerous studies exploring the spillover channels through which economic exchanges between countries affect their productivity. Theoretically speaking, cross-border economic activities such as trade and investment flows or labor migration can affect involving countries' production efficiency, gains from economic activities, or even long-run balanced growth path.

Foreign direct investment (FDI) is one of those activities. Through foreign companies' investment activities, host countries may boost their production capabilities. The transmission of advanced technology, organizational patterns, managerial skills and know-how may accompany the FDI flows from home to host countries. The question we are interested in this article is to explore whether FDI inflows have any effects on host countries' productivity growth.

The majority of previous literature focuses either on aggregate FDI flows or foreign investment at the micro level. In this article, we pay attention to the effects of bilateral FDI flows on host countries' productivity dynamics at the macro level, a topic rarely investigated before. Also, since the effects of FDI may depend on the country types, we distinguish home and host countries along the North (i.e. developed countries) and South (i.e. developing countries). By separating the FDI effects between different country-type pairs, we provide a more nuanced picture about the spillover effects of FDI.

We find that bilateral FDI inflows have no significant effects on either host countries' productivity growth or the productivity gap between host countries and the frontier country. To gain a better understanding about the impact of FDI, we decompose the effects of bilateral FDI flows into physical capital growth and human capital. The results show there tends to be no significant effects of FDI on either host countries' productivity growth or the productivity gap between host countries and the frontier. After decomposing the effects of FDI, we find FDI tends to promote host countries' human capital growth, but only for South-South countries. No evidence shows FDI has any impact on either labor productivity or TFP by sector.

The rest of the paper is organized as follows. Section 2 introduces the literature review. Section 3 describes the data, empirical model and estimation methodology, and presents the empirical results. Section 4 introduces the robustness analysis. The decomposition analysis is displayed in Section 5 and the final section concludes.

1.2. Literature Review

The research on productivity spillovers has grown significantly since the 1990s, following closely the surge in global trade and financial flows during this period. The findings of this literature however, are quite heterogeneous. Among the possible channels, one strain of literature focuses on productivity spillovers through international trade. Madsen (2007) and Alcalá and Ciccone (2004) both find trade has large and significant effects on productivity growth and productivity convergence. The former attaches importance to knowledge transmission by international trade and the latter finds the international trade can increase total factor productivity (TFP). Likewise, there has been significant work exploring how research and development (R&D) activities can affect different economies' relative productivity dynamics (Coe and Helpman, 1995; Pottelsberghe de la Potterie, 1998; Keller, 1998; Engelbrecht, 1997). R&D capital is accumulated by R&D activities, just like FDI inflows can stimulate the accumulation of physical capital. Both of R&D and FDI activities can spur technological advances and knowledge dispersions in the host countries.

Most of the evidence on FDI productivity spillovers is based on micro level studies - either firm level or industry level, especially in manufacturing. As Devarajan, *et al*. (2001) point out, manufacturing technology is "closer to being universally available" within one country and it is not likely to be affected by natural forces, which makes it a primary candidate for productivity spillover investigations. Also, studies on productivity spillovers and FDI at micro level may provide some insights for macro level investigations, since under some conditions or assumptions, economic activities at micro level can be scaled up to macro level. Keller and Yeaple (2003) study trade and FDI related technology spillover effects among manufacturing firms in the United States over 1978-1996, and find that FDI accounts for a significant share of productivity gains while trade takes only a smaller part. Haddad and Harrison (1993) focus on manufacturing firms' productivity in Morocco and find evidence that sectors with more foreign firms tends to have a smaller productivity dispersion, casting doubts on the subsidy policies granted to foreign firms, in the hope that foreign firms can bring advanced technology to domestic firms. Kokko *et al*. (1996) analyze changes in the technological gap between domestic firms and foreign firms in the Uruguayan manufacturing sector in 1998 and find the only firms with moderate technological gaps with foreign counterparts enjoy positive and statistically significant spillovers, suggesting that FDI spillover effects are conditional on the technology gap between domestic and foreign firms. As such, the potential for spillovers between, for example, developing and developed country multinationals may be severely limited. Generalizing their conclusion to the macro level, we may argue that the gains from bilateral FDI become significant only when the host and home countries are not very different in terms of income levels or technological advancement, which is an empirical testable hypothesis. To this end, Barrios and Strobl (2002) use Spain's accession to EU as a natural experiment to evaluate the FDI on productivity spillovers. Spain used to be characterized as a low productivity country before joining EU and since then, has attracted large amounts of FDI. They find that Spanish firms only with adequate absorptive capacity enjoy positive spillover effects.

As to FDI spillovers at the macro level, most of the previous literature investigates the effects of FDI on economic growth. Balasubramanyam *et al*. (1996) test the effects on growth in developing countries with different trade policies and find that FDI tends to have stronger effects on countries with outward-oriented policies than with inward-oriented trade policies. Borensztein *et al*. (1998) point out that FDI can promote economic growth only when the host country's human capital passes a certain threshold, suggesting that the host country should have a sufficient absorptive capability to digest the advance technology brought by foreign firms. Choe (2003) shows that FDI Granger-causes growth and growth also Granger-causes FDI, but the results are more apparent from the direction of economic growth to FDI. Li and Liu (2005) find that FDI and economic growth have an increasingly endogenous relationship – FDI can promote growth, and the increased economic activities may attract more FDI to flow in. Doytch and Uctum (2011) use country-level data and find that manufacturing FDI tends to increase economic growth in most of countries while service FDI may spur service sector's growth but is likely to hurt manufacturing industries.

We argue that FDI is like a "composite bundle of capital stocks, know-how, and technology" and therefore, its effects on growth should be "manifold" (De Mello Jr, 1997). FDI inflows can promote capital accumulation to increase economic growth, but we are interested in the "absorption" effects: after removing its effects on resource accumulation, how FDI can promote productivity in host countries? In other words, what we explore in this article is the growth effects generated by the increase in productivity.

Surprisingly, there has been only limited work done on FDI and productivity spillovers at the macro level. Kawai (1994) argues that productivity change is important to explain the growth patterns in developing countries; trade policies, productivity gap and macroeconomic stability may affect total factor productivity. De Mello Jr (1999) analyzes panel data over 1970-1990 and finds that FDI can boost growth in the host country by technological upgrading and knowledge spillovers, and the net effects of FDI on TFP depends on country-specific factors.

Most of the above literature focuses on aggregate FDI and related factors, and there have been only few studies using bilateral rather than aggregate FDI. To our best knowledge, there has been no previous literature on the effects of bilateral FDI on the productivity spillovers at macro level, and this article is the first one to target this topic. Using bilateral rather than total FDI allows us to take home countries' characteristics into consideration, and analyze whether FDI from different home countries could have differential effects on host countries' productivity dynamics.

We believe the spillover effects of FDI inflows depend on the type of both host and home countries. Amighini and Sanfilippo (2014) analyze the export upgrading of African countries and find FDI inflows from South countries have different impact from North countries. Schiff and Wang (2008) investigate the trade-related technology diffusion and find that the effects also depend on whether the home country is a Northern country. Johnson (2006) places importance on host countries, and finds FDI tends to promote economic growth in developing countries but not developed countries. Dutt (2012) analyzes South-South and North-South interactions, and points out that there exist considerable intrinsic differences between the North and the South in terms of technology adaption, income elasticity of demand, sectoral structure of goods and services and other aspects. He also suggests that the South-South interactions (including emerging South) are not sufficient to serve as an engine of growth, and Southern countries still need interactions with the North, especially for technology transfer and markets. Bahar *et al* (2014) argue that technology diffusion decays with distance, and countries similar to each other are likely to do a better job in absorbing knowledge from each other. In consequence, we believe whether a country from the North or the South tends to affect its interaction with other countries, and the similarity between host and home countries is also important for technology transfer and knowledge diffusion. The exact effect of FDI flows for different country-type pairs is an empirical question which will be tested in the following chapters of this article. Here, we just want to mention that we distinguish the effects of different types for both host and home countries to investigate the impact of FDI flows on South-South (S-S), North-South (N-S), South-North (S-N) and North-North (N-N) countries.

Defining Northern and Southern countries is not a quite straightforward task. Based on the previous literature, we argue that compared to Southern countries, Northern countries have higher income, better technology, higher educational levels and more advanced managerial skills, so that FDI flows from Northern countries are supposed to bring advanced technology, managerial skills, and know-how, which are conducive to host countries' productivity growth. After comparing the existing country group definitions, we find the often-used "high-income OECD countries" classification fits the above features. However, many of the newly existing definitions including the ones from the World Bank and the International Monetary Fund (IMF) define Northern countries based on current economic performance. Since our data span is 1990-2012, we want our selected Northern countries to be representative over the whole time period. We take the insights of the definitions from the World Bank and IMF, also Aykut and Ratha (2004), Aleksynska, Havrylchyk (2013) and the United Nations Conference on Trade and Development (UNCTAD), to create our own Northern country group. In the robustness check, we will use some alternative classifications to test whether our findings are sensitive to the definitions of Northern and Southern countries.

1.3. Empirical Analysis

1.3.1. Model Speciation and Estimation Methodology

We explore the effects of bilateral FDI on productivity growth dynamics using equation (1) below, which is based on Doytch and Uctum (2011), Bwalya (2006), Borensztein et al (1998), Choe (2003), and Balasubramanyam *et al* (1996):

$$Prodgrowth_{i,t} = \alpha * \ln income_{i,t-1} + \beta_1 * FDI_{i,j,t-1} + \beta_2 * North_i * FDI_{i,j,t-1} + \beta_3 * North_j * FDI_{i,j,t-1} + \beta_4 * North_i * North_j * FDI_{i,j,t-1} + \gamma' X_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \qquad (1)$$

where $Prodgrowth_{i,t}$ refers to the growth rate of country *i*'s productivity in year t, and ε is the error term.

$FDI_{i,j,t}$, which is our main focus of interest, is FDI inflows from country *j* to country *i* as a share of country *i*'s GDP over time *t*. As is the general practice, we normalized FDI by host country's GDP to correct for size and scale difference between host countries and FDI flows. We follow the conventions and use the order home-host countries as the country pair in which FDI inflows from home country to host country. In this model, the impacts of FDI flows on host countries' average productivity growth for S-S, N-S, S-N and N-N country pairs are β_1, $\beta_1 + \beta_3$, $\beta_1 + \beta_2$, and $\beta_1 + \beta_2 + \beta_3 + \beta_4$, respectively. Since there is no previous literature about this topic to give us insights for result expectations, we leave it an open question and will give our results in the following subsections. We will also discuss the measurement of productivity more in depth later in this section.

$lnincome_{i,t-1}$ is the logarithm of GDP per capita in country *i* in year *t-1*, a proxy for initial income. The parameter α shows the effects of the lagged income level on the growth rate of TFP. We may expect richer countries are better at promoting productivity, but countries lagged behind may have the advantage of catching up so probably they enjoy fast productivity growth in the transitory period.

$X_{i,t}$ is a vector of country i's characteristics, including:

Inflation rate, measured by the percentage change of GDP deflator. High inflation rate may cause distortions and create inefficiencies in resource allocation, harming economic growth as well as productivity (Fischer, 1993; Bitros *et al*, 2006). But Kumar *et al* (2012) find only limited effect of inflation on sectoral productivity in Australia from 1965 to 2007. Likewise, Freeman and Yerger (2000) show there is no consistent relationship between inflation and productivity in 12 OECD nations over 1954-1996. Therefore, the expectation of inflation's impact on productivity growth is not very clear.

Openness to trade, measured by the sum of import and export as a share of GDP, reflects how open a country is to the rest of the world in terms of trade. Miller and Upadhyay (2000) find that higher openness tends to increase productivity. Similarly, Edwards (1998) using data from 93 countries over 1960-1990, shows that higher productivity growth is associated with more open countries. However, Rodriguez and Rodrik (2001) find little evidence that open trade policy promotes economic performance. Therefore, the impact of openness on productivity is still an open question.

Government consumption as a share of GDP is usually used as the measure of government size, which may affect the resource allocation between private and public sector as well as government policies. Increasing public sector size may cause inefficiencies and create distortions to the market. Peden and Bradley (1989), for example, find that increased government size is associated with reduction in economic performance. However, Ram (1986) shows there tends to be a positive relationship between government size and productivity among 115 countries, perhaps due to the "externality" and "crowding-in" effects of government sector on the rest of the whole economy. The effect of government size on productivity is an empirical question and needs to be investigated.

The share of domestic credit to private sector (as % of GDP), a proxy for financial development, is a measure for financial resources given to the private sector. Guillaumont Jeanneney *et al* (2006) investigate productivity in China and find financial development has significant contribution to productivity growth. Alfaro *et al* (2004; 2009) investigate the indirect effects of financial development on productivity, pointing out that only with well-developed financial markets, FDI is beneficial to economic performance and total factor productivity. Therefore, we expect financial development has a positive effect on productivity.

In order to estimate Eq. (1), probably the simplest method is to use pooled OLS as suggested by the standard econometric textbooks, which assumes homogeneity among countries over time (Greene, 2011; Cameron and Trivedi, 2005). However, this assumption is subject to specification error and fails to take country-specific characteristics into consideration. The omitted variable and potential endogeneity problems may lead to biased estimates. Therefore, we choose to add fixed effects to control for the unobserved country-specific time-invariant and time-varying effects, and use the IV method for the potentially endogenous variables. In this specification, we used the lagged FDI (in years *t-2* and *t-3*) as instruments for FDI in year *t-1*.

Since the further lagged FDI variables are used as instruments for lagged FDI, we should test whether the instruments are: (i) valid, being orthogonal to the error term, and (ii) not weak, being able to explain the variation of lagged FDI based on some statistical criteria. The validity of instruments is tested by the over-identification test, which checks whether the model is correctly specified. The weak instrument issue is tested by Cragg-Donald Wald F-statistic (where the null hypothesis the chosen variables being weak instruments). Stock and Yogo (2005) has put forward the critical values under different criteria or using different parameters, which can be used as reference whether the F-statistic is large enough to reject the null hypothesis.

The specification (1), however, does not allow us to test whether FDI flows help stimulate convergence between host countries and the productivity frontiers. Particularly speaking, whether FDI inflows shrink or widen the productivity gap between host and frontier countries is an issue that remains unanswered. Therefore, to investigate this question, we extend equation (1) using the following specification:

$$\ln\left(\frac{A_{i,t}}{A_{j,t}}\right) = \alpha * lnincome_{i,t-1} + \beta_1 * FDI_{i,j,t-1} + \beta_2 * North_i * FDI_{i,j,t-1} + \beta_3 * North_j * FDI_{i,j,t-1} + \beta_4 * North_i * North_j * FDI_{i,j,t-1} + \gamma' X_{i,t} + \delta_{ij} + \delta_t + \varepsilon_{i,t} \qquad (2)$$

where $\ln\left(\frac{A_{i,t}}{A_{j,t}}\right)$ is the relative productivity level of the country *i* compared to country *j*. The βs indicate whether there is productivity convergence between the two countries. In the following regressions, we investigate the impact of FDI inflows on relative productivity between host country *i* and the frontier country USA. In the robustness check, we also use the weighted average of G-7 countries as the productivity frontier.

1.3.2. Measurement of Total Factor Productivity

Productivity is usually interpreted as the ratio of output to input. To increase total output, one has to increase either input (accumulation) or productivity or both, and the former represents the movement along the same production function curve while the latter refers to the shift of the production function. This paper investigates whether the inflows of FDI can lead to spillover effects on host country's productivity. One reason why this paper uses productivity rather than growth is that it is more closely related to new technology innovation or adoption (Eaton and Kortum, 1996). One problem for using productivity is that there are different measurements of productivity and they can lead to different results even if used in the same empirical test. In applied macroeconomic analysis, productivity can be measured in multiple ways (Bernard and Jones, 1996): (i) labor productivity, measured by GDP per capita or per worker; (ii) total factor productivity (TFP), measured by Solow residual; (iii) total technological productivity (TTP). TTP shows which country can produce more if granted the same amount of inputs. Since TTP is usually not directly comparable and depends heavily on the production function's form, this paper uses TFP as the main measurements of productivity.

However, TFP can be more than technology advancement. Hulten (2001) summarizes the rich literature of TFP and points out that TFP can also be organizational innovation and improvement in efficiency (which are wanted), and measurement error and omitted variables (which are unwanted). This measurement of our ignorance cannot be better solved at this time, and we accept TFP as the proxy for the "wanted" aspect – technology advancement, organizational innovation and other forms in efficiency gains.

The traditional way of calculating TFP is the growth accounting (Hulten, 2001). The idea of growth accounting is using the overall growth minus the share due to the increase of inputs, so the residual is viewed as the growth part due to technology advancement. There is lots of criticism of growth accounting, because it requires strong assumption of perfect competition, payment to each input by its marginal product, and correct specification of production function, which seem not so realistic in the real world. However, since growth accounting is still a widely used way of calculating TFP, and it is easy to compare with other studies about productivity spillovers, growth accounting is used in this paper as the primary way of calculating TFP.

The starting point is to assume the form of the general production function. Some simplifying assumptions are applied for the convenience of computation in the previous literature. First, the technology advancement is Hicks neutral, so that it can be separated from the inputs variables. Second, the inputs market is competitive and each input is paid by its marginal product, so that we do not need to calculate output elasticities and can use the income shares of the inputs instead. The general production function has the form:

$$Y_{i,t} = A_{i,t} * K_{i,t}^{\alpha} * (L_{i,t} * H_{i,t})^{\beta} \qquad (3)$$

$Y_{i,t}$ is the total output, and $K_{i,t}$, $L_{i,t}$ and $H_{i,t}$ are capital, labor and human capital in country i at time t. $A_{i,t}$ is believed to be the technology level at time t, which is the variable of interest – TFP. The coefficients α and β are the income shares of capital and labor, respectively. In this production function, α and β vary across countries and across time[1]. Under the assumption of constant returns to scale, $\alpha+\beta=1$.

We can transform it by taking the logarithmic differential of the above function. We follow Griffith *et al* (2004) and Cameron *et al* (2005) to use the superlative index based on the translog production function. One of the biggest advantage of the translog production function is that it allows for more flexible elasticities. The superlative index is developed by Diewert (1976), and a functional form being "superlative" means that there exists second-order approximation to a twice differentiable linearly homogenous function. The superlative index has been widely used to investigate production, cost or utility functions, and it can approximate any of these smooth functions. Törnqvist index is a widely-used superlative index, which uses the average value shares in the consecutive periods as weights. In this article, we use the average income shares between period *t* and *t-1* as the proxy for output elasticities to calculate the growth rate of TFP at *t*.

$$\Delta lnY_{i,t} = \Delta lnA_{i,t} + \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right) * \Delta lnK_{i,t} + (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right)) * \Delta lnL_{i,t} + (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right)) * \Delta lnH_{i,t} \qquad (4)$$

To get the growth rate of $A_{i,t}$, we subtract the growth rates of capital and labor from the total output growth, and the residual is the so-believed TFP[2].

[1] We also follow the standard assumption and make α equal to 2/3 and β 1/3, and find the results are highly correlated with the baseline specification.

[2] Some articles such as Van Beveren (2012) use other estimations to calculate firm's TFP, such as IV and GMM, because firm's inputs are endogenous and depend on firm's characteristics such as efficiency, there is entry and exit of firms to make attrition or selection bias problem, and there might be omitted price bias for inputs and outputs. These considerations are not likely to be relevant of or not big concerns of macroeconomic TFP calculations at country level. So this article follows the previous literature to use growth accounting instead of other estimations.

$$\ln\left(\frac{A_{i,t}}{A_{i,t-1}}\right) = \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right) * ln\left(\frac{K_{i,t}}{K_{i,t-1}}\right) - (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right)) * ln(\frac{L_{i,t}}{L_{i,t-1}}) - (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{i,t-1}\right)) * ln(\frac{H_{i,t}}{H_{i,t-1}}) \quad (5)$$

The above equation defines the relative productivity of country *i* at time *t* compared to its previous period. Also, we can follow Cameron *et al* (2005) to get the relative productivity of county *i* compared to another country *j* at some time period *t*:

$$\ln\left(\frac{A_{i,t}}{A_{j,t}}\right) = \ln\left(\frac{Y_{i,t}}{Y_{j,t}}\right) - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{j,t}\right) * ln\left(\frac{K_{i,t}}{K_{j,t}}\right) - (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{j,t}\right)) * ln(\frac{L_{i,t}}{L_{j,t}}) - (1 - \frac{1}{2} * \left(\alpha_{i,t} + \alpha_{j,t}\right)) * ln(\frac{H_{i,t}}{H_{j,t}}) \quad (6)$$

In this equation, we use the average income shares of country *i* and *j* at *t*. In Griffith *et al* (2004), the relative TFP are calculated in comparison with the geometric mean of all countries' productivity levels, and then the difference of the relative TFP levels between country *i* and *j* are computed as TFP gap. The idea behind the two methods is very similar, except that the latter has a common comparison point and so the relative TFP are transitive. The relative levels of TFP between two countries allows us to investigate the possible productivity convergence.

1.3.3. Data

The majority of bilateral FDI data come from the Organisation for Economic Co-operation and Development (OECD) and the United Nations Conference on Trade and Development (UNCTAD). OECD data set has bilateral FDI information between North-North, North-South and South-North countries over 1990-2012. UNCTAD dataset includes bilateral FDI for both North and South countries over 1990-2012. To merge the two datasets, we give the priority to OECD dataset since we believe the developed countries have better capabilities of collecting and organizing data; for

UNCTAD dataset, the FDI inflow from country *j* to country *i* should be equal to the FDI outflow from country *j* to country *i*, and we follow the host country first if they are not equal. The bilateral FDI data have been normalized as a share of the host country's GDP.

For TFP calculation, we use GDP data in constant 2005 US dollars from the World Development Indicators (WDI), total labor force from WDI, human capital as the years of schooling and returns to education, and labor income shares from the Penn World Tables (PWT), and gross capital formation in constant 2005 US dollars from WDI. We also use alternative capital data sources such as capital stock at current PPPs in constant 2005 US dollars from PWT, and find the calculated TFPs are highly correlated with our initial results. To preserve the most observations, we use gross capital formation data from WDI.

Figure 1 displays FDI flows as a share of host countries' GDP categorized by country-type pairs. We can see there exists big variation in S-S vs. N-S groups. One reason for this pattern is that some Southern countries have relatively smaller economic sizes, so moderate amounts of FDI inflows may lead to significant ratio of FDI to their GDP. Northern home countries invest a bigger share in both Southern host countries and Northern host countries, indicating the North is the major source of FDI outflows. Bigger fluctuations and more points are observed in later years than in the earlier year, indicating potential missing FDI values as time goes back to the beginning of our time period. Figure 3 shows the numbers of observations for bilateral FDI flows by year, which shows the unbalanced panel structure and there are only a few observations in the earlier years. We leave the potential sample selection problem to the robustness check in Section 4.

Figure 2 shows the scatter plots for TFP growth rates in South and North countries, respectively. The TFP growth rates of both country groups are around 0%, but there is a higher variation among Southern than Northern countries.

Country characteristics are taken from various sources. Import and export as a share of GDP, inflation rate, government consumption as a share of GDP, and the share of domestic credit to private sector are from WDI.

Table 1 shows the main data sources for the main variables and Table 2 gives summary statistics of the data.

1.4. Empirical Results

1.4.1. Baseline Empirical Results

Table 3 and Table 4 show the baseline regression results for equation (1) and equation (2), respectively. We introduce both country and year fixed effects to control the country-specific and time-specific effects. The p-value of Hansen over-identification test and Cragg-Donald F statistic are large enough in all the specifications to justify the instruments are valid and not weak at traditional significance levels.

In Table 3, we use fixed effects in the first four columns and 2-step GMM in the last four columns. In columns (1)-(2) and (5)-(6), we just use the FDI as a share of the host countries' GDP and do not consider any country type. While in columns (3)-(4) and (7)-(8), we distinguish the country-type pairs and estimate the impacts of FDI flows on host countries' productivity growth for S-S, N-S, S-N, and N-N pairs, respectively. Country characteristics are included in Columns (2), (4), (6) and (8). The first column displays the results of a stripped-down model, without taking into account country type or any country characteristics. The lagged FDI inflows are positive but insignificant at conventional levels. Host countries' lagged income has a positive and very significant effect on its current productivity growth, indicating richer host countries are better at promoting productivity growth. Column (2) introduces host countries' characteristics. Lagged FDI inflows still have positive but insignificant effect, and the coefficient of initial income is positive and significant at 0.01 level. Inflation rate is negative but not significant, indicating weak evidence showing higher inflation rate is associated with lower productivity growth. Openness to trade is negative and significant at conventional levels, which means after controlling for other factors, openness tends to harm productivity growth in host countries. The negative effect is not consistent with much of the previous literature (Harrison, 1996; Miller and Upadhyay, 2000). However, there are also some empirical studies showing the relationship between openness and productivity or economic performance is not conclusive (Edwards, 1998; Rodriguez and Rodrik 2001)[3]. As a result, we may not feel very surprised about the possible negative signs here[4]. Government consumption as a share to GDP has no significant effect on productivity growth. Domestic credit to private sector has positive and highly significant impacts, indicating better financial development in the host country tend to promote its productivity growth after controlling for other variables. However, the coefficients of country characteristic variables should be interpreted with caution. First, some of the previous literature tests the impacts of these characteristics on economic performance by using different model specifications. When we are adding additional

[3] For example, Rodriguez and Rodrik (2001) claim that openness may not serve as an adequate proxy for policy considerations and may be prone to measurement error.
[4] We also exclude the openness to trade in the regressions and get essentially the same result.

variables into our model, if the new variables are correlated with our characteristics, the coefficients of these characteristics are very likely to change or even switch signs or jump between being significant and insignificant. As a result, we should not expect our results about country characteristics have certain similarity with the previous literature. Second, the host country's characteristics are potentially endogenous, and thus their coefficients are likely to be biased[5]. But what we need is the accurate estimation of coefficients of our variables of interest – lagged FDI flows, and the coefficients of the country characteristics are not our big concern. In our model, we use more lagged FDI as instruments to solve the potential endogeneity problem of lagged FDI, which is able to correct the bias on FDI coefficients based on some statistical criteria. Third, the coefficients only tell the direct estimated effects of controls on the dependent variable under our model specification, while the overall effects (direct plus indirect effects) could be very different.

In Column (3) and (4), we estimate the effects of FDI inflows for different country-type pairs. Column (3) is a bare bone specification which does not include country characteristics, while Column (4) is our preferred specification which includes not only the country types but also country characteristics. The results for the two columns are essentially the same as Columns (1) and (2), except that the FDI effects between different country types are included. The coefficients of FDI for S-S, N-S, S-N, and N-N display either positive or negative signs, but all of them are insignificant at any conventional levels, which means FDI inflows may not be the key factor to promote host countries' productivity.

[5] Theoretically, we can use lagged variables as instruments for each potentially endogenous variables to correct their estimates. But that will eat the degrees of freedom and may create additional biases which may affect the coefficients of our variables of interest.

In Columns (5)-(8), we follow the specifications of first four columns and use 2-step GMM regressions. We get slightly different but essentially the same results.

Table 4 displays the results from equation (2), in which we use host country as country *i* and USA as the frontier country *f*. Since USA is believed to be the productivity frontier in most industries (Bartelsman *et al*, 2008; Cameron *et al*, 2005), we use this equation to test whether there exists conditional productivity convergence between the host country and the frontier, or in other words, whether FDI inflows can promote host country's productivity convergence toward the frontier after controlling for other factors. The results are not very promising, and we do not detect any significant productivity convergence effect of FDI flows. In all the specifications, the p-value of Hansen over-identification test is large enough not to reject the null hypothesis that the model is correctly specified, and Cragg-Donald F statistic is large enough to reject the null hypothesis of weak instruments.

The coefficients of the control variables does not change much except for openness to trade and financial development. Openness to trade tends to promote host country's productivity convergence toward the frontier country, which is consistent with most of the previous literature. Financial development has negative impact on productivity convergence, which is not consistent with our previous results. However, we can take insights from Loayza and Ranciere (2006), who find that financial development might be negatively correlated with economic performance in the short run due to financial fragility in the transitionary period[6].

The literature about FDI and productivity convergence at macro level is very limited so we take insights from other relevant topics to discuss our findings. Mayer-

[6] Excluding financial development does not affect our conclusion.

Foulkes and Nunnenkamp (2009) investigate FDI and per-capita income convergence relative to USA and find that FDI flows tend to accelerates convergence for high-income countries while increase the gap between low-income countries and USA. If the same pattern is true for productivity, it is not surprising to see overall an insignificant effect is detected since the positive and negative effects may cancel out each other. Lee (2009) finds FDI flows tend to contribute to productivity convergence in manufacturing sector, but not as effective as trade and not in service sector. Based on his findings, it is possible that FDI flows have no significant effect on host countries' overall productivity.

1.4.2. Sensitivity Analysis

FDI inflows as a share of host country's GDP are negative for some countries over some periods, which means these countries experience net FDI outflows by non-residents. Since FDI inflows are supposed to bring advanced technology, managerial skills, and know-how to host countries, FDI's productivity spillovers are supposed to take place in the net FDI-receiving countries. Also, we find several countries have zero FDI inflows from their partners, and we are not sure whether they are true zeroes or due to missing values. Following our benchmark specification (Columns (4) and (8) in Table 3), in Table 5 we keep non-negative FDI inflows in Columns (1) and (6), and only keep positive FDI inflows in Columns (2) and (7). The results are essentially identical to our baseline results.

As a second robustness check, we control for the heavily right-skewed nature of the FDI flows' distribution. Many observations of FDI inflows are very small compared to the host countries' economic size. The 75 percentile of FDI inflows as a share of host country's GDP is only 0.00448, which might be a reason why FDI inflows tend to have insignificant effect on productivity spillovers. In Columns (3) and (8), we report the regression results by only using FDI inflows as a share of GDP equal to or above 0.1[7], and once again, no significant result is found.

Third, we control for sensitivity of our results to the numbers of sources of FDI flows. The dependent variable of equation (5) is home country invariant, which means productivity of one host country may correspond to many FDI sources at home country-year level. If some host countries have only a limited source of their FDI inflows (only a few home country-year pairs) while other host countries have tremendous amounts of sources (huge amounts of investing country-year pairs), the regression results may be dragged by the countries with tremendous amounts of sources and thus be potentially biased. Figure 4 displays the distribution of home country-year pair for host countries and we can see the distribution is right-skewed. In Column (4), we keep the host countries with the number of home country-year below the 75 percentile (617), and the results are essentially the same[8].

Figure 1 shows FDI flows as a share of host countries' GDP. Figure 3 displays the number of observations for bilateral FDI flows for each year. We can see that there are less and less observations as well as smaller and smaller fluctuations as we go back to earlier years. In other words, we see more and more missing values as we go from forth to back. The unbalanced panel data potentially bring sample selection problem. If the missing values are not randomly distributed, fixed effects and 2-step GMM might

[7] We also use FDI share beyond alternative thresholds and find the results are essentially the same.

[8] We test different thresholds and the conclusion is not affected. The conclusion is also true for those above 75 percentile. The regression results are not very likely to be drive by home country-year pair, but we also test this case and still get essentially the same results.

lead to biased results, and that is perhaps why we got insignificant effects in the previous regressions. If we knew the reason why the dataset is unbalanced, we could have figured out the way to deal with it. Unfortunately, we do not have enough information to build a perfectly corrected model to solve this problem. Perhaps one may be tempted to create a balanced panel in which we have the same number of observations for each year. However, we are creating bias if the pattern of missing values is systematic. Also, one may think about using some censored or truncated models instead. However, our FDI as a share of GDP can take both positive and negative value and is not censored or truncated at any specific level. To correct the potential sample selection bias, we have to think about alternative way to settle this problem. To this end, we introduce an indicator, which equals to one if the FDI value is not missing and zero otherwise. We add the lagged indicators up to some periods to control for the occurrence pattern. If there is some systematic reason for some countries to receive FDI inflows, the past presence indicators should have taken it into consideration. In Column (6), we include the lagged indicator up to 10 periods and still find insignificant results for FDI flows. We also use lagged indicator with varying periods and get essentially the same results, which indicates the unbalanced panel may not be a big problem for our conclusion.

How about the sensitivity of our results to the definition of North and South? Since we have created our own Northern country group and assigned all the other countries to the Southern group, there might be concern that our results are sensitive to the definitions of Northern or Southern countries. In Table 6[9], we follow the category

[9] To save space, we only report the coefficients and standard deviations of FDI variables from fixed effects models. Results of 2-step GMM models are very similar.

"high income OECD members" from WDI[10] in Column (1) and also "Advanced Economies" from IMF[11] in Column (2). The results show that the effects of FDI flows on host countries' productivity growth are indistinguishable from zero at conventional significance levels.

Instead of clear distinction between Northern and Southern countries, there are some emerging countries[12] that share some characteristics of Northern countries, but fall short of the standards of developed countries. Compared to typical Southern countries, these emerging countries are more like their advanced counterparts. In Column (3) of Table 6, we redefine both developed and emerging countries as Northern countries and all other countries in the South group. The reclassification results still show that no significant effect is detected.

We have shown that potential self-selection bias does not affect our conclusion by introducing lagged indicators. Also we want to know whether our results are robust to alternative time spans. The period 1990-1995 only accounts for 10% of the whole observations of bilateral FDI flows. In Column (4) we drop this time span and only use years after 1995. We do not find any significant result over the shorten time period.

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[10] It includes: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Israel, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, South Korea, Spain, Sweden, Switzerland, United Kingdom and United States.

[11] It includes: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong (China), Iceland, Ireland, Italy, Israel, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, San Marino, Singapore, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Taiwan, United Kingdom and United States.

[12] We take the insights from IMF, FTSE, Standard & Poor's, Dow Jones and other sources to create our emerging country group, which includes: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Estonia, Egypt, Hungary, India, Indonesia, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Peru, Philippines, Poland, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Thailand and Turkey.

It is possible that our results are driven by the outliers. In Columns (5) and (6), we drop the upper 1% and lower 1% countries based on their normalized FDI inflows and income per capita. We do not find any effects that are distinguishable from zero.

Instead of dropping either negative FDI or non-positive FDI flows in the previous analysis, in Column (7) we introduce dummies for zero FDI and negative FDI flows. If host countries receive either zero or negative FDI, the corresponding dummy is assigned to 1. The regression results still show that FDI flows tend to have insignificant effect on host countries' productivity growth.

Since we run one regression for different country-type combinations Eq. (1), we are restricting other variables to have the same marginal grouped across the combination types. In Column (8), we use alternative specification displayed in Equation (7) and allow different marginal effects of other variables on host countries' productivity growth[13]. Once again, we do not find any essentially different results.

$$Prodgrowth_{i,t} = \alpha * lnincome_{i,t-1} + \beta * FDI_{i=S\ or\ N, j=S\ or\ N, t-1} + \gamma' X_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \qquad (7)$$

We are concerned whether our results are sensitive to selected regions. In Table 7, we drop each region once based on WDI regional classifications[14]. All the regression results show that FDI flows have insignificant impact on host countries' productivity growth. We also apply the same procedures in Table 6 and Table 7 to productivity convergence and get similar conclusions[15].

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[13] We run 4 separate regressions for S-S, N-S, S-N and N-N countries. To save space, we only report the results for FDI variables in one column.

[14] To save space, only the results of fixed effects models are reported. The results of 2-step GMM are essentially identical.

[15] To save space, the results are not reported.

In Table 4, we have reported the results of Equation (2), where we put USA as the productivity frontier. In Table 8, we use G7 group[16] (major advanced economies) as frontier instead and follow the specifications of Columns (4) and (8) in Table 4. We use unweighted average of these 7 countries in Columns (1) and (5), which means each G7 country receives equal importance for GDP, physical capital, labor, human capital, and as a result, productivity. In Columns (2) and (6), we use GDP as the weight to calculate the composite relative productivity, with countries having larger economic size receiving more importance. In Columns (3) and (7), we use population as weight to consider the country size when calculating relative TFP. Also we are concerned that richer countries may have unique advantages in promoting productivity, so we use GDP per capita (a proxy for richness) as the weight to get relative productivity in Columns (4) and (8). All the regressions show insignificant impact of FDI flows on productivity convergence of host countries toward TFP frontier.

1.5. The Decomposition of Effects of FDI Inflows

Some of the previous literature has found significant effects of FDI on GDP growth rates. We focus on FDI and productivity spillovers, and total factor productivity is viewed as a residual after excluding the contribution of capital, labor and human capital from overall economic growth rates. In order to have an overall look at the effects of FDI, this section decomposes its effects to different components of the growth rates. We apply equation (1) and replace the productivity growth rates with physical capital growth rates and human capital growth rates.

Table 9 shows the effects of FDI on the growth rates of capital and human capital. Columns (1) and (2) display the impact of un-directed FDI inflows on host

[16] It includes: Canada, France, Germany, Italy, Japan, United Kingdom and United States.

countries' capital growth rates, and Columns (5) and (6) show the effects of un-directed FDI on host countries' human capital growth rate. Columns (3), (4) and (7), (8) display the effects of directed FDI on host countries' capital growth and human capital growth. FDI tends to have no impact on host countries' capital growth but it is likely to promote human capital growth. Once we use the directed FDI, only South-South pair shows statistical significance for human capital growth.

So far, we have not found any evidence that FDI can either promote host countries' productivity growth or shrink the productivity gap between host countries and the frontier. However, it is likely that FDI can be effective in one particular sector. We test the impacts of FDI on growth and convergence of labor productivity and TFP in three sectors: agriculture, industry and service. The Sectoral value added and employment data are from WDI and Sectoral capital formation data are from OECD. Once again, we do not detect any significant effects of FDI[17].

1.6. Conclusion

This article investigates the effects of bilateral FDI on productivity spillovers. First, it uses the host countries' productivity growth rates as dependent variable, and then uses the gap of productivities between host countries and frontier country USA as dependent variable. In order to solve the potential endogeneity and omitted variable problems, we use fixed effects, 2-step GMM and instrumental variables to correct the potential biasedness.

The results show there tends to be no significant effects of FDI on either host countries' productivity growth or the productivity gap between host countries and the frontier. After decomposing the effects of FDI, we find FDI tends to promote host

[17] To save space, regression results are not reported.

countries' human capital growth, but only for South-South countries. No evidence shows FDI has any impact on either labor productivity or TFP by sector.

Our findings show that there still exists enormous scope for the improvement of the effectiveness and contribution of FDI flows. Instead of attracting FDI flows without discrimination, host countries are supposed to distinguish which FDI flows are conducive to the growth rates of either productivity or other components, and which FDI flows only crowd out domestic investment to hurt capital accumulation. Perhaps some countries do not have the capability of screening at this time, but those mentioned above are possible in the future.

Out work is restricted by the limitation of the data. For example, we do not know much about the missing FDI observations in the early years. Perhaps with more data in the future, we can do better work based on bilateral FDI flows.

Figure 1.1: FDI Flows as A Share of Host Country's GDP

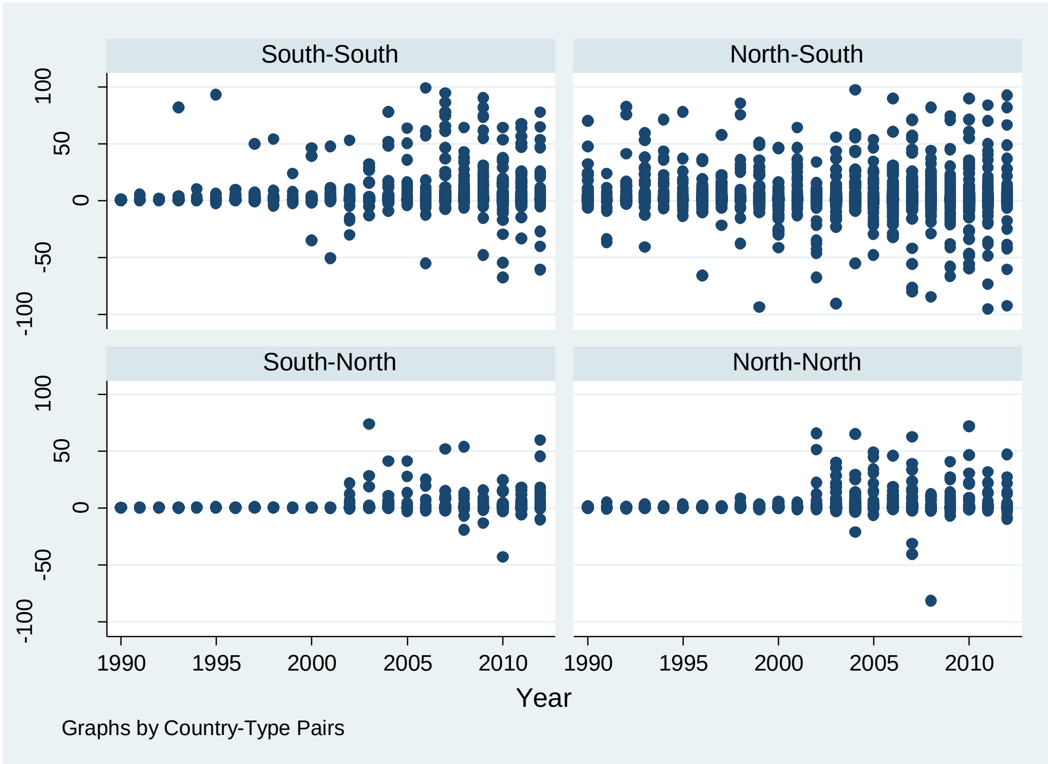

Figure 1.2: Growth Rates in South and North Countries

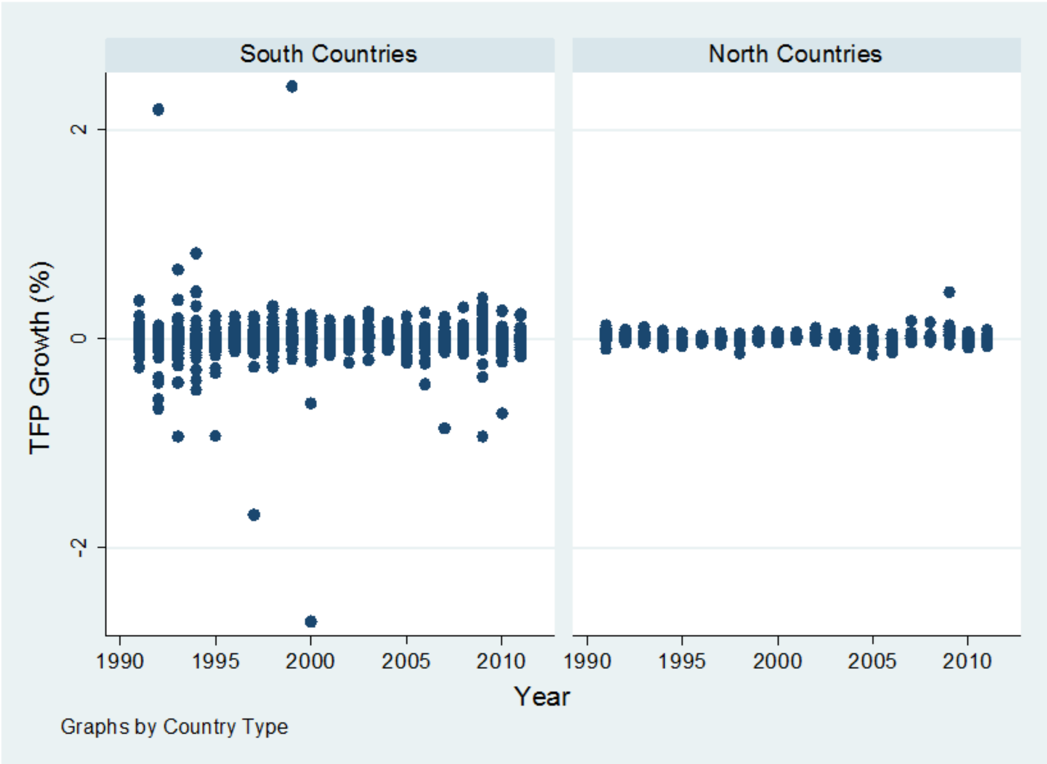

Figure 1.3: Numbers of Observations for Bilateral FDI Flows

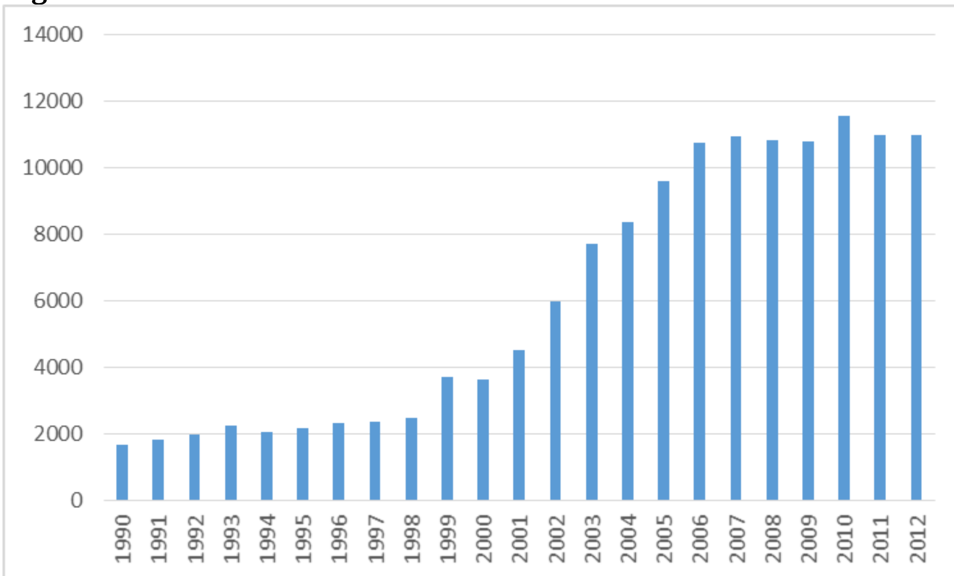

Figure 1.4: Distribution of Home Country-Year Pair

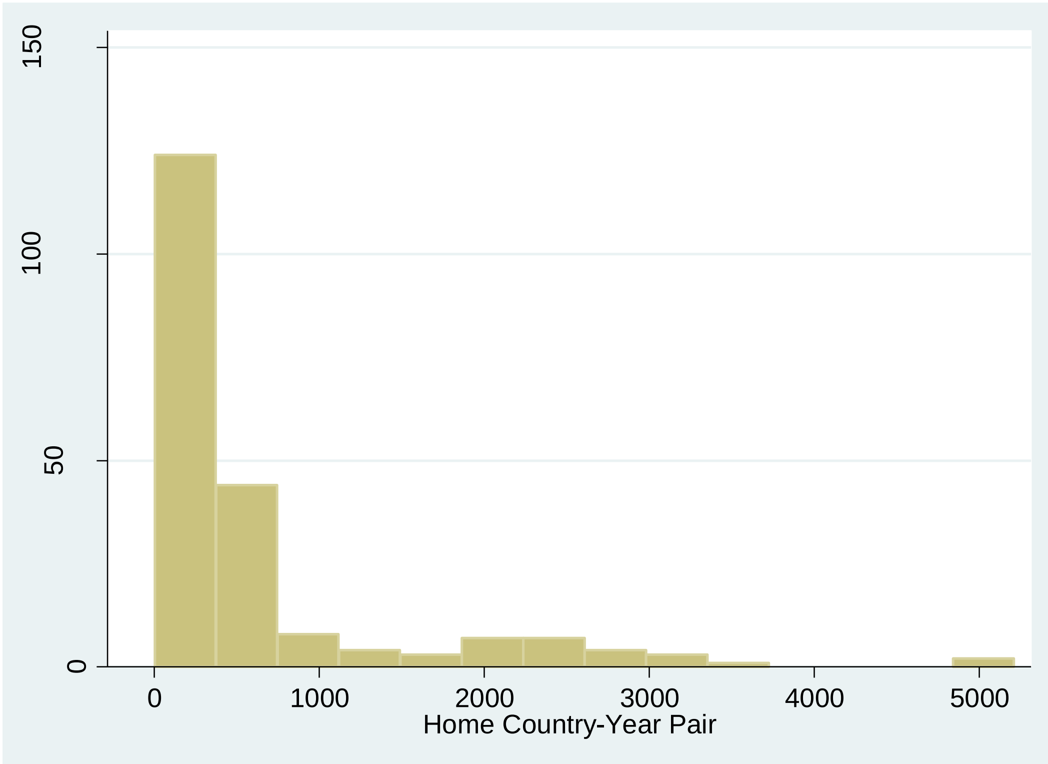

Table 1.1: Data Sources for the Main Variables

	Data Sources
Bilateral FDI	OECD (2013), UNCTAD (2013)
GDP per capita	WDI (2015)
Labor force	WDI (2015)
Human capital	PWT (2015)
Gross capital formation	WDI (2015)
Import and export as a share of GDP	WDI (2015)
Inflation rate	WDI (2015)
Government consumption as a share of GDP	WDI (2015)
Domestic credit to private sector	WDI (2015)

Table 1.2: Summary Statistics of the Data

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Bilateral FDI (%)	139,625	0.137	2.492	-95.33	99.03
Productivity growth rate (%)	1,931	0.000417	0.140	-2.711	2.419
Relative TFP (Compared to USA)	2,083	-0.682	0.615	-3.051	1.510
GDP per capita (constant 2005 US$)	4,083	10,095	16,422	50.04	158,803
GDP (constant 2005 million US$)	4,282	223,466	972,499	16.04	1.414e+07
Gross capital formation (constant 2005 million US$)	3,067	71,573	258,481	-16.97	3.172e+06
Labor force (million)	4,215	15.31	63.14	0.0321	787.6
Human capital	2,924	2.412	0.571	1.129	3.619
Labor income share	2,772	0.530	0.137	0.0897	0.917
Import and export as a share of GDP (%)	4,109	86.28	51.75	0.309	531.7
Inflation rate (%)	4,273	45.62	541.3	-31.57	26,766
Government consumption as a share of GDP (%)	3,927	16.43	8.355	2.047	156.5
Domestic credit to private sector (%)	3,713	45.89	44.37	0.491	319.5
Number of group	3,774	3,774	3,774	3,774	3,774

Table 1.3: Baseline Regression Results – Productivity Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	2-step GMM	2-step GMM	2-step GMM	2-step GMM
FDI	0.00362	0.00373			0.00352	0.00363		
	(0.00328)	(0.00340)			(0.00328)	(0.00340)		
FDI (S-S)			0.0151	0.0208			0.0141	0.0218
			(0.0147)	(0.0196)			(0.0146)	(0.0196)
FDI (N-S)			-1.29e-05	0.000381			-0.000116	0.000281
			(0.00142)	(0.00135)			(0.00141)	(0.00135)
FDI (S-N)			-0.00143	-0.00143			-0.00146	-0.00142
			(0.00265)	(0.00253)			(0.00265)	(0.00253)
FDI (N-N)			-0.00233	-0.00227			-0.00222	-0.00216
			(0.00239)	(0.00228)			(0.00239)	(0.00228)
Lnincome	0.111***	0.109***	0.110***	0.108***	0.111***	0.109***	0.110***	0.108***
	(0.00523)	(0.00571)	(0.00525)	(0.00574)	(0.00523)	(0.00571)	(0.00525)	(0.00572)
Inflation		-8.68e-06		-8.63e-06		-8.70e-06		-8.70e-06
		(6.24e-06)		(6.23e-06)		(6.24e-06)		(6.23e-06)
Openness		-0.000414***		-0.000416***		-0.000413***		-0.000415***
		(3.56e-05)		(3.56e-05)		(3.56e-05)		(3.55e-05)
Government size		0.000970		0.00100		0.000965		0.000981
		(0.000628)		(0.000628)		(0.000628)		(0.000627)
Government stability		0.000177***		0.000180***		0.000178***		0.000180***
		(2.42e-05)		(2.41e-05)		(2.42e-05)		(2.41e-05)
Observations	60,855	59,215	60,855	59,215	60,855	59,215	60,855	59,215
R-squared	0.179	0.224	0.180	0.225	0.179	0.224	0.181	0.225
Number of group	8,275	8,061	8,275	8,061	8,275	8,061	8,275	8,061
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.4529	0.4119	0.2447	0.3103	0.4529	0.4119	0.2447	0.3103
Cragg-Donald F	428.217	413.139	175.819	132.456	428.217	413.139	175.819	132.456

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1.4: Baseline Regression Results – Relative Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects	2-step GMM	2-step GMM	2-step GMM	2-step GMM
FDI	-0.00197	-0.00471			-0.00213	-0.00423		
	(0.00297)	(0.00433)			(0.00288)	(0.00417)		
FDI (S-S)			-0.00306	-0.00351			-0.00228	-0.00166
			(0.0199)	(0.0236)			(0.0198)	(0.0235)
FDI (N-S)			-0.00427	-0.00832			-0.00382	-0.00784
			(0.00405)	(0.00585)			(0.00395)	(0.00554)
FDI (S-N)			-0.00186	-0.00189			-0.00223	-0.00250
			(0.00363)	(0.00347)			(0.00355)	(0.00335)
FDI (N-N)			-0.00588	-0.00591			-0.00595	-0.00601
			(0.00509)	(0.00501)			(0.00509)	(0.00500)
Lnincome	0.0459***	0.0572***	0.0456***	0.0566***	0.0458***	0.0573***	0.0455***	0.0564***
	(0.00830)	(0.00727)	(0.00837)	(0.00738)	(0.00829)	(0.00726)	(0.00836)	(0.00737)
Inflation		7.15e-05***		7.14e-05***		7.15e-05***		7.15e-05***
		(4.53e-06)		(4.54e-06)		(4.53e-06)		(4.54e-06)
Openness		0.00124***		0.00124***		0.00124***		0.00124***
		(5.88e-05)		(5.96e-05)		(5.87e-05)		(5.95e-05)
Government size		0.0187***		0.0188***		0.0187***		0.0188***
		(0.000704)		(0.000710)		(0.000703)		(0.000709)
Credit		-0.000399***		-0.000399***		-0.000400***		-0.000399***
		(3.13e-05)		(3.14e-05)		(3.13e-05)		(3.14e-05)
Observations	60,887	59,244	60,887	59,244	60,887	59,244	60,887	59,244
R-squared	0.240	0.312	0.239	0.309	0.240	0.312	0.239	0.309
Number of group	8,275	8,061	8,275	8,061	8,275	8,061	8,275	8,061
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.8337	0.6832	0.8523	0.6394	0.8337	0.6832	0.8523	0.6394
Cragg-Donald F	430.421	415.053	201.605	157.296	430.421	415.053	201.605	157.296

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1.5: Robustness Check (1) – Productivity Growth

VARIABLES	(1) FE FDI≥0	(2) FE FDI>0	(3) FE FDI>0.1	(4) FE jt<617	(5) FE Indicator	(6) GMM FDI≥0	(7) GMM FDI>0	(8) GMM FDI>0.1	(9) GMM jt<617	(10) GMM Indicator
FDI (S-S)	0.00859	0.00638	-0.0125	-7.84e-05	-0.0123	-0.00813	-0.00817	-0.0137	-0.0548	-0.0703
	(0.0141)	(0.0142)	(0.0177)	(0.0302)	(0.0338)	(0.0217)	(0.0216)	(0.0247)	(0.0511)	(0.0603)
FDI (N-S)	0.000404	0.000202	7.25e-05	0.000797	0.00224	-0.00765	-0.00717	-0.00539	0.00598*	-0.00486
	(0.00140)	(0.00143)	(0.00154)	(0.00203)	(0.00167)	(0.00576)	(0.00546)	(0.00496)	(0.00312)	(0.00303)
FDI (S-N)	-0.00137	-0.00115	-0.000610	-0.100	0.000605	-0.00187	-0.00166	-0.000818	-0.505**	-0.00243
	(0.00230)	(0.00259)	(0.00225)	(0.230)	(0.00230)	(0.00317)	(0.00342)	(0.00320)	(0.224)	(0.00369)
FDI (N-N)	-0.00204	-0.00214	-0.00170	0.0231	-0.00201	-0.00522	-0.00569	-0.00452	0.00587	-0.00377
	(0.00268)	(0.00278)	(0.00252)	(0.0291)	(0.00198)	(0.00567)	(0.00622)	(0.00543)	(0.0623)	(0.00305)
Lnincome	0.105***	0.0942***	0.114***	0.112***	0.125***	0.0573***	0.0609***	0.0260	0.307***	-0.226***
	(0.00630)	(0.00871)	(0.0204)	(0.0180)	(0.00518)	(0.00810)	(0.00975)	(0.0212)	(0.0344)	(0.00785)
Inflation	-7.04e-06	-7.91e-06	1.04e-05	5.30e-05***	0.00158***	7.29e-05***	5.02e-05***	7.72e-05***	0.000110***	0.000223
	(6.53e-06)	(6.32e-06)	(2.75e-05)	(1.34e-05)	(0.000106)	(5.16e-06)	(4.32e-06)	(1.88e-05)	(1.56e-05)	(0.000139)
Openness	-0.000433***	-0.000161***	-0.000199***	0.000423***	1.39e-05	0.00127***	0.00107***	0.000731***	-0.00236***	-0.000273***
	(4.12e-05)	(4.87e-05)	(7.49e-05)	(9.48e-05)	(4.04e-05)	(6.68e-05)	(8.39e-05)	(0.000123)	(0.000145)	(6.14e-05)
Govn’t size	0.00147**	0.00368***	0.00561***	0.00408***	-0.00547***	0.0193***	0.0179***	0.0154***	0.00862***	0.0136***
	(0.000712)	(0.000960)	(0.00211)	(0.00119)	(0.000621)	(0.000787)	(0.000835)	(0.00161)	(0.00146)	(0.000897)
Credit	0.000153***	0.000188***	0.000213**	0.000342***	0.000295***	-0.000452***	-5.45e-05	-4.36e-05	-0.00121***	-0.000942***
	(2.79e-05)	(4.14e-05)	(8.50e-05)	(0.000116)	(2.57e-05)	(3.53e-05)	(4.40e-05)	(8.05e-05)	(0.000153)	(3.20e-05)
Observations	51,047	25,972	7,319	8,756	47,897	51,074	25,991	7,330	8,778	47,917
R-squared	0.217	0.153	0.115	0.047	0.070	0.310	0.296	0.257	0.340	0.289
Number of group	7,813	3,989	1,472	1,373	7,584	7,813	3,990	1,474	1,373	7,584
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.4277	0.3415	0.1720	0.1247	0.0714	0.7799	0.7967	0.5646	0.7848	0.9989
Cragg-Donald F	143.127	72.697	18.676	15.457	165.518	143.221	72.759	18.710	20.100	150.645

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

Table 1.6: Robustness Check (2) – Productivity Growth

VARIABLES	(1) WDI Classification	(2) IMF Classification	(3) North + Emerging Countries	(4) After 1995	(5) Drop FDI Outliers	(6) Drop Income per capita Outliers	(7) Zero and Negative FDI Dummies	(8) Alternative Specification
FDI (S-S)	0.0189	0.0150	-0.000333	0.0194	0.0307	-0.00797	0.0206	0.00786
	(0.0169)	(0.0154)	(0.0164)	(0.0213)	(0.152)	(0.0190)	(0.0195)	(0.0217)
FDI (N-S)	0.00426	0.00414	0.00154	0.000653	-7.93e-05	0.00270	0.000304	0.00279
	(0.00334)	(0.00325)	(0.00192)	(0.00149)	(0.00164)	(0.00373)	(0.00139)	(0.00379)
FDI (S-N)	-0.000549	-0.000396	-0.00114	-0.00146	-0.00277	0.0337	-0.00157	0.117
	(0.00166)	(0.00144)	(0.00216)	(0.00258)	(0.00208)	(0.470)	(0.00256)	(0.458)
FDI (N-N)	0.00206	0.00217	0.00297	-0.00247	-0.0192	0.0458	-0.00224	0.0355
	(0.00357)	(0.00393)	(0.00443)	(0.00246)	(0.0276)	(0.0391)	(0.00228)	(0.0297)
Lnincome	0.108***	0.108***	0.109***	0.104***	0.105***	0.188***	0.107***	
	(0.00572)	(0.00572)	(0.00577)	(0.00662)	(0.00698)	(0.00975)	(0.00582)	
Inflation	-8.52e-06	-8.56e-06	-8.73e-06	-0.000193***	-1.64e-05***	-0.00217***	-8.43e-06	
	(6.23e-06)	(6.23e-06)	(6.24e-06)	(2.36e-05)	(3.52e-06)	(6.86e-05)	(6.42e-06)	
Openness	-0.000417***	-0.000416***	-0.000412***	-0.000433***	-0.000446***	-0.000289***	-0.000415***	
	(3.60e-05)	(3.59e-05)	(3.53e-05)	(3.81e-05)	(4.02e-05)	(6.47e-05)	(3.56e-05)	
Government size	0.000979	0.000978	0.000990	6.16e-05	0.000705	0.00169**	0.000995	
	(0.000628)	(0.000628)	(0.000629)	(0.000710)	(0.000667)	(0.000687)	(0.000629)	
Credit	0.000178***	0.000178***	0.000177***	0.000188***	0.000184***	0.00138***	0.000167***	
	(2.41e-05)	(2.41e-05)	(2.42e-05)	(2.77e-05)	(2.61e-05)	(0.000291)	(2.55e-05)	
Zero FDI							-0.0197**	
							(0.00765)	
Negative FDI							0.00217	
							(0.0138)	
Observations	59,215	59,215	59,215	55,593	55,470	25,519	59,215	
R-squared	0.224	0.225	0.226	0.225	0.223	0.389	0.219	
Number of group	8,061	8,061	8,061	8,032	7,796	3,765	8,061	
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
p value of Hansen	0.7859	0.7804	0.3515	0.3262	0.3532	0.7841	0.0037	
Cragg-Donald F	83.935	70.625	85.488	108.314	7.684	8.724	13.171	

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

Table 1.7: Robustness Check (3) – Productivity Growth

VARIABLES	(1) Fixed Effects No East Asia and Pacific	(2) Fixed Effects No Europe and Central Asia	(3) Fixed Effects No Latin America and the Caribbean	(4) Fixed Effects No Middle East and North Africa	(5) Fixed Effects No North America	(6) Fixed Effects No South Asia	(7) Fixed Effects No Sub-Saharan Africa
FDI (S-S)	0.00370	0.0191	0.0204	0.0207	0.0205	0.0210	0.0220
	(0.0332)	(0.0245)	(0.0236)	(0.0197)	(0.0195)	(0.0198)	(0.0188)
FDI (N-S)	0.000534	-0.000241	2.23e-05	0.000340	0.000362	0.000389	0.000740
	(0.00134)	(0.00128)	(0.00168)	(0.00136)	(0.00135)	(0.00135)	(0.00133)
FDI (S-N)	-0.00146	-0.00135	-0.00138	-0.00150	-0.00142	-0.00145	-0.00153
	(0.00246)	(0.00231)	(0.00248)	(0.00256)	(0.00254)	(0.00253)	(0.00258)
FDI (N-N)	-0.00202	-0.00193	-0.00218	-0.00231	-0.00229	-0.00226	-0.00221
	(0.00210)	(0.00195)	(0.00224)	(0.00232)	(0.00231)	(0.00228)	(0.00227)
Lnincome	0.161***	0.0911***	0.110***	0.106***	0.109***	0.108***	0.107***
	(0.00853)	(0.00427)	(0.00634)	(0.00580)	(0.00576)	(0.00594)	(0.00576)
Inflation	-5.62e-06	-5.95e-06***	3.62e-06	-8.15e-06	-8.92e-06	-8.44e-06	-9.45e-06
	(6.61e-06)	(1.74e-06)	(5.39e-05)	(6.18e-06)	(6.25e-06)	(6.23e-06)	(6.30e-06)
Openness	-0.000438***	-0.000549***	-0.000540***	-0.000416***	-0.000389***	-0.000419***	-0.000443***
	(4.46e-05)	(3.37e-05)	(4.03e-05)	(3.59e-05)	(3.59e-05)	(3.58e-05)	(3.36e-05)
Government size	0.00280***	0.00141***	-0.000232	0.000971	0.000929	0.00106*	2.80e-05
	(0.000771)	(0.000547)	(0.000757)	(0.000658)	(0.000636)	(0.000635)	(0.000607)
Credit	0.000170***	0.000171***	0.000203***	0.000181***	0.000179***	0.000179***	0.000198***
	(2.69e-05)	(1.83e-05)	(2.65e-05)	(2.43e-05)	(2.47e-05)	(2.44e-05)	(2.46e-05)
Observations	52,184	46,483	50,903	57,851	57,817	58,712	56,323
R-squared	0.247	0.225	0.236	0.230	0.217	0.227	0.283
Number of group	7,229	6,185	7,048	7,833	7,851	8,001	7,569
Country FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.2084	0.2530	0.3131	0.3459	0.3010	0.3148	0.4671
Cragg-Donald F	67.513	75.516	96.255	129.437	129.354	130.097	173.724

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

Table 1.8: Robustness Check (4) – Relative Productivity

VARIABLES	(1) Fixed Effects Unweighted	(2) Fixed Effects Weighted GDP	(3) Fixed Effects Weighted Population	(4) Fixed Effects Weighted GDP per capita	(5) 2-step GMM Unweighted	(6) 2-step GMM Weighted GDP	(7) 2-step GMM Weighted Population	(8) 2-step GMM Weighted GDP per capita
FDI (S-S)	0.00104	-0.000203	0.000327	0.000777	0.00301	0.00176	0.00227	0.00277
	(0.0220)	(0.0225)	(0.0224)	(0.0221)	(0.0220)	(0.0225)	(0.0224)	(0.0220)
FDI (N-S)	-0.00813	-0.00816	-0.00814	-0.00814	-0.00768	-0.00770	-0.00768	-0.00768
	(0.00570)	(0.00574)	(0.00572)	(0.00571)	(0.00539)	(0.00543)	(0.00541)	(0.00540)
FDI (S-N)	-0.00186	-0.00183	-0.00183	-0.00186	-0.00243	-0.00241	-0.00241	-0.00242
	(0.00354)	(0.00349)	(0.00349)	(0.00353)	(0.00344)	(0.00337)	(0.00338)	(0.00343)
FDI (N-N)	-0.00592	-0.00591	-0.00592	-0.00591	-0.00606	-0.00604	-0.00606	-0.00606
	(0.00498)	(0.00498)	(0.00499)	(0.00497)	(0.00496)	(0.00497)	(0.00498)	(0.00496)
Lnincome	0.0991***	0.0856***	0.0874***	0.0981***	0.0988***	0.0853***	0.0871***	0.0978***
	(0.00701)	(0.00713)	(0.00711)	(0.00702)	(0.00700)	(0.00712)	(0.00710)	(0.00702)
Inflation	7.65e-05***	7.47e-05***	7.53e-05***	7.61e-05***	7.65e-05***	7.48e-05***	7.53e-05***	7.61e-05***
	(4.21e-06)	(4.30e-06)	(4.28e-06)	(4.22e-06)	(4.21e-06)	(4.30e-06)	(4.28e-06)	(4.22e-06)
Openness	0.00117***	0.00118***	0.00118***	0.00116***	0.00117***	0.00118***	0.00118***	0.00116***
	(5.84e-05)	(5.87e-05)	(5.86e-05)	(5.85e-05)	(5.84e-05)	(5.87e-05)	(5.86e-05)	(5.84e-05)
Government size	0.0180***	0.0183***	0.0182***	0.0181***	0.0180***	0.0183***	0.0182***	0.0181***
	(0.000684)	(0.000693)	(0.000692)	(0.000685)	(0.000683)	(0.000692)	(0.000691)	(0.000684)
Credit	-0.000393***	-0.000393***	-0.000389***	-0.000397***	-0.000393***	-0.000393***	-0.000389***	-0.000397***
	(3.05e-05)	(3.07e-05)	(3.07e-05)	(3.05e-05)	(3.05e-05)	(3.07e-05)	(3.07e-05)	(3.05e-05)
Observations	59,244	59,244	59,244	59,244	59,244	59,244	59,244	59,244
R-squared	0.278	0.380	0.368	0.295	0.278	0.380	0.368	0.295
Number of group	8,061	8,061	8,061	8,061	8,061	8,061	8,061	8,061
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
p value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.4821	0.5290	0.5144	0.4898	0.4821	0.5290	0.5144	0.4898
Cragg-Donald F	157.296	157.296	157.296	157.296	157.296	157.296	157.296	157.296

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

Table 1.9: Decomposition – Bilateral FDI

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Fixed Effects	2-step GMM	Fixed Effects	2-step GMM	Fixed Effects	2-step GMM	Fixed Effects	2-step GMM
	Physical Capital Growth				Human Capital Growth			
FDI	-0.00176	-0.00177			2.11e-05**	2.12e-05**		
	(0.00131)	(0.00128)			(9.10e-06)	(9.06e-06)		
FDI (S-S)			-0.0353	-0.0330			0.00226**	0.00222**
			(0.0331)	(0.0329)			(0.00110)	(0.00108)
FDI (N-S)			-0.00744	-0.00846			-1.86e-05	-1.88e-05
			(0.00786)	(0.00783)			(0.000101)	(0.000101)
FDI (S-N)			-0.00171	-0.00147			-2.58e-05	-1.39e-05
			(0.00683)	(0.00663)			(6.95e-05)	(6.91e-05)
FDI (N-N)			0.00258	0.00138			5.94e-06	4.17e-06
			(0.00279)	(0.00274)			(6.64e-05)	(6.64e-05)
Lnincome	-0.339***	-0.339***	-0.352***	-0.349***	-0.00156**	-0.00156**	-0.00261***	-0.00261***
	(0.103)	(0.0985)	(0.0407)	(0.0398)	(0.000768)	(0.000768)	(0.000256)	(0.000256)
Inflation	-4.93e-05	-4.93e-05	2.78e-05	2.80e-05	7.20e-07	7.22e-07	1.86e-07	1.85e-07
	(5.31e-05)	(5.30e-05)	(1.70e-05)	(1.70e-05)	(5.02e-07)	(5.02e-07)	(1.82e-07)	(1.82e-07)
Openness	0.000733	0.000737	0.001000***	0.000977***	-3.08e-05***	-3.08e-05***	-3.22e-05***	-3.21e-05***
	(0.000728)	(0.000705)	(0.000210)	(0.000205)	(7.52e-06)	(7.52e-06)	(2.07e-06)	(2.07e-06)
Government size	-0.00583	-0.00589	-0.00423	-0.00394	0.000178***	0.000178***	0.000279***	0.000279***
	(0.00943)	(0.00907)	(0.00353)	(0.00347)	(4.62e-05)	(4.62e-05)	(1.52e-05)	(1.51e-05)
Credit	0.000963	0.000974	-0.000329	-0.000345*	1.06e-06	1.05e-06	1.80e-05***	1.80e-05***
	(0.00154)	(0.00145)	(0.000210)	(0.000204)	(4.44e-06)	(4.44e-06)	(8.20e-07)	(8.19e-07)
Observations	2,305	2,305	71,638	71,638	2,138	2,138	63,650	63,650
R-squared	0.023	0.023	0.074	0.074	0.199	0.199	0.292	0.293
Number of group	144	144			130	130		
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
p value of F statistic	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p value of Hansen	0.9833	0.9833	0.0849	0.0849	0.8952	0.8952	0.4238	0.4238
Cragg-Donald F	567.385	567.385	105.516	105.516	474.325	474.325	157.943	157.943

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

Chapter 2: Target at the Right Level: Aid, Spillovers and Growth in Sub-Saharan Africa

2.1. Introduction

Previous literature has focused substantially on the effectiveness of foreign aid. Is aid effective in reducing poverty and promoting economic growth in recipient regions (Burnside and Dollar, 2000; Hansen and Tarp, 2001; Collier and Dollar, 2002; Easterly, 2003; Hansen and Tarp, 2004; Rajan and Subramanian, 2008)? The answer to this question has very important policy implications and could affect donors as well as other international community to make future decisions of aid allocations. This topic has been under hot debates during the past few years. However, the various conclusions hardly make a consensus.

Due to data limitations, most of the early studies pay attention to the effectiveness of aid inflows to the recipient country's overall economic growth rate. But we should not expect all the aid has been allocated across the entire country evenly. For example, if aid was going to a very small locality, a moderate amount of aid flow would only stimulate local economic activity instead of the entire country's growth. Perhaps the "aggregation bias" is one reason why most of the literature cannot get consensus of the impact of aid on the economic growth of the recipient countries. Another under-studied issue is that aid going to one place may also affect its neighbors through various channels – the spillover effects. For example, one region might benefit not only from the aid flowing in that place directly, but also from the aid flowing to its neighbors through various channels such as resource movements and technology dissemination. Aid flows attract or distract resources movements across different places, which could affect economic performance outside the recipient location. Thus, ignoring potential spillover effects might lead to overestimating or underestimating the true effectiveness of aid.

This article contributes to the literature by exploring aid effectiveness and aid spillovers at the sub-national level in Sub-Saharan Africa. Sub-Saharan Africa is the home to most of the least developed countries (LDCs) with an urgent need for economic growth and development. As a typical aid-receiving region, Sub-Saharan Africa receives tremendous amount of aid every year. The United Nations Millennium Goals aims “to eradicate extreme poverty and hunger” as one of its top targets. As such, a large amount of assistance has been transferred to this region in recent years. For example, some ambitious individuals and organizations have built various projects across this continent, which attracts many positive comments as well as doubts. One famous program is the Millennium Villages Project launched by Jeffrey Sachs and his colleagues. They claim that the project has achieved several important goals, such as decreasing disease prevalence, promoting agricultural production and increasing family income (Sanchez *et al*., 2007). However, Munk (2013) doubts the project could end poverty and calls Jeffrey “the idealist”. Using country GDP data to evaluate the effectiveness of this project is not only inappropriate but also misleading since its programs are scattered around a couple of separate villages across different countries. Local aid effectiveness cannot be explained by country-level evaluation and should be taken care of once we focus on sub-national economic activities.

Unlike cross-country studies which typically assume country independence across borders, regions within one country should have more active interactions with each other because barriers within one country are generally much lower than across countries. Therefore, it is necessary to take into account the possibility of more intensive interactions when focusing on sub-national economic activities. Economic activities in one region tend to affect other regions as well. As a result, spillovers play a very important role in sub-national aid effectiveness. This article assumes that: (1) there exist aid spillover effects within a country, but once moving across the country borders, spillover effects vanish; (2) spillovers only exist across adjacent neighbors, and would vanish beyond that. I make the above assumptions for the following reasons: (1) aid could create new incentives to attract resource movements from one place to another, but once touching the country boundary, the movements are blocked; (2) most of the aid projects targeted at local level are very specifically located, thus I expect resource movements to take place only in short distances and only the adjacent neighbors are affected. These simplifying assumptions can retain the essential interests being explored and reduce the computational burden in this article.

By using a geocoded aid project dataset and night lights data as proxy for economic activities, I am able to focus on local aid effectiveness induced by aid received at different aggregate levels in Sub-Saharan Africa. I use the second order administrative division (ADM2, such as district, equivalent to U.S. county) as the primary unit of analysis. I also apply geographic information systems (GIS) methods to establish adjacent neighbor weights matrices among ADM2s to capture the potential spillover effects. To deal with the classical simultaneity problem between aid and growth, I use adjusted aid series by two-stage least squares (2SLS) approach.

By using rigorous regressions and tests, I find that: (1) aid targeted at ADM2 level tends to promote local economic growth while aid received at more aggregate levels is negatively related with local economic activity; (2) there exists positive aid spillovers across local adjacent neighbors. The results are robust to a variety of sensitivity tests. I also explore several extension topics relevant to aid literature and find that: (1) aid at the local level promotes total economic flourish and slows down population growth, while aid at more aggregate levels depresses total economic activities but stimulates population growth; (2) there exist diminishing returns to direct aid, but aid from neighbors exhibits weak increasing returns possibly through technology and knowledge spillovers; (3) there is no robust evidence showing aid effectiveness is conditional on policy or institutions, and one possible reason is data limitations – policy and institutions are measured at country level instead of sub-national level.

These findings have very important policy implications. First, more specifically targeted aid tends to be more effective to promote local economic growth, while highly likely fungible aid at more aggregate levels would do the opposite; as a result, if we would like to stimulate local economic activities, we should focus on specific aid projects instead of aid given to governments at a more aggregate level. Second, we should reduce barriers to resource movement and knowledge dissemination within the country to promote positive spillover effects.

This article is organized as follows. Section 2 discusses the recent literature. Section 3 presents the model and discusses estimation methodology. Section 4 describes the data. Section 5 displays regression results. Section 6 shows robustness checks and makes extensions. Section 7 concludes and gives policy implications.

2.2. Literature Review

There has been an enormous growth in literature focusing on aid effectiveness since the seminal research launched by Boone (1996), who found that aid does not affect investment but increases government sizes. Following his research, a large number of paper also derived similar conclusions, showing that aid is rarely conducive to growth. Easterly (2003) doubts aid effectiveness argued by Burnside and Dollar (2000). Roodman (2007) argues the previous conclusions of positive association between aid and growth is not robust. In a later article (Roodman, 2015), he argues that Clemens *et al*. (2012) fail to remove contemporaneous endogeneity and once this issue is addressed, no evidence shows aid supports growth. Rajan and Subramanian (2008) show little evidence of aid effectiveness, either positive or negative. Doucouliagos and Paldam (2009) summarize the aid literature in the past 40 years and they find little evidence showing aid is effective.

However, quite a few articles find the opposite. Dalgaard *et al*. (2004) find overall positive relationship between aid and growth. Clemens *et al*. (2012) based on previously published articles, find increasing aid could stimulate investment and growth. Askarov and Doucouliagos (2015b) investigate aid and growth in transitional countries and find that aid has an average positive impact on growth in these countries.

One possible reason for the mixed conclusions reached by the previous literature is that they suffer from the so-called “aggregation bias”. Aid projects may have been scattered around different places in a given country. Sometimes, summing up the total amount of aid and investigating the aggregate impact on a country's economic growth is meaningless and cannot provide any useful implications. Unfortunately, there is little work done exploring aid effectiveness within one country. Dreher and Lohmann (2015) is one among the rare articles which examine aid effectiveness at sub-national level. They use a previous version of the geocoded aid data and find that positive correlation exists between aid and growth at the local level in 130 countries over 2000-2011. However, they fail to solve the potential simultaneity problem and thus could not make any causal argument that aid causes growth. Additionally, finding appropriate instruments for aid is notoriously hard, as pointed out in the literature. In Section 3, based on my model specification, I explain further details about the previously used instruments and how I follow a novel procedure, which was recently proposed by Brückner (2013).

What is more, at the sub-national level, individuals are supposed to have more economic interactions than at country level, since barriers to resource movements and knowledge dissemination are much lower at the sub-national level than at the country level. However, most of the literature ignores this issue. To the best of my knowledge, Askarov and Doucouliagos (2015a) is the only article that discusses aid spillovers. They analyze aid spillovers across transitional countries and find that positive net spillovers exist through increased technology levels and currency appreciation. To capture the possibility of more intensive interactions between individuals, talking about spillovers analysis at the sub-national level are necessary and needed. As far as I know, my research is the first to examine aid spillovers at the sub-national level.

My article is also related with the literature on conditional effectiveness of aid, that is, aid effectiveness conditional on a third variable. This topic has been in hot discussions in recent years and various conclusions have been attended. Based on current publications and debates, policy index is among the most popular conditional variables. Burnside and Dollar (2000) in a seminal article show that good policies stimulate the positive relationship between aid and growth, otherwise little effect is found. Collier and Dollar (2002) analyze the aid allocation patterns and conclude that the impact of aid on the poverty reduction depends on poverty level and policy qualities. There are also other conditional variables under way. Easterly (2003) and Chong *et al*. (2009) find little evidence that aid increases economic growth when good institutions are observed. Dalgaard *et al*. (2004) argue that aid is less effective in tropical countries, suggesting that climate and geographic factors may also play a role in aid effectiveness. Lessmann and Markwardt (2012) find aid tends to be more effective in more fiscal centralized countries. My benchmark work mainly focuses on unconditional aid effectiveness, but further explorations about conditional effectiveness of aid are also discussed in Section 6.

My research is also relevant to the literature focusing on non-linear aid effectiveness and diminishing returns to aid. If aid affects growth through investment and capital accumulation, based on the neo-classical theory, we should observe that aid stimulates growth, but the marginal contribution falls as the amount of aid rises. Burnside and Dollar (2000), Lensink and White (2001), and Collier and Dollar (2002) all find evidence that diminishing returns to aid exists and aid effectiveness depends on the amount of aid received. However, no literature discusses the non-linear effectiveness of aid spillovers. If aid has spillover effects, since the spillovers do not directly increase the capital accumulation of recipient's neighbors, aid spillovers should behave very differently from diminishing returns. I will discuss this issue in Section 6.

2.3. Model Specification

The main focus of this article is to investigate aid effectiveness and aid spillovers at the sub-national level. Therefore, based on the previous aid and growth literature, I adopt the main regression function as follows:

$$growth_{i,t} = \alpha_0 + \alpha_1 * \ln(1 + lightspc_{i-1,t}) + \beta_1 * \ln(1 + aid_{i,t-1}^{ADM2}) + \beta_2 * \ln(1 + aid_{-i,t-1}^{ADM2}) + \beta_3 * \ln(1 + aid_{i,t-1}^{ADM1}) + \beta_4 * \ln(1 + aid_{i,t-1}^{country}) + \gamma' X_{i,t-1} + \delta_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

where $growth_{i,t}$ is the growth rate of income per capita in ADM2 *i* at *t*. Following previous literature (Burnside and Dollar, 2000; Collier and Hoeffler, 2004; Clemens et al., 2012), I use four-year averages in this model to smooth business cycle fluctuations. $\ln(1 + lightspc_{i-1,t})$ represents the logarithm of lagged income per capita level in ADM2 *i*. If the convergence growth story applies to sub-Saharan Africa, we should expect α_1<0, which means faster growth should be observed in poorer regions. $aid_{i,t-1}^{ADM2}$ is the total amount of aid received by ADM2 *i* at *t-1*, while $aid_{-i,t-1}^{ADM2}$ is the total amount of aid received by *i*'s neighbors[18]. $aid_{i,t-1}^{ADM1}$ is the fair share (total amount divided by the number of ADM2s) of total amount of aid received by the ADM1 where ADM2 *i* locates at *t-1*, excluding the amount of aid received at ADM2 level[19]. $aid_{i,t-1}^{country}$ is the fair share of total amount of aid received by the country where ADM2 *i* locates at t-1,

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[18] Both of the two variables contain aid with precision levels 1-3, see appendix for further discussions.
[19] Aid with precision level 4, see appendix for further discussions.

excluding the amount of aid received at ADM2 and ADM1 levels[20]. In other words, $aid_{i,t-1}^{ADM1}$ measures the net part of average aid share at more aggregate level at ADM1 level, and $aid_{i,t-1}^{country}$ at country level. The sums of each direct aid variable ($aid_{i,t-1}^{ADM2}$, $aid_{i,t-1}^{ADM1}$, and $aid_{i,t-1}^{country}$) are mutually exclusive and collectively exhaustive. δ_i and δ_t are fixed effects capturing ADM2-specific and time-invariant parts.

$X_{i,t-1}$ is a matrix of lagged control variables. Due to data limitation, the conflict intensity is the only variable that varies at ADM2 level, and all other control variables are measured at the country level:

General government final consumption expenditure, is measured by government expenditure as a share of GDP. According to the neo-classical theory, an increase in government expenditure could increase income through multiplier process. However, if a jump in government spending leads to a rise in interest rate, government expenditure could "crowd out" private investment. Lin (1994) finds government expenditure is positively associated with growth in the short-run but not in the medium-run. Devarajan *et al*. (1996) find a negative relationship between government expenditure and economic growth, as a result of potential resource misallocation. The impact of government expenditure on economic growth is, therefore, an empirical question.

Inflation rate, measured by the percentage change in GDP deflator, theoretically is expected to have positive impact on growth if it is mild and hurt economic growth when there is hyperinflation (Bruno and William, 1998). The findings of Khan and Abdelhak (2011) are consistent with the above theory: they find that inflation is negatively related with growth when inflation rate is above a threshold level: 1-3

[20] Aid with precision levels 5-8, see appendix for further discussions.

percentage points for developed countries and 11-12 percentage points for developing countries. Table 2 shows the average inflation rate over 4-year period is 11.109%, touching the threshold set by the Khan and Abdelhak (2011). Therefore, I expect inflation has a negative impact on growth in Sub-Saharan Africa.

Openness to trade is the ratio of sum of imports and exports to GDP in one country. Based on the new growth theory, international trade can improve technology and institutions, which increases economic growth. Harrison (1996) finds that there exists a positive association between openness and growth in developing countries. Edwards (1998) shows that more open countries tend to have faster total factor productivity growth. As a result, positive impact of openness on economic growth is expected in Sub-Saharan Africa.

ICRG composite score measures the institutional development level of a country, calculated as the sum of the risk scores in 12 subcategories, including government stability, socioeconomic conditions, investment profile, internal conflict, external conflict, corruption, military in politics, religious tensions, law and order, ethnic tensions, democratic accountability, and bureaucracy quality. The composite scores range from 0 to 100, with higher scores representing better institutions. Acemoglu *et al.* (2001) find that better institutions tend to increase economic growth.

Conflict intensity, measured as the continuous intensity of conflict incidence across Africa continent, is the only control variable at sub-national level in equation (1). Since conflict tends to interrupt economic transaction and law of order, I expect higher conflict intensity is associated with lower economic growth.

This article focuses on aid effectiveness and aid spillovers at sub-national level, the major variables of interest are β_1, β_2, β_3 and β_4. However, the effect might also work in the other direction that is from growth to aid. If countries with faster growth systematically receive more or less aid, the simultaneity and reverse causality problem will lead to biased estimators even in a large sample. For example, donors may use aid as a reward for countries which have good economic performance, or allocate more aid to more struggling countries to alleviate poverty. Since aid in the previous period can be perceived as predetermined in current period, lagging aid variables by one period can help alleviate the simultaneity problem. However, if serial correlation exists, aid in one period would be correlated with aid in the next period, with the latter potentially correlated with current economic growth. Chong, *et al.* (2009) address the simultaneity in the aid-growth regressions and suggest using instrumentation to solve the problem. Therefore, we need to find good instruments for aid, which should be correlated with aid variables conditional on other exogenous variables, but uncorrelated with the error term in the original aid-growth regression.

However, as the previous studies show, finding instruments for aid is notoriously hard. Boone (1994), and Burnside and Dollar (2000) use population sizes in recipient countries as instruments for aid. But Clemens *et al*. (2012) show that heavily depending on population size induces weak instrument problem, which indicates population size cannot explain much variation in aid after controlling other exogenous variables. Rajan and Subramanian (2008), and Lessmann and Markwardt (2012) use the relationship between donors and recipients, such as historic relationship, political allies and common languages. The limitation of using relationship variables in this article is that most of the time these variables are defined at the country level. Therefore, they cannot capture aid variation when focusing on sub-national regions. Hansen and Tarp (2001), Lessmann and Markwardt (2012), Angeles and Neanidis (2009), and Askarov and Doucouliagos (2015) apply further lagged aid variables such as aid at *t-2* or *t-3* to build exclusion restriction, but potential serial correlation imposes doubts on the validity of this type of instruments, as mentioned previously. If lagged aid variables are somehow correlated with lagged growth rate (very likely), while growth variable behaves serial correlation, lagged aid variables are invalid to serve as instruments for current growth.

Brückner (2013) argues that large negative causal effect from growth to aid should be accounted for to estimate aid effectiveness on growth. He provides a novel way of building instrumentation and isolating the exogenous part of aid in the aid-growth circle. In the first step, he runs a regression of aid on growth, using rainfall and international commodity price as instruments for growth. Next, he removes the endogenous part of the aid based on the estimated regression coefficients. Then, he uses the "uncontaminated" aid as the instruments for aid-growth regression.

Following his procedure, first I regress aid on growth to capture the potential effects of growth on aid:

$$\ln(1 + aid_{t-1}) = a_i + b_t + c * growth_{i,t} + \epsilon_{i,t} \qquad (2)$$

where $\ln(1 + aid_{t-1})$ is the general form of logged level of aid received at *t-1,* and includes $aid_{i,t-1}^{ADM2}$, $aid_{-i,t-1}^{ADM2}$, $aid_{i,t-1}^{ADM1}$, and $aid_{i,t-1}^{country}$; $growth_{i,t}$ is the growth of income per capita in *i* at *t*. a_i and b_t are ADM2 fixed effects and time fixed effects. I use air temperature and precipitation[21] in region *i* at time *t* as instruments for $growth_{i,t}$, since African economy is heavily based on agriculture and these weather conditions are assumed to affect agricultural output contemporaneously. The exclusion restriction is that current weather conditions should not affect any lagged aid flows.

After capturing the potential endogeneity by c, I measure the adjusted logged aid series as follows:

$$\ln(1 + aid_{t-1}^{*}) = \ln(1 + aid_{t-1}) - c * growth_{i,t} \quad (3)$$

This adjusted aid series is assumed to be exogenous to $growth_{i,t}$ and is used as instruments for $\ln(1 + aid_{t-1})$ in equation (1). Brückner (2013) shows the above process generates consistent estimates of the coefficients of aid variables in equation (1) when simultaneity problem is present.

2.4. Data Description

Table 1 lists the data sources for the main variables used in regressions. The geocoded aid data are from the World Bank Geocoded Research Release, Level 1, Version 1.3 database complied by AidData (Tierney *et al*., 2011), which covers 5,881 projects (5,684 geocoded projects) with 61,243 locations (one project can have multiple locations) around the world over the period 1995-2014. Each aid project is attached with geographic longitude and latitude as well as precision level[22]. The amount of aid disbursement in terms of current US dollars for each aid project is also depicted in the database.

Figures 1-3 show pictures of aid projects allocations across Sub-Saharan Africa at different administrative levels.

[21] The original instrument international commodity price used in Brückner (2013) is not available at the sub-national level in Sub-Saharan Africa.
[22] See appendix for details.

It is a well-known problem that the quality of national accounting data in Africa is low and unreliable. Jerven (2013) in his book illustrates in detail about the poor national accounting statistics in Africa, and how little we know about Africa based on these poor numbers. What is more, GDP or income data at sub-national level in Africa have been barely reported. As a result, I need to use reliable proxy for local economic activities. Recent work has already pointed out that the night lights data can be used to measure economic activity (Elvidge *et al*., 2001; Elvidge *et al*., 2009; Sutton and Costanza, 2002). Henderson *et al*. (2012) in their seminal paper use night lights data to adjust income data in major developing countries, and they find positive elasticity of GDP with respect to lights. Therefore, in this article, I use night lights as my proxy for local income. The night lights data (1992-2013) are observed from satellites of the United States Air Force Defense's Meteorological Satellite Program, which move around the circle out of the earth for 14 times a day. The night lights data cover the intensity of the nights on earth between 65 degree South and 75 degree North, which includes most of the area for human economic activities. The night lights data are depicted as small pixels across the whole world with different lights intensities (from 0 to 63, with 63 the biggest intensity).

Geocoded worldwide population data are from CIESIN and CIAT. Like night lights, population data are also depicted as pixels, with each pixel attached with the population counts falling in that pixel. The continuous data make population measurement at sub-national level possible. This dataset is based on national census survey so the data are only available every five years (1990, 1995 and 2000). They also made the estimated data in years 2005, 2010 and 2015. For the rest of the years, I use linear interpolation to get the projected population to fill the gaps.

Administrative boundaries are from the Global Administrative Areas Database, which provides administrative boundaries at different administrative levels in each country. Each administrative unit is depicted as a polygon, with descriptive information about that unit being attached.

The Armed Conflict Location & Event Data Project (ACLED) (1997-2015) and Uppsala Conflict Data Program (UCDP) (1987-2012) provide geocoded conflicts data, with each conflict incidence displayed as a single point on the map. Since one conflict incidence is not likely to be confined on one single point, based on the incidence locations, I build continuous conflict kernel density weighted by fatalities across the African continent.

Air temperature and precipitation monthly data (1900-2014) are from the website of Center for Climatic Research, Department of Geography, University of Delaware. Like the night lights and population data, both of the weather conditions are depicted as continuous pixel data across the world for the past century. The pixel data capture variation in weather conditions within one country. I take the year average to get annual data series.

Government expenditure, inflation, money supply, openness and fiscal surplus are from World Development Indicators of the World Bank. All of the above variables are only available at country level. ICRG composite score is the sum of the ICRG institutional scores in all the subcategories, also measured at country level. Table 1 lists the data sources for major variables.

Table 2 provides the summary statistics of the data. A typical region gets 220,932.9 US dollars annually at ADM2 level, and is expected to receive 81,441.43 dollars and 7,071.052 dollars from ADM1 and country levels. The mean of aid its weighted neighbor receives at ADM2 level is 228,552 dollars. The annual growth rate of income per capita each year in a typical ADM2 is only 0.042% on average.

GIS appendix discusses the description and processing procedures of spatial data in more details.

2.5. Regression Results

Table 3 shows regression results for Equation (2). In the first stage, I use air temperature and precipitation as instruments for economic growth, as displayed in Column (1). Both air temperature and precipitation have statistical significance, and they are also jointly significant at 1% level. In Columns (2)-(5), I use $aid_{i,t-1}^{ADM2}$, $aid_{-i,t-1}^{ADM2}$, $aid_{i,t-1}^{ADM1}$, and $aid_{i,t-1}^{country}$ as dependent variables, respectively, to estimate parameter c in Equation (2) for simultaneity effects from growth to aid. The instruments for growth in the first stage pass over-identification test in all the columns.

Table 4 shows the regression results for Equation (1). In Column (1), only $aid_{i,t-1}^{ADM2}$ is included in the regression. The coefficient of aid received by this ADM2 is positive and significant at 1% level, indicating aid has positive impact on economic growth at ADM2 level. A 1% increase in lagged aid tends to increase economic growth by 0.979%, which means doubling the aid amount is likely to almost double the growth rate. Lagged income level has negative and significant influence on current growth rate, which is consistent with growth convergence theory: less advanced regions tend to have faster economic growth on average. Government expenditure is negatively associated with economic growth, which indicates there exist potential “crowding out” effects at ADM2 level. Inflation tends to increase transaction costs and harm local economic activities and hence acts as an obstacle to economic growth. ADM2s in countries with higher degrees of openness also enjoy more benefits from international transactions, which are conducive to their growth. Conflict intensity is unexpectedly positively related with economic activities, but does not have significant effect after controlling for other variables, which might be the result of multicollinearity among control variables. We should keep in mind that all the control variables except for conflict intensity are measured at country level due to data limitation and thus the coefficients of these characteristic variables are only indicative, not definitive. Both the Cragg-Donald Wald F statistic and Kleibergen-Paap rk Wald F statistic are far greater than the critical values calculated by Stock and Yogo (2005), indicating the instruments have good power to explain the endogenous aid variables.

In Column (2), I add weighted aid received by adjacent neighbors to capture the potential spillover effects of aid at ADM2 level. The coefficient of aid from this ADM2 is still positive and significant, with the magnitude only slightly reduced. Aid received by the neighbors of *i* also has positive and significant impact on region *i*’s economic growth. The magnitude of spillovers to ADM2 *i* is almost half of the direct effects of aid received by *i*. Thus, ignoring the potential spillover effects of aid can lead to underestimation of the aid effectiveness at local level by almost a third, since the direct aid amount is almost equal to the weighted aid amount from neighbors on average.

Askarov and Doucouliagos (2015a) investigate aid spillovers in transitional economics. They find that aid has positive impact on the growth of recipients but has negative net spillovers on other countries. The channels for negative aid spillovers, they analyze, are emigration of skilled workers and development of institutional environment. Also, they give some explanations for potential positive spillovers: currency appreciation in recipient country could increase imports from nearby countries; established expertise and technical assistant programs could promote total factor productivity and knowledge spillovers to other regions. Since my model captures the spillover effects within one country, the seemingly sensible explanation for the case in this article is improved total factor productivity and knowledge dissemination. However, it is still possible that income effect matters here: aid promotes economic growth and income in recipient regions, and residents in these recipient regions purchase more goods and services from nearby regions, generating positive spillovers to the neighbors.

Only $aid_{i,t-1}^{ADM1}$ is included in Column (3), which captures the effectiveness of the fair share of aid received at more aggregate level (aid received at ADM1 level divided by the number of ADM2s in that ADM1, after excluding aid directly targeted at ADM2 level). Aid received at ADM1 level is negatively associated with economic growth in ADM2 *i*, which means aid targeted at a more aggregate level tends to harm local economic activities. Trade openness and ICRG score switch signs, probably due to potential multicollinearity of these control variables and aid at more aggregate levels.

Based on Column (3), Column (4) adds aid at ADM2 level back. The regression results still shows aid at ADM2 level tends to promote local growth while aid received at more aggregate level is likely to harm growth in ADM2 *i*. The magnitude of aid effectiveness at ADM2 level shrinks by about 20% while the negative impact of aid at

ADM1 level increases by roughly 30%. After including local aid, openness to trade regains positive conditional marginal effects on growth.

In Column (5), $aid_{i,t-1}^{country}$ is the only included aid variable, which measures the effectiveness of fair share of aid at country level (aid targeted at country level divided by the number of ADM2s in that country, after excluding aid targeted at ADM2 and ADM1 levels). Similar to the result in Column (3), the coefficient in Column (5) also shows negative effects of aid on growth.

Column (6) includes all the aid variables in the regression and is my benchmark specification. The coefficient of aid at ADM2 and ADM1 levels still retains the same signs and significance, only with the magnitude slightly reduced. The effectiveness of aid at country level gets the impact cut by almost two thirds, but it is still negative and statistically significant. The regression results indicate that aid targeted at local level tends to promote local growth, while aid targeted at more aggregate levels is likely to hurt local economic growth. For a region with an average amount of aid inflows, the total aid effectiveness on growth at all levels is positive but statistically insignificant[23]. The finding of insignificant total effects is consistent with Rajan and Subramanian (2008), who find little robust aid effectiveness using cross-country data. However, their research is subject to aggregation bias and does not reveal detailed patterns at different levels.

The previous literature provides some insights on my findings. Van de Walle and Mu (2007) investigate the impact of aid on road project in Vietnam and they find that most of the aid allocated stuck to the road sector and no evidence shows that aid

[23] The p-value is 0.822.

was appropriated for other sectoral constructions. On contrary, Boone (1996) finds aid generally increases the size of the government without promoting investment or human development indicators at the country level. More specifically targeted aid tends to be less fungible compared to “general” aid, since a specific project can make detailed plans and track the expenditure without much effort. While aid generally given to a more aggregated level such as ADM1 or country is more likely to be misappropriated for other purposes. What is more, Svensson (2000) shows that foreign aid provides rent-seeking opportunities and is associated with higher corruption. Asongu (2012) also finds evidence that aid promotes corruption in Africa. Easily fungible aid tends to fuel corruption and hurt institutional environment at more aggregate levels, and perhaps that is why we observe negative aid impacts at both ADM1 and country levels. Another conjecture is that locally targeted aid may stimulate participation of local community, who are usually supposed to have better knowledge about local conditions (Feeney, 1998). Also, this case is one example justifying Easterly’s argument that “bottom-up” approach may work better than “top-down” approach in some development policy designs (Easterly, 2008).

Based on Column (6), Column (7) uses OLS approach for the same regression. The coefficients of aid variables at ADM2 levels reverse signs and become both statistically and economically insignificant. The marginal effects of aid at ADM1 and country levels still preserve statistical significance, but their marginal effects drop substantially. Since OLS cannot solve the potential simultaneity problem, the results displayed in Column (7) are potentially biased even in large sample. The comparison between Columns (6) and (7) illustrates that failing to deal with simultaneity problem in aid-growth regressions can lead to very biased results. Failing to remove the potential negative causal impact of growth on aid is one possible reason why previous literature finds conflicting conclusions about aid effectiveness.

2.6. Robustness and Further Exploration

2.6.1. Robustness Check

Several tests are applied in this section to check the robustness of the baseline results (Table 3, Column (6)). In Column 1 of Table 5, considering that some regions might have unstable growth from satellites observations and remote sensing processing, I exclude observations with growth rates below 1st percentile or above 99th percentiles. The coefficients of aid variables shrink substantially to about 20% of the original levels, but still keep the same signs and statistical significance. This exercise suggests that much of the variation is driven by the so-called “outliers”. However, without further information, I cannot tell whether that is the result of data noise or aid is especially effective in these regions.

About 10% of the observations see zero night lights per capita, probably there existed less than enough economic activities to have the lights to be detected by the satellites. Worried by the potential underestimation of the aid effectiveness resulting from undetectability, I exclude all the observations with zero night lights per capita level, which account for about 10% observations. Column 2 displays the new results: all the aid variables have almost the same coefficients as in the baseline regression. The zero income level is not a big concern to affect the aforementioned conclusions.

Contrary to the undetectability problem, sometimes accidents or other incidences would cause abnormally high detected lights. For example, gas flares, which are often observed in the petroleum production field, tend to produce unusually highly intensified lights although little economic activity is underway. Another possibility is the forest fires, which produce lots of lights but are barely qualified to serve as proxy for human economic activities. Columns (3) and (4) keep observations with night lights per capita level less than 95th percentile and 99th percentile, respectively. The magnitudes of coefficients get reduced by 40% and 80% for each case. The underlying indication is that observations with top 5% income levels tend to capture a lot of variations in lights and when excluded, aid effectiveness falls.

Some regions may have received disproportionate aid compared to other regions. They are, in terms of aid amount received, aid outliers. In the last two columns, I exclude observations with aid greater than 99th percentile and 95th percentile. The results barely impose any suspects on my baseline regression results.

The main purpose of taking 4-year averages is to smooth the economic fluctuation and business cycle. However, we need to be aware that how many observations have been using to construct the average in each 4-year period. If in one 4-year period, there are too few observations to make the average (such as only 1 observation in one 4-year window), then the calculated average tends to be further away from the mean and the fluctuation of the sampling distribution gets increased. Therefore, the results are likely to be biased. In Table 6 Column (1), I only include the 4-year window with no less than 2 observations to make the average. The number of observations drops by a half and the coefficient estimates are doubled. Neither the signs nor statistical significance is changed. Column (2) retains these 4-year windows with no less than 3 observations and the conclusions are retained.

The means of aid variables see a jump from the first period (1995-1998) to the second period (1999-2002)[24]. One possible reason is there exist potential missing values in the first period which are not counted in the dataset. Since the regression model uses lagged aid as the key independent variable to explain current economic growth, the regression in the second period is like to suffer from the potential problem of noisy data. Column (3) drops the observations using the first period aid and still gets consistent results.

The previous literature uses fiscal surplus, money supply M2 and openness to trade as measurements of fiscal policy, monetary policy and trade policy. Thus, Column (4) replaces government expenditure with fiscal surplus. Compared to the baseline regression, sample size drops by roughly a half. Column (5) substitutes money supply M2 for inflation rate. In Column (6), both government expenditure and inflation rate are replaced by the alternative measures. In the last column, considering different measurements may capture elements from different aspects, I simply include fiscal surplus and money supply M2 as additional control variables. Column (5) shows essentially the same results as baseline regression, while other columns display larger marginal effects due to dramatically reduced sample sizes. However, the signs and significance of coefficient estimates are not changed and therefore, the previous conclusions are still preserved.

2.6.2. Further Exploration

Equation (1) explains the aid effectiveness on income per capita growth, measured by night lights per capita growth, and therefore focuses on the impact of foreign aid on

[24] The mean of logged aid variables in the first period are 1.448, 3.323, 2.687 and 1.612, and in the second period are 2.938, 5.436, 5.131 and 2.676.

welfare and living standards. An increase in income per capita can result from an increase in total income (total night lights) or decrease in population or both. To distinguish which channel is more important in Sub-Saharan Africa, Table 7 Column (1) replaces the night lights per capita growth and night lights per capita level with total night lights growth and total night lights level in ADM2 *i* and keeps everything else unchanged. All the aid variables retain the same sign – aid tends to have positive impact on total lights growth at ADM2 level, but becomes negative at more aggregate levels. However, the magnitudes of coefficients are much smaller than in Table (4): doubling aid amount only increases total income by around 6% through both direct effects and spillover effects. Moreover, the negative influence at the more aggregate levels is also cut substantially. However, I do observe that aid tends to promote total economic activities at local level and do the opposite at more aggregate levels. The pattern of aid effectiveness on total income of local regions is consistent with the baseline result in aid-growth regression (Table (4), Column (6)).

Column (2) uses population growth in region *i* as the dependent variable and population head counts as the lagged level variable. All the aid variables have reversed signs: aid tends to reduce population growth at ADM2 level but promote it at more aggregate levels. The negative impact of aid received by ADM2 *i* on the population growth in the same ADM2 is not statistically significant. The negative sign can be explained by income effects: as income increases, people tend to reduce fertility rate as well as population growth, just like the trend in rich countries in recent years. The negative impact from neighbors is probably due to labor movements – when aid comes in the neighbors, it creates new job opportunities there and attracts workers from nearby regions; as a result, labor tends to move from region *i* to its neighbors and therefore region *i* would see a decrease in population growth, as argued by Askarov and Doucouliagos (2015a). Aid received at more aggregate levels, could attract labor immigration in a larger area, and tends to promote population growth. But we should be aware that the size of the impact on population growth is pretty small and is economically insignificant.

Column (3) adds the quadratic terms of all aid variables to capture the potential non-linear aid effectiveness. Based on Clemens *et al*. (2012), aid exhibits diminishing returns, which could be captured by the positive marginal effects of aid on growth and negative quadratic aid terms. Except for weighted aid from neighbors, all the direct aid variables and their quadratic terms are consistent with diminishing returns patterns, which suggests the aid effectiveness is a downward parabola. The x-coordinates of the vertices of the four parabolas of logged $aid_{i,t-1}^{ADM2}$, $aid_{i,t-1}^{ADM1}$, and $aid_{i,t-1}^{country}$ are 7.195 , 5.131, and 6.568. Since the mean of logged aid variables are 3.183, 4.884, and 3.728, all the direct aid variables except for weighted aid are on the upward sloping part of their effectiveness. The coefficients of $aid_{i,t-1}^{ADM2}$ and $aid_{i,t-1}^{ADM1}$ are statistically significant at conventional levels while aid received at country level does not show significance. We can conclude that there exist diminishing returns to aid directly received at each level in Sub-Saharan Africa, and all of them fall on the left side of the vertices - the positive marginal effects part. No evidence shows diminishing returns to aid spillovers $aid_{-i,t-1}^{ADM2}$. On the contrary, aid spillovers display increasing returns, but the coefficient is not statistically significant. The vertex (minimum point) of the weighted aid has x-coordinate 5.576. Since an average country has logged weighted aid of 5.682, the amount of average weighted aid, is located at the upward-sloping part of its effectiveness parabola. The functional channels of aid spillovers are mainly resource movements, income effects and technology and knowledge spillovers, which are very different from direct aid which tends to promote investment and capital accumulation directly. Probably that is one reason no evidence shows diminishing returns to weighted aid received by nearby regions. Based on theories of increasing returns and endogenous growth, one possibility is that the spillovers, at least partly, function through technology and knowledge spillovers channels, because technology and knowledge exhibit increasing returns in the production process (Romer, 1986).

Burnside and Dollar (2000) analyze aid effectiveness conditional on policy and conclude that aid promotes growth in developing countries with good fiscal, monetary and trade policies while aid has little effects otherwise. They build a composite policy index based on the contribution of each policy variable (fiscal policy, monetary policy and trade policy) to growth. Next, they include policy and interaction between aid and policy as the independent variable in the aid-growth regression. To make our results comparable with their research and other literature, I use fiscal surplus and money supply as measurements of fiscal policy and monetary policy. Following their procedure, Column (4) reports the 2SLS regression results. All the aid variables are consistent with the baseline specification, while all the interaction terms are statistically insignificant. There is no evidence showing aid effectiveness is conditional on policy, which is consistent with Askarov and Doucouliagos (2015b). One reason might be that all the policies are measured at country level so they are not very accurate when we are considering the local effectiveness and local spillovers. Another possible reason is that the policy data quality of Africa is poor and unable to give indication for this issue.

Apart from policy, institution is another condition which determines aid effectiveness argued by aid literature. Burnside and Dollar (2000) find aid has positive effects on growth conditional on institutional quality. In Column (5), I include the interaction between aid and ICRG score, where ICRG score is a proxy for institutions measured at country level. All the coefficients of aid variables switch signs while the interaction terms have consistent signs with the baseline regression. Aid received at local level has positive impact conditional on institutions and negative conditional effect beyond that. An average country has ICRG score 56.721, so average conditional effects of aid variables are 9.359, 6.977, -12.535 and -15.201. As a result, the net aid effectiveness of aid variables are positive, positive, negative and negative, consistent with the baseline regression. The interaction terms at ADM2 level are only marginally significant, which means probably no strong evidence shows that there might exist systematically stories why institutions could affect aid effectiveness in this way. The negative signs of interactions at more aggregated levels are unexpected. One possibility is still that, we have the same problem as discussed in the policy issue: aid effectiveness conditional on national institutions are probably inaccurate and the results should be interpreted with caution. Similarly, Chong *et al*. (2009) find little evidence that better institutions could increase aid effectiveness.

2.7. Concluding Remarks

This article investigates aid effectiveness and aid spillovers at the sub-national level in Sub-Saharan Africa. Overcoming the aggregation bias and potential simultaneity problem, detailed aid effectiveness patterns have been revealed by using GIS and spatial analytical techniques. Using ADM2 as the administrative unit of analysis, I find that aid targeted at local level tends to promote local economic growth, while aid received at more aggregate levels depresses local economic activities. There exist positive aid spillovers of aid across adjacent neighbors at the local level. The conclusion is very robust to outliers exclusion and different model specifications. I also find that, aid at the local level promotes total economic flourish and slows down population growth, while aid at more aggregate levels depresses total economic activities but stimulates population growth. Aid directly received at all levels exhibits diminishing returns, while aid spillovers show weak increasing returns. There is no systematical evidence showing that aid effectiveness depends on policy or institutions.

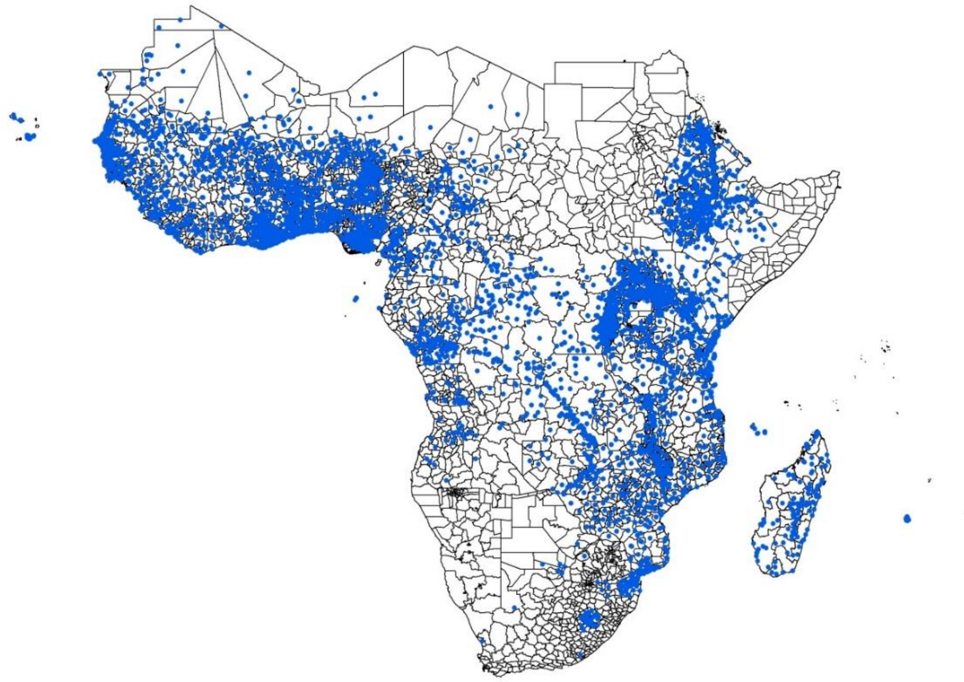
The above findings have very profound policy implications. If the aim is to promote local economic growth, we should focus more on specifically targeted and less-fungible aid projects rather than aid generally given to governments at more aggregate levels. Aid at more aggregate levels might be misappropriated for other purposes and create reek-seeking problems to cause corruption and hurt institutional environment.

Aid received by one ADM2 is likely to positively impact its neighbors' growth, generating positive spillovers. The possible channels are resource movements and technology and knowledge dissemination. To promote the positive spillovers, we should reduce barriers to these activities within the country.

Based on the neo-classical theory, aid directly received is supposed to increase investment and capital accumulation, which should exhibit diminishing returns. My findings are consistent with this theory. However, aid spillovers do not promote capital accumulation in neighbor regions and on the opposite, exhibit increasing returns. Although this result is not statistically significant, we can still argue that aid spillovers partly function through technology and knowledge dissemination, which is consistent with the new-growth theory. If this story is true, promoting positive aid spillovers is very desirable to increase the effectiveness of aid.

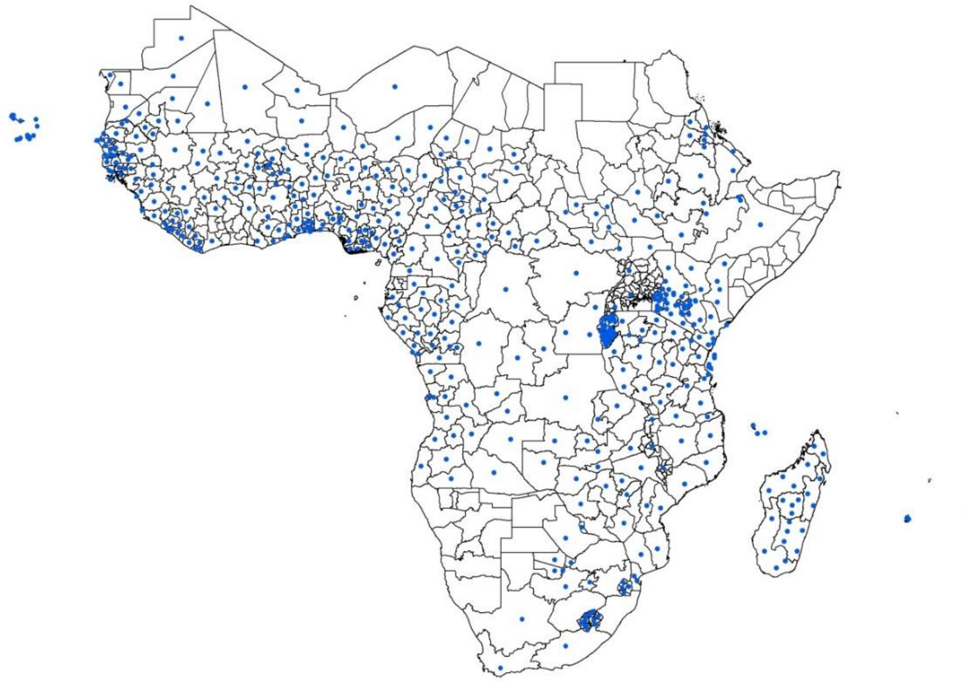
However, there are some limitations in this article. For example, policy and institutions measurements are not available at the sub-national level. As a result, I did not find any systematic story about conditional aid effectiveness. If data are available in the future, that will be a very interesting investigation topic.

Figure 2.1: Aid Projects at ADM2 Level in Sub-Saharan Africa



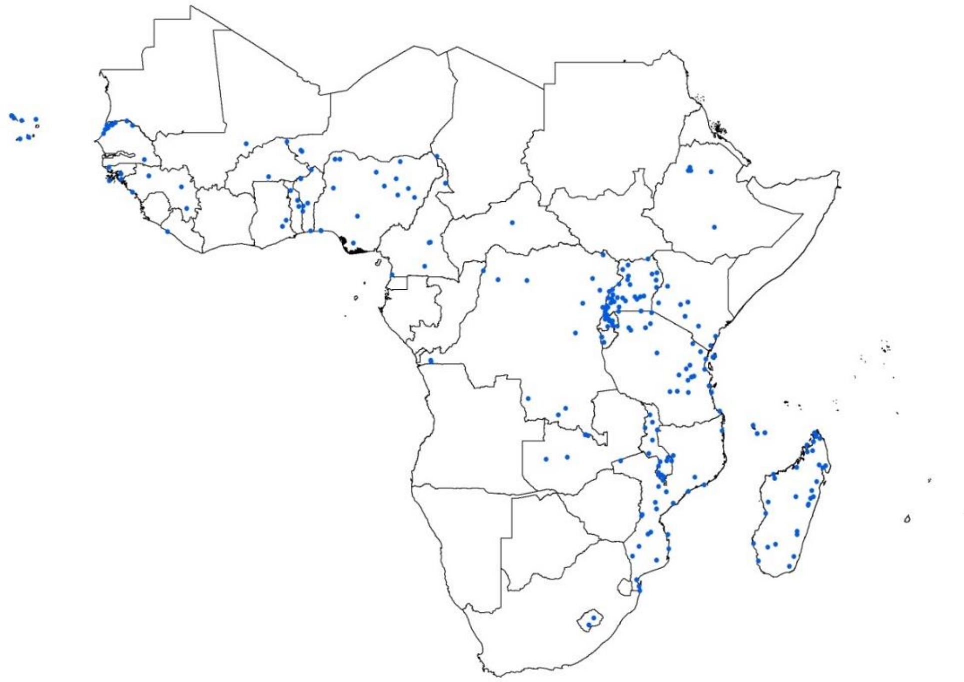
Note: This map shows ADM2 boundaries and aid projects at ADM2 level in Sub-Saharan Africa. ADM2 boundaries are drawn as polygons and aid projects at ADM2 level are depicted as points.

Figure 2.2: Aid Projects at ADM1 Level in Sub-Saharan Africa



Note: This map shows ADM1 boundaries and aid projects at ADM1 level in Sub-Saharan Africa. ADM1 boundaries are drawn as polygons and aid projects at ADM1 level are depicted as points.

Figure 2.3: Aid Projects at Country Level in Sub-Saharan Africa



Note: This map shows country boundaries and aid projects at country level in Sub-Saharan Africa. Country boundaries are drawn as polygons and aid projects at country level are depicted as points.

Table 2.1: Data Sources for the Main Variables

	Data Sources
Aid	AidData (2015)
Night lights	NOAA (2015)
Population	CIESIN and CIAT (2015)
Administrative boundary	Global Administrative Areas Database (2015)
Conflicts	ACLED (2016), UCDP (2016)
Air temperature	University of Delaware (2016)
Precipitation	University of Delaware (2016)
Government expenditure as a share of GDP	WDI (2016)
Inflation rate	WDI (2016)
Money supply as a share of GDP	WDI (2016)
Openness as a share of GDP	WDI (2016)
Fiscal surplus as a share of GDP	WDI (2016)
ICRG score	ICRG (2013)

Table 2.2: Summary Statistics

	N	Mean	Std.Dev.	Min	Max
$aid_{i,t-1}^{ADM2}$	11,619	220,932.9	946,818.8	0	2.88e+07
$aid_{-i,t-1}^{ADM2}$	11,619	228,552	568,713.4	0	1.22e+07
$aid_{i,t-1}^{ADM1}$	11,619	81,411.43	211,936.4	0	3,420,069
$aid_{i,t-1}^{country}$	11,619	7,071.052	19,378.9	0	134,349.4
$growth_{i,t}(\%)$	11,619	0.043	0.735	-16.081	18.651
$\ln(1 + lightspc_{i-1,t})$	11,619	5.054	2.864	0	11.203
$population_{i,t-1}$	11,619	181,432.9	224,338.6	26.922	4,021,980
$conflict_{i,t-1}$	11,619	59.737	737.316	0	40,191.03
$air\ temperature_{i,t-1}$	11,548	24.387	3.894	5.858	30.858
$precipitation_{i,t-1}$	11,548	88.333	45.954	0.460	325.654
$government\ expenditure_{i,t-1}$	11,619	13.669	4.905	2.804	28.930
$inflation_{i,t-1}$	11,619	19.689	37.427	-4.476	319.518
$money\ supply_{i,t-1}$	11,559	27.709	15.863	8.552	78.341
$openness_{i,t-1}$	11,619	65.500	27.987	19.428	253.047
$fiscal\ surplus_{i,t-1}$	6,193	-1.360	3.662	-9.447	21.973
$ICRG\ score_{i,t-1}$	11,619	56.721	10.439	29.608	79.308

Table 2.3: Simultaneity Regression

VARIABLES	(1) $growth_{i,t}$	(2) $aid^{ADM2}_{i,t-1}$	(3) $aid^{ADM2}_{-i,t-1}$	(4) $aid^{ADM1}_{i,t-1}$	(5) $aid^{country}_{i,t-1}$
$air\ temperature_{i,t}$	0.057***				
	(0.021)				
$precipitation_{i,t}$	-0.002***				
	(0.0006)				
$growth_{i,t}$		-21.180*	-14.680*	23.190*	11.850*
		(12.040)	(8.592)	(13.070)	(6.843)
Constant	-1.320**				
	(0.541)				
Observations	22,584	15,056	15,056	15,056	15,056
R-squared	0.034	-22.038	-9.793	-23.974	-9.627
Number of ADM2	3,764	3,764	3,764	3,764	3,764
ADM2 FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
p-value of F statistic	0.000	0.000	0.000	0.000	0.000
Hansen J	-	0.518	0.167	0.130	0.878

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. This table displays the results of Equation (2), regressing growth on aid with air temperature and precipitation as instruments for growth. Column (1) shows the first-stage regression with $growth_{i,t}$ as the dependent variable. Columns (2)-(5) show the second-stage regressions, with$aid^{ADM2}_{i,t-1}$, $aid^{ADM2}_{-i,t-1}$, $aid^{ADM1}_{i,t-1}$, and $aid^{country}_{i,t-1}$ as dependent variables, respectively. Refer to Table 2 for further explanations.

Table 2.4: Baseline Regression Results

VARIABLES	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) OLS
$aid_{i,t-1}^{ADM2}$	0.979***	0.861***		0.667***		0.649***	-0.0004
	(0.116)	(0.107)		(0.077)		(0.074)	(0.001)
$aid_{-i,t-1}^{ADM2}$		0.405***		0.611***		0.606***	-0.0003
		(0.052)		(0.071)		(0.069)	(0.001)
$aid_{i,t-1}^{ADM1}$			-0.790***	-1.042***		-0.945***	-0.009***
			(0.081)	(0.115)		(0.104)	(0.002)
$aid_{i,t-1}^{country}$					-0.680***	-0.234***	-0.006***
					(0.067)	(0.031)	(0.002)
$\ln(1 + lightspc_{i-1,t})$	-17.660***	-16.430***	-28.010***	-28.910***	-25.540***	-30.280***	-18.280***
	(3.519)	(3.866)	(3.314)	(3.477)	(2.991)	(3.482)	(2.425)
$government\ expenditure_{i,t\text{-}}$	-0.233***	-0.283***	-0.050***	-0.342***	-0.159***	-0.386***	-0.002
	(0.033)	(0.041)	(0.015)	(0.045)	(0.018)	(0.048)	(0.002)
$inflation_{i,t-1}$	-0.044***	-0.059***	-0.020***	-0.089***	0.048***	-0.069***	0.003***
	(0.007)	(0.009)	(0.004)	(0.012)	(0.005)	(0.010)	(0.0008)
$openness_{i,t-1}$	0.020***	0.027***	-0.009***	0.018***	-0.010***	0.015***	-0.002***
	(0.004)	(0.005)	(0.003)	(0.004)	(0.002)	(0.004)	(0.0003)
$ICRG\ score_{i,t-1}$	-0.061***	-0.077***	0.081***	0.020	0.064***	0.031**	0.010***
	(0.013)	(0.016)	(0.011)	(0.014)	(0.007)	(0.014)	(0.001)
$conflict_{i,t-1}$	0.0003*	0.0002	9.83e-06	0.0002	3.67e-05	0.0002	-1.85e-05
	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(6.80e-05)	(0.0002)	(2.09e-05)
Constant	1.991***	0.769	2.933***	3.801***	2.336***	4.231***	0.021
	(0.524)	(0.564)	(0.443)	(0.725)	(0.317)	(0.731)	(0.072)
Observations	11,386	11,386	11,386	11,386	11,386	11,386	11,619
R-squared	-15.523	-18.662	-10.263	-27.472	-4.912	-27.047	0.270
Number of ADM2	2,863	2,863	2,863	2,863	2,863	2,863	3,096
ADM2 FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
p-value of F statistic	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cragg-Donald Wald F	394.924	164.658	590.419	74.705	1201.773	56.872	-
Kleibergen-Paap rk Wald F	78.642	35.205	104.665	27.981	129.458	21.681	-

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

Table 2.5: Robustness Check to Outliers

VARIABLES	(1) 1st<growth<99th	(2) income>0	(3) income<99th	(4) income<95th	(5) aid<99th	(6) aid<95th
$aid_{i,t-1}^{ADM2}$	0.113***	0.702***	0.364***	0.131***	0.682***	0.899***
	(0.007)	(0.083)	(0.041)	(0.014)	(0.079)	(0.112)
$aid_{-i,t-1}^{ADM2}$	0.108***	0.727***	0.344***	0.126***	0.610***	0.676***
	(0.006)	(0.085)	(0.038)	(0.013)	(0.071)	(0.085)
$aid_{i,t-1}^{ADM1}$	-0.170***	-1.027***	-0.538***	-0.200***	-0.966***	-1.200***
	(0.009)	(0.117)	(0.058)	(0.020)	(0.108)	(0.145)
$aid_{i,t-1}^{country}$	-0.040***	-0.302***	-0.131***	-0.048***	-0.231***	-0.170***
	(0.004)	(0.040)	(0.017)	(0.006)	(0.032)	(0.033)
$\ln(1+lightspc_{i-1,t})$	-14.420***	-30.200***	-28.140***	-28.760***	-30.600***	-33.150***
	(1.182)	(3.627)	(3.429)	(2.504)	(3.553)	(3.964)
$government\ expenditure_{i,t-1}$	-0.072***	-0.536***	-0.221***	-0.085***	-0.413***	-0.633***
	(0.005)	(0.066)	(0.027)	(0.010)	(0.053)	(0.083)
$inflation_{i,t-1}$	-0.013***	-0.073***	-0.039***	-0.014***	-0.071***	-0.109***
	(0.001)	(0.011)	(0.005)	(0.002)	(0.010)	(0.015)
$openness_{i,t-1}$	0.002***	0.005	0.008***	0.003***	0.017***	0.0280***
	(0.0007)	(0.006)	(0.002)	(0.0008)	(0.004)	(0.006)
$ICRG\ score_{i,t-1}$	0.010***	-0.014	0.022***	0.013***	0.035**	0.100***
	(0.003)	(0.018)	(0.008)	(0.003)	(0.015)	(0.021)
$conflict_{i,t-1}$	2.61e-05	0.0002	9.75e-05	2.47e-05	0.0001	1.29e-05
	(3.44e-05)	(0.0002)	(9.98e-05)	(3.81e-05)	(0.0002)	(0.0001)
constant	0.690***	9.384***	2.311***	0.764***	4.507***	4.324***
	(0.128)	(1.102)	(0.404)	(0.150)	(0.777)	(0.950)
Observations	11,133	9,678	11,263	10,799	10,905	9,686
R-squared	-5.247	-26.727	-16.652	-6.314	-27.768	-32.992
Number of ADM2	2,838	2,507	2,837	2,733	2,827	2,661
ADM2 FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
p-value of F statistic	0.000	0.000	0.000	0.000	0.000	0.000
Cragg-Donald Wald F	279.542	47.479	95.961	232.189	52.492	38.100
Kleibergen-Paap rk Wald F	121.845	20.363	23.095	29.875	20.960	17.880

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

Table 2.6: Robustness Check to Model Specifications

VARIABLES	(1) n≥2	(2) n≥3	(3) no first period aid	(4) fiscal surplus	(5) M2	(6) fiscal surplus and M2	(7) fiscal surplus and M2 added
$aid_{i,t-1}^{ADM2}$	1.235***	1.381***	0.599***	1.285***	0.634***	1.039***	1.305***
	(0.196)	(0.236)	(0.077)	(0.204)	(0.070)	(0.136)	(0.210)
$aid_{-i,t-1}^{ADM2}$	1.593***	1.658***	0.577***	1.320***	0.571***	0.876***	1.738***
	(0.248)	(0.284)	(0.074)	(0.208)	(0.063)	(0.115)	(0.274)
$aid_{i,t-1}^{ADM1}$	-2.513***	-2.755***	-1.056***	-2.078***	-0.879***	-1.520***	-2.526***
	(0.370)	(0.436)	(0.128)	(0.314)	(0.093)	(0.190)	(0.383)
$aid_{i,t-1}^{country}$	-1.429***	-1.459***	-0.075***	-1.335***	-0.287***	-1.291***	-1.820***
	(0.252)	(0.281)	(0.025)	(0.219)	(0.035)	(0.172)	(0.304)
$\ln(1 + lightspc_{i-1,t})$	-34.640***	-36.090***	-46.280***	-22.110***	-28.410***	-19.190***	-23.770***
	(5.314)	(5.789)	(4.429)	(5.297)	(3.180)	(3.984)	(4.880)
$government\ expenditure_{i,t-1}$	-1.745***	-1.947***	-0.137***		-0.259***		-1.468***
	(0.271)	(0.327)	(0.037)		(0.034)		(0.229)
$inflation_{i,t-1}$	0.0571*	0.076*	-0.091***	-0.164***			0.085***
	(0.033)	(0.039)	(0.014)	(0.034)			(0.028)
$openness_{i,t-1}$	0.223***	0.277***	0.025***	0.234***	0.016***	0.091***	0.389***
	(0.039)	(0.055)	(0.005)	(0.039)	(0.004)	(0.018)	(0.063)
$ICRG\ score_{i,t-1}$	0.069	0.306**	0.072**	-0.238***	0.007	0.086**	0.149*
	(0.083)	(0.147)	(0.029)	(0.078)	(0.012)	(0.038)	(0.076)
$conflict_{i,t-1}$	0.0001	0.001	0.0001	-0.003***	0.0002***	-9.75e-05	-0.0003
	(0.002)	(0.003)	(0.0002)	(0.0009)	(4.84e-05)	(5.98e-05)	(0.0006)
$fiscal\ surplus_{i,t-1}$				-0.151***		-0.303***	-0.433***
				(0.057)		(0.051)	(0.083)
$money\ supply_{i,t-1}$					-0.100***	-0.0009***	-0.446***
					(0.014)	(0.0002)	(0.084)
constant	10.037**	-4.177	-0.902	3.531	6.099***	-8.261***	6.709
	(4.378)	(5.678)	(1.087)	(3.370)	(0.825)	(2.637)	(3.704)*
Observations	5,219	4,892	8,589	5,921	11,809	6,404	5,633
R-squared	-41.340	-46.401	2,863	-46.417	-25.385	-31.182	-48.608
Number of ADM2	1,893	1,823	-18.476	2,137	3,024	2,298	2,065
ADM2 FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES
p-value of F statistic	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cragg-Donald Wald F	13.820	11.530	46.714	14.217	62.108	22.923	12.752
Kleibergen-Paap rk Wald F	11.614	9.875	17.828	11.265	23.261	16.992	11.211

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

Table 2.7: Further Explorations

VARIABLES	(1) total lights	(2) population	(3) quadratic aid	(4) policy	(5) institutions
$aid_{i,t-1}^{ADM2}$	0.052***	-4.78e-05	2.662***	0.817*	-8.061*
	(0.009)	(4.38e-05)	(1.029)	(0.465)	(4.616)
$aid_{-i,t-1}^{ADM2}$	0.060***	-0.0001***	-2.035	0.750***	-5.905*
	(0.008)	(4.14e-05)	(2.029)	(0.277)	(3.257)
$aid_{i,t-1}^{ADM1}$	-0.063***	0.0002***	5.136*	-1.870***	10.560*
	(0.012)	(6.51e-05)	(2.752)	(0.594)	(5.618)
$aid_{i,t-1}^{country}$	-0.037***	0.0001***	1.603	-0.493	13.080**
	(0.005)	(2.08e-05)	(2.874)	(2.301)	(6.293)
$(aid_{i,t-1}^{ADM2})^2$			-0.185**		
			(0.078)		
$(aid_{-i,t-1}^{ADM2})^2$			0.182		
			(0.151)		
$(aid_{i,t-1}^{ADM1})^2$			-0.501**		
			(0.236)		
$(aid_{i,t-1}^{country})^2$			-0.122		
			(0.262)		
$\ln(1 + level_{i-1,t})$	-0.778***	0.011***	1.557	-20.790***	-50.020***
	(0.019)	(0.0009)	(17.840)	(4.105)	(15.980)
$government\ expenditure_{i,t-1}$	-0.035***	2.63e-05	0.445		1.277
	(0.007)	(2.96e-05)	(0.343)		(0.785)
$inflation_{i,t-1}$	-0.005***	-2.05e-05***	0.055		0.411*
	(0.001)	(6.36e-06)	(0.105)		(0.221)
$openness_{i,t-1}$	0.0004	-6.50e-05***	-0.024**		0.090**
	(0.0006)	(2.22e-06)	(0.010)		(0.040)
$ICRG\ score_{i,t-1}$	0.030***	2.15e-05**	-0.067*	-0.076	0.029
	(0.003)	(9.46e-06)	(0.035)	(0.096)	(0.096)
$conflict_{i,t-1}$	-4.03e-05	3.64e-08	-0.0001	-7.22e-05	0.002
	(4.00e-05)	(1.30e-07)	(0.0004)	(8.29e-05)	(0.001)
$policy_{i,t-1}$				-79.540***	
				(26.410)	

Continued Table 7

VARIABLES	(1) total lights	(2) population	(3) quadratic aid	(4) policy	(5) institutions
$aid_{i,t-1}^{ADM2} * policy_{i,t-1}$				3.526	
				(11.330)	
$aid_{-i,t-1}^{ADM2} * policy_{i,t-1}$				0.434	
				(6.127)	
$aid_{i,t-1}^{ADM1} * policy_{i,t-1}$				4.253	
				(12.850)	
$aid_{i,t-1}^{country} * policy_{i,t-1}$				-13.950	
				(55.710)	
$aid_{i,t-1}^{ADM2} * ICRG\ score_{i,t-1}$					0.165*
					(0.089)
$aid_{-i,t-1}^{ADM2} * ICRG\ score_{i,t-1}$					0.123*
					(0.064)
$aid_{i,t-1}^{ADM1} * ICRG\ score_{i,t-1}$					-0.221**
					(0.110)
$aid_{i,t-1}^{country} * ICRG\ score_{i,t-1}$					-0.268**
					(0.127)
constant	5.215***	-0.034***	-91.933	108.047	312.634**
	(0.381)	(0.006)	(256.415)	(347.632)	(132.134)
Observations	11,386	11,386	11,386	6,404	11,386
R-squared	0.286	0.409	-66.765	-31.332	-250.554
Number of ADM2	2,863	2,863	2,863	2,298	2,863
ADM2 FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
p-value of F statistic	0.000	0.000	0.000	0.000	0.009
Cragg-Donald Wald F	32.908	30.434	0.598	1.741	0.805
Kleibergen-Paap rk Wald F	10.714	9.856	1.128	0.598	0.556

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

Appendix 2.A. Country List

Table 2.A.1: Country List

Angola	Gabon	Nigeria
Benin	Gambia, The	Rwanda
Botswana	Ghana	São Tomé and Principe
Burkina Faso	Guinea	Senegal
Burundi	Guinea-Bissau	Seychelles
Cabo Verde	Kenya	Sierra Leone
Cameroon	Lesotho	Somalia
Central African Republic	Liberia	South Africa
Chad	Madagascar	South Sudan
Comoros	Malawi	Sudan
Congo, Dem. Rep.	Mali	Swaziland
Congo, Rep	Mauritania	Tanzania
Côte d'Ivoire	Mauritius	Togo
Equatorial Guinea	Mozambique	Uganda
Eritrea	Namibia	Zambia
Ethiopia	Niger	Zimbabwe

Source: World Bank

Appendix 2.B. GIS Processing Details

This research heavily relies on Geographic Information Systems (GIS) knowledge and skills to process the data. This appendix summarizes the major GIS work used in this paper.

Country boundary polygon data are from the Global Administrative Areas Database. This database provides administrative boundaries data at different levels (up to ADM5, only available for France and Rwanda at that level) for each country. Many countries have the data at a more aggregated administrative level (such as ADM1 or ADM2), but not at a less aggregated level (such as ADM4 or ADM5). For most Sub-Saharan countries, ADM2 is the reasonable choice because that is the administrative level that could balance precision at sub-national level against availability of the data for many countries. The database provides boundaries for each individual country as a single map, and I use the Plugin “MMQGIS” in QGIS (Version 2.10.1) to merge the individual countries into a single continent[25].

To capture the spillover effects, a matrix containing the information how one ADM2 is related to other ADM2s by using certain weights needs to be established. In this paper, I use adjacency weighting. The weighting matrices are calculated using R (Version 3.2.4 Revised). The package “spdep” provides the function “poly2nb”, which can extract the information of the adjacent neighbors for each ADM2 to build the adjacency matrix.

Aid data are from the World Bank Geocoded Research Release, Level 1, Version 1.3 database complied by AidData, which covers 5881 projects (5684 geocoded projects) with 61243 locations (one project can have multiple locations) around the world over 1995-2014. Each record has a precision code value attached to indicate the precision of the location aid is targeted. The precision levels are:

Table 2.A.2: Precision Code Table

Precision Code Value	Precision Code Description
1	coordinates correspond to an exact location or populated place
2	coordinates correspond to a location that is known to be within 25km of the coordinates or a division smaller than ADM2
3	coordinates correspond to an ADM2 division (as defined by GAUL)
4	coordinates correspond to an ADM1 division (as defined by GAUL)
5	estimated coordinates of a large feature, such as rivers or national parks
6	coordinates correspond to the entire country, project operates in sub-national locales but they are not known
8	coordinates correspond to the entire country, it is likely that the funding goes to a government ministry or financial institution

Note: This table is copied directly from the attached pdf file of the database. The initial table does not have “7” value.

[25] One advantage of using QGIS is that it can read zip files directly. Since the Global Administrative Areas Database makes the data of each country a zip file, using QGIS is much more time-efficient than other computer programs.

I calculate the aid flowing to an ADM2 by summing the aid records with precision code no more than 3 within the boundary of that ADM2, and the aid flowing to an ADM1 with precision code value 4, and the aid flowing to a country beyond 4. All the calculations are computed in R (Version 3.2.4 Revised).

This paper uses night lights data as the proxy for economic activities, considering the unavailability of GDP data at sub-national level and poor quality of GDP data at country-level in Sub-Saharan Africa. The night lights dataset uses 30 arc-second pixels (1/120th of a degree of latitude and longitude, approximately 0.86 square kilometers at the equator) to represent the light intensity on the earth. Pixels are on a scale from 0 to 63, with 0 no light and 63 the highest lights intensity. The data shows the yearly average lights intensity on the earth over 1992-2013. For some years, two satellites were used and the data are reported separately. For the overlapping years, this paper takes the average of the both satellites, which is consistent with the convention[26]. I use ArcGIS desktop (Version 10.3) to create a Model Builder[27] which incorporates the toolbox command "Zonal Statistics as Table" to sum and export the total lights falling within each ADM2.

The population count grid data are from CIESIN and CIAT, with 2.5 arc-minutes resolution (about 4.625 kilometers times 4.625 kilometers at the equator) in years 1990, 1995 and 2000, also the estimated data in 2005, 2010 and 2015. The dataset is based on national census survey so the data are only available every five years. I use interpolation to calculate the population data for the rest of the years. This has been the one of the best available and one of the most popular data sources at sub-national level

[26] "Night Lights and ArcGIS: A Brief Guide", http://economics.mit.edu/files/8945

[27] Using Model Builder is an efficient way to process multiple collections of the data using the same procedure.

as far as I know. I followed almost the same procedure as the night lights data to calculate and export the population data in each ADM2: using ArcGIS desktop (Version 10.3) to create a Model Builder which incorporates the toolbox command “Zonal Statistics as Table” to sum the data up at ADM2-level.

After getting the night lights data and population data in each ADM2, the night lights per capita, which is a proxy for well-being or standard of living, is just computed by dividing total night lights by total population in that ADM2[28].

Conflicts geocoded data are from the Armed Conflict Location & Event Data Project (ACLED) (1997-2015) and Uppsala Conflict Data Program (UCDP) (1987-2012). Each conflict event is displayed as a point on the map with additional explanatory information attached. I use ArcGIS (Version 10.3) Model Builder with “Kernel Density” tool incorporated to build a raster map of conflicts kernel density weighted by facilities in each year, and extract the density based on ADM2 polygons[29].

Air temperature and precipitation data are got from the databases “Terrestrial Air Temperature: 1900-2014 Gridded Monthly Time Series (Version 4.01)” and “Terrestrial Precipitation: 1900-2014 Gridded Monthly Time Series (Version 4.01)”, which are available on the website of Center for Climatic Research, Department of Geography, University of Delaware. The data are monthly time-series data from 1900 to 2014, with 0.5 by 0.5 degree resolution (about 55.5 kilometers by 55.5 kilometers at the

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[28] Since night lights data and population data do not have the same resolution, resampling the data and doing raster calculation to make a single raster map for night lights per capita would cause unnecessary information loss and thus the result might not be very accurate. Calculating total lights and population falling within one ADM2 and then dividing the two numbers to get night lights per capita is more desirable.

[29] Some previous work just simply sum the conflicts based on each ADM2. However, a conflict event displayed as a point does not necessarily indicate that event was happening at a single point and was confined within that ADM2 (since no precision code is attached). Many conflict events are destructive, or at least, disruptive, in some scope, so I build kernel density first instead of simply summing them up.

equator). Since the resolution is not very precise at ADM2-level, I use the “small” option[30] from the function “extract” from “raster” package used in R (Version 3.2.4 Revised) to preserve more observations for the yearly average as well as the dispersion in one year of air temperature and precipitation in each ADM2.

[30] Otherwise no value would be returned if the polygon does not touch the center of any raster cells.

Chapter 3: Foreign Aid Allocation and Conflict in Sub-Saharan Africa: A Spatial Analytical Approach

3.1. Introduction

Foreign aid has become an increasingly important part of international assistance in recently years. Tremendous amount of aid has flown to the less developed countries (LDC) around the world during the last decade. There have been concerns about the effectiveness of foreign aid, as well as its impacts on other aspects of social and economic development, such as peace.

In many situations, wars and violence are destructive. They not only abrupt law and order for normal economic activities, but also destroy or run out infrastructure, labor and other resources which could have been used for production. As such, violence is an important concern in poverty eradication and economic development promotion considerations. The possible effects of foreign aid on armed conflict has been a hotly debated topic in recent aid-related literature.

Most of the studies of this topic focus on the impacts of aid received by a country on the conflict falling within its territory, and many use panel data for the investigations. Collier and Hoeffler (2002) find that aid does not affect conflict risk directly, but does affect it indirectly through growth rate and primary commodity exports. Collier and Hoeffler (2007) note that aid can increase military spending, which can fuel conflict, or reduce conflict if rebellions are deterred. De Ree and Nillesen (2009) find aid flows have a significant negative impact on the probability of conflict to continue, but not on the probability of conflict to start. Nielsen et al. (2011) conclude that a reduction in aid flows could lead to increased probability of conflict onset in 139 countries.

The investigations at country level provide invaluable insights of the effects of aid on conflict in Sub-Saharan Africa, a typical region of aid receiving. However, in many situations, both aid and conflict can be viewed as local activities. As a result, exploring this topic at local level is necessary. Crost et al. (2014) use an arbitrary poverty line as the cutoff for regression discontinuity design in Philippines, and find that barely eligible municipalities have more conflict casualties than barely ineligible counterparts. Findley et al. (2011) employ geo-referenced aid data and conclude that fungible aid tends to promote conflict in three African countries. Strandow et al. (2016) also investigate this topic by using the geo-referenced data, and find that aid is positively related to the probability of violent conflict under a matching design.

Following Findley et al. (2011) and Strandow et al. (2016), this paper also uses geo-referenced aid data from AidData.org to investigate the possible impacts of aid on armed conflict at individual aid project points. Instead of focusing on the probability of conflict onset or continuation, I will capture conflict intensity by investigating the effects of aid on local aid occurrences and fatalities. Also, I will look at conflict of different time precisions and of different types. To my best knowledge, this paper is the first one to investigate the effects of local aid on local conflict occurrences and fatalities of different time precisions and types.

However, the impacts of aid on conflict is not easy to identify because donors may give aid based on their anticipated conflict in recipients or other factors that are closely related to conflict. The potential endogeneity problem has prevented the cause effects of aid on conflict from being identified. Perhaps the most popular way of solving this problem is to use instrument variables, which are supposed to be correlated with aid, but not directly correlated with conflict. For example, Collier and Hoeffler (2002) use lagged aid variable to instrument aid in current period. What is more, De Ree and Nillesen (2009) use GDP levels of donor countries as instruments for aid given to recipients. The aid effectiveness literature also provides possible instruments such as population sizes in recipient countries (Boone, 1994; Burnside and Dollar, 2000) and historical, political and cultural connections between donors and recipients (Rajan and Subramanian, 2008; Lessmann and Markwardt, 2012). Also, other solutions have been adopted as well. For example, Nielsen et al. (2011) address endogeneity problem by using matching method to make the aid shocks "as if random".

Once focusing on the local level, the conventional instruments for aid variable such as the donors' or recipients' characteristics or the relations between donors and recipients do not vary within one country. With limited choices, lagged aid may serve as workable instruments for current aid – conditional on other control variables, lagged aid variables are correlated with current aid, but do not affect conflict directly. Instrumenting for current aid enables me to bypass the endogeneity problem and make indicative results for further explorations.

The rest of this paper is organized as follows: Chapter 2 gives numerical models being used in empirical test; Chapter 3 introduced both spatial and non-spatial data and summarizes statistics of the data; Chapter 4 shows regression results with further exploration; the last chapter concludes and makes further discussions.

3.2. Empirical Model

To investigate the possible effects of aid on conflict at local level, based on current literature (De Ree and Nillesen, 2009; Findley et al, 2011), I use the following regression model:

$$conflict_{i,t+1} = \beta_0 + \beta_1 * conflict_{i,t} + \beta_2 * \ln\left(1 + aid_{i,t}\right) + \gamma' X_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \qquad (1)$$

Where $conflict_{i,t+1}$ is the number of conflict occurrences or fatalities in region *i* at *t*. In current aid literature, four-year period is often built to smooth economic fluctuations. Following Burnside and Dollar (2000), Collier and Hoeffler (2004) and Clemens et al. (2012), I construct four-year windows as the time unit of my study. $conflict_{i,t}$ is the conflict intensity in current period. The aid variable $aid_{i,t}$ is the aid commitment to region *i* at time *t*, in terms of US dollars. If current aid commitment has impacts on future conflict intensity, we should expect the coefficient β_2 is statistically different from zero. δ_i and δ_t are region fixed effects and time fix effects to capture region-specific and time specific impacts on future conflict.

The control variables are captured by matrix $X_{i,t}$, which includes: logged night lights as proxy for economic activities in region *i* at *t*; logged population in region *i* at *t*; natural resource rents as percentage of GDP at country level; ICRG scores for religious tensions, ethnic tensions and military in politics, all of which are measured at country level. All these control variables are expected to affect future conflict directly.

3.3. Data

The aid dataset being used in this article is from AidData.org. AidData provides data for 5684 geocoded aid projects in 61243 locations worldwide over 1995-2014. One project can be located in multiple places, and in that case, the aid amount is evenly split to each location. For each location, a precision code is also attached to indicate the coverage scope, from an exact location to the entire country. Based on the data record, 1-3 are assigned to aid projects within ADM2s (second administrative divisions, equivalent to U.S. counties), 4 to aid projects within ADM1s (first administrative divisions, equivalent to U.S. states), 5 and above to the country level. For most aid projects in Sub-Saharan Africa, the precision codes are no more than 3, which mean these aid projects are at most targeted at an area no larger than ADM2s, such as districts or counties. For aid going to ADM1s, I divide the total amount of aid by the numbers of ADM2s in that ADM1, to get the fair share of aid amount to each ADM2. For aid going to a country, I follow the same step to calculate the fair share of aid mount given to each ADM2. Then I add aid going directly to ADM2s, the fair share of aid amount to that ADM2 at both ADM1 and country levels, to get the total amount of aid each ADM2 receives. For example, if one ADM2 receives $1,000,000 directly, and it is supposed to get $300,000 from ADM1 and $200,000 from the country, the total amount of aid going to that ADM2 is $1,500,000.

Armed conflict events geocoded datasets are from Armed Conflict Location & Event Data Project (ACLED) (1997-2015). Armed conflict events are defined as events with political authority (such as government) involved and force used under political purposes or motivations. I use both conflict occurrences and fatalities to capture the conflict intensity across African continent in different years. Also, a time precision level is attached for each conflict event, which can be day, week or month, meaning that either the conflict event actually lasted for days, weeks or months, or the event was within several days, weeks or months based on current information. Also, a type is assigned to each conflict event, which can be: Battle-No change of territory, Battle-Non-state actor overtakes territory, Battle-Government regains territory, Headquarters or base established, Strategic development, Riots/Protests, Violence against civilians, Non-violent transfer of territory, and Remote violence. In this paper, I combine the first three types into one single composite type – Battle, since essentially they are the same in nature regardless of the final results.

Administrative boundary datasets are from Global Administrative Areas Database, which are available at different administrative levels (district, provincial and national levels). To control for other possible factors that are correlated with conflict, I use night lights data from NOAA as proxy for economic activities, and gridded population data from CIESIN and CIAT, both of which vary at local level.

The control variable natural resource rents as a percentage of GDP is retrieved from World Development Indicators (WDI), as an approximation for part of resources available for being looted. Scores for religious tensions, ethnic tensions and military in politics are from ICRG, being measured on a 0 to 6 scale, with 0 the highest religious tensions, the highest ethnic tensions and the highest military in politics for each case.

Table 1 lists the main datasets and their sources. Table 2 shows the summary statistics of the data.

3.4. Regression Results

Table 3 shows the regression results for equation (1), using total conflict occurrences and fatalities as dependent variables. Columns (1) and (6) only include aid, current conflict level and fixed effects, instrumenting current aid by aid in two lagged periods (*t-1* and *t-2*). Based on the two columns, Columns (2) and (7) add ADM2 level control variables – total lights and population. Country level control variables – natural resources rents, religious tensions, ethnic tensions, and military in politics are introduced into Columns (3) and (8) as well. My baseline regressions, as displayed in Columns (3) and (8), include variable of interest, current conflict, ADM2 level control variables and country level control variables, and two way fixed effects, with current aid being instrumented by aid in two lagged periods. Current aid tends to negatively affect both future conflict occurrences and fatalities – a one percentage point increase in aid tends to decrease conflict occurrences by 0.00258 and conflict fatalities by 0.01321, or doubling aid tends to decrease conflict occurrences by 0.258 and conflict fatalities by 1.321. Regions with higher current conflict are likely to suffer higher future conflict, as indicated by the estimated coefficient of current conflict occurrences and fatalities. Total economic activities, as with night lights as proxy, are positively associated with future conflict, with the possibility that more resources are available for being looted. Population is negatively correlated with future conflict, but is only significant for conflict fatalities. Natural resources rents as a percentage of GDP tends to promote future conflict occurrences, but has insignificant impacts on conflict fatalities. Regions with higher religious tensions are likely to see higher conflict occurrences and fatalities in the next period. Ethnic extensions and military in politics are at most marginally significant in contributing future conflict. It is possibly that aid donors choose the receipt regions by conflict in the previous period. In Columns (4) and (9), I calculate the propensity score of aid receiving based on characteristics in the previous period and add the score as additional control variable in regression. Adding propensity score does not change my conclusion, but the score itself shows positive and significant effects on future conflict. The finding indicates that the expectation of receiving aid can intensify conflict, while actual receiving aid tends to reduce conflict. Columns (5) and (9) display OLS results, with aid insignificantly impacting conflict occurrences and has much smaller effects on conflict fatalities, which indicates that failing to solve the endogeneity problem may get misleading conclusions.

The finding of negative effects of aid on conflict is consistent with Collier and Hoeffler (2002), De Ree and Nillesen (2009), and Nielsen et al. (2011), who find statistically and economically significant negative relationships between aid and conflict. The possible channels, they argue, are that aid helps to increase government's military power (or potential) to preserve peaceful status, in which aid deters conflict; also, aid can also help to promote economic conditions to reduce conflict.

Table 4 displays robustness check results for the baseline regressions (Columns (3) and (8) in Table (3)). Columns (1) and (6) show the results for those regions with positive conflict occurrence and fatalities, respectively. Some regions have extremely high conflict, and Columns (2) and (7) restrict regressions being taking for regions below the 95th percentile of conflict. Columns (3) and (8) only considers aid mount being received to be less than 95th percentile. Columns (5) and (9) only allows regions with positive lights and columns (5) and (10) only keep regions with positive population. Almost all the results show the pattern which is consistent with the initial conclusion.

Table 5 displays further exploration. In the first two columns, I take the first different of conflict and add fixed effects back to control for potential trend. The coefficients of aid are still negative, but aid now has insignificant effects on conflict fatalities. In Columns (3) - (6), I classify countries with lower than mean income as low-income countries and high-income countries otherwise. Aid has negative impact on both conflict occurrence and fatalities for low-income countries, but insignificant effects on high-income countries.

Table 6 displays the regression results for conflict occurrences and fatalities by time precision, indicating the level of certainty of the date, which can be day, week and month. For example, if one conflict event has “week” as its time precision, that means either the conflict event actually lasted for weeks, or the event was within several days or weeks, but not months. Aid tends to have positive and significant effects on future conflict with time precision “day”, but the magnitude and/or statistical significance drop as precision moves from day to week to month. Aid seems to be especially effective in reducing conflict occurrences or fatalities with higher level of certainty of the date. Another possibility is that for conflict events with no accurate information, there are too much “noises” for the data quality, which may lead to insignificant results.

Table 7 shows the regression results of the impacts of aid on conflict occurrences by type. Current aid tends to reduce conflict occurrences with the following types: battle, strategic development, violence against civilians, transfer of territory, and remote violence. Aid flows are also likely to decrease conflict fatalities with the types: battle, riots/protests, violence against civilians, and remote violence. Regression of conflict fatalities on aid for transfer of territory is not possible due to too little variation.

In the previous regression analyses, I find that total economic activities tends to promote conflict while population is negatively associated with future conflict. If that pattern is true, income per capita, a proxy for richness, should be positively correlated with future conflict. In this paper, since GDP data are not available at sub-national level for most of African countries, I use night lights divided by population to get night lights per capita, as a proxy for income per capita.

Table 9 shows the regression results for equation (1), with logged night lights per capita replacing logged night lights and logged population. By nature, the new regression equation is a model with restriction that the coefficient of logged night lights being set equal to the coefficient of logged population. The restricted model, however, enables us to explore the possible patterns of income per capita and future conflict in Sub-Saharan Africa. The baseline regressions, as shown in Columns (3) and (7), indicates that richer regions tend to see higher conflict occurrences and fatalities in the following period. A one percentage point increase in night lights per capita is associated with an increase of conflict occurrences by 0.1359 and conflict fatalities by 0.3194 in the next period. Once again, OLS regressions fail to solve the endogeneity problem and lead to false conclusion that aid has insignificant impacts on conflict, as shown in Columns (4) and (8). I also test the effects of aid on conflict occurrences and fatalities by time precision and by type, and find similar conclusions as being discussed previously. Table 10 shows the tested empirical relationship between income per capita and conflict by time precision. Tables 11 and 10 display the regression results of conflict occurrences and fatalities on aid. Similar patterns are detected as compared to the unrestricted model.

The positive association of income per capita and future conflict is confusing and counterintuitive. One possible reason is that Sub-Saharan countries have very low income per capita on average, and increasing income marginally means there will be more resources available for being looted. After income per capita hits some threshold, higher income is negatively correlated with conflict. In other words, the effects of income per capita has non-linear impacts on conflict. Table 13 shows the regression results with squared logged night lights per capita added based on Table 9. The squared logged aid has positive and significant impacts on conflict occurrences, justifying the existence of non-linear inverse U shaped relationship between income per capita and conflict occurrences. Unfortunately, Sub-Saharan Africa has average night lights per capita (0.0287) located on the left-hand side of the topmost point (with x-axis night lights per capita 1.0414, about 36 times as the average of Sub-Saharan Africa), and an increase in night lights per capita raises conflict occurrences in the following period. No significant non-linear effects are detected for conflict fatalities.

However, because of unavailability of local GDP per capita data, I use night lights as proxy for local economic activities. The previous literature shows positive associations existing between GDP and night lights, as well as between GDP per capita and income per capita. But it is not the case that once GDP increases, night lights also rise proportionately. Henderson et al. (2012) show that the elasticity of measured GDP growth to night lights growth is around 0.3. Also, NOAA reported that some bright parts of the night lights in Africa were caused by gas flares, which can rarely represent human economic activities. The magnitude – the x-axis of the topmost point being 36 times as much as the average of Sub-Saharan Africa – should be interpreted with caution when applying to GDP data. In 2015, Sub-Saharan Africa has GDP per capita

2,312 in current US dollars. Multiply it by 36 gets 83,232 US dollars, which is almost the income per capita of Switzerland.

Tables 14-16 test the non-linearity of income per capita on conflict occurrences and fatalities by time precision and by type. The non-linear relationship seems to exist only for conflict occurrences with higher levels of time precision, and only for one particular type – violence against civilians.

Table 17 adds squared logged aid term to test possible non-linear effects of aid on future conflict. No evidence is found that aid has non-linear effects on conflict occurrences or fatalities when different control variables are introduced.

3.5. Conclusion

This paper investigate the effects of aid on future conflict and finds that aid tends to reduce both conflict occurrences and fatalities in the following period. That is, aid flows help to bring order and peace in the receiving regions. Aid is particularly effective when conflict events with higher levels of time precision get involved, or when certain types of conflict events are under way.

The empirical results shows that income per capita has non-linear effects on conflict occurrences. Unfortunately, Sub-Saharan Africa has income per capita located on the increasing part of the parabola, so adding income per capita marginally tends to increase the resources available to loot, and promote conflict as a result. The non-linear pattern also indicates that Sub-Saharan Africa needs a big push to get out of the low-income-conflict trap. Since aid can reduce conflict occurrences and fatalities, foreign aid, as a result, can alleviate conflict and play an important role in this process.

Table 3.1: Data Sources

Data	Data Sources
Aid	AidData (2015)
Conflict	ACLED (2017)
Night lights	NOAA (2015)
Population	CIESIN and CIAT (2015)
Administrative boundary	Global Administrative Areas Database (2015)
Natural Resource Rents	WDI (2017)
Religious tensions	ICRG (2013)
Ethnic tensions	ICRG (2013)
Military in Politics	ICRG (2013)

Table 3.2: Summary Statistics of Data

	N	Mean	Std. Dev.	Min	Max
Conflict Occurrence					
Total	76940	1.5210	10.6252	0	665
By time					
Day	76940	1.3446	9.6963	0	663
Week	76940	0.1033	1.0468	0	89
Month	76940	0.0731	1.9050	0	216
By type					
Battle	76940	0.4836	4.9129	0	376
Headquarters/base established	76940	0.0096	0.2481	0	26
Strategic development	76940	0.1052	1.1485	0	67
Riots/protests	76940	0.3485	2.6599	0	134
Violence against civilians	76940	0.4694	3.7126	0	259
Transfer of territory	76940	0.0298	0.9394	0	158
Remote violence	76940	0.0748	1.4499	0	142
Fatalities					
Total	76940	8.3752	362.1699	0	64672
By time					
Day	76940	7.2661	338.0884	0	60561
Week	76940	0.5718	15.8841	0	2010
Month	76940	0.5372	90.7399	0	25000
By type					
Battle	76940	5.4918	318.0226	0	61071
Headquarter/base established	76940	0.0003	0.0580	0	15
Strategic development	76940	0.0027	0.2320	0	50
Riots/protests	76940	0.0917	4.9020	0	1018
Violence against civilians	76940	2.3821	98.0157	0	25000
Transfer of territory	76940	0.0260	5.0984	0	1000
Remote violence	76940	0.3806	21.4675	0	5000
Aid ($)	76919	6.85e+07	2.95e+08	0	9.47e+09
Lights	72409	1485.909	4270.281	0	84233
Population	80073	192782.8	329871.4	0	7955719
Lights per capita	72409	0.0287	0.1677	0	11.1728
Natural Resource Rents (% of GDP)	962	13.9099	14.0389	0.0011	89.1661
Religious tensions	576	4.1663	1.3152	0	6
Ethnic tensions	576	3.2307	1.1478	0	5
Military in politics	576	2.4627	1.6964	0	6

Table 3.3: Baseline Regression

VARIABLES	(1) Occurrence	(2) Occurrence	(3) Occurrence	(4) Occurrence	(5) Occurrence	(6) Fatalities	(7) Fatalities	(8) Fatalities	(9) Fatalities	(10) Fatalities
ln(aid)	-0.343***	-0.404***	-0.258***	-0.402***	-0.00748	-1.990***	-2.335***	-1.321***	-1.678***	-0.304**
	(0.101)	(0.126)	(0.0728)	(0.0986)	(0.0194)	(0.381)	(0.464)	(0.315)	(0.386)	(0.133)
Conflict	0.563***	0.567***	0.522***	0.512***	0.339**	-0.109	-0.113*	-0.0697	-0.0697	-0.000784
	(0.135)	(0.136)	(0.178)	(0.181)	(0.150)	(0.0673)	(0.0682)	(0.0658)	(0.0661)	(0.00310)
ln(lights)		0.237***	0.187***	0.225***	0.152***		0.116	0.557**	0.658**	0.123
		(0.0794)	(0.0488)	(0.0510)	(0.0480)		(0.431)	(0.272)	(0.285)	(0.447)
ln(population)		-2.742	-2.447*	-0.552	-0.561		-14.33***	-9.269***	-4.208*	-2.908
		(1.743)	(1.330)	(1.313)	(1.102)		(4.715)	(2.730)	(2.544)	(2.321)
Natural resource rents			0.0464***	0.0132	0.00870			-0.120	-0.208**	-0.359***
			(0.0170)	(0.0157)	(0.0114)			(0.110)	(0.103)	(0.0993)
Religious tensions			0.915**	1.991***	0.257*			6.856***	9.562***	0.770
			(0.423)	(0.617)	(0.131)			(1.667)	(2.315)	(0.983)
Ethnic tensions			-0.354*	-1.137***	0.807***			-1.060	-3.046**	-0.812
			(0.185)	(0.330)	(0.249)			(0.919)	(1.301)	(1.174)
Military in politics			0.148	0.334*	0.314**			-1.171**	-0.707	0.0700
			(0.148)	(0.175)	(0.123)			(0.573)	(0.654)	(0.550)
Aid Propensity Score				21.32***					54.96***	
				(4.709)					(15.55)	
Observations	11,538	11,439	9,615	9,615	12,820	11,538	11,439	9,615	9,615	12,820
R-squared	0.141	0.129	0.132	0.106	0.130	-0.042	-0.070	-0.005	-0.022	0.008
Number of id	3,846	3,813	3,205	3,205	3,205	3,846	3,813	3,205	3,205	3,205
ADM2 FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	281.582	204.588	504.738	349.635	-	282.403	205.505	515.039	352.846	-
Kleibergen-Paap rk Wald F	146.614	112.174	259.025	162.123	-	147.168	112.656	266.830	164.680	-
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	-	19.93	19.93	19.93	19.93	-
Hansen test	0.0030	0.0051	0.3103	0.2964	-	0.9886	0.8412	0.8853	0.4307	-

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Robustness Check

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	Occurrence	Occurrence	Occurrence	Occurrence	Occurrence	Fatalities	Fatalities	Fatalities	Fatalities	Fatalities
	Conflict>0	Conflict<95th	Aid<95th	Lights>0	Population>0	Conflict>0	Conflict<95th	Aid<95th	Lights>0	Population>0
ln(aid)	-0.476***	0.00280	-0.103*	-0.283***	-0.258***	-3.793***	-0.0710***	-0.844***	-1.252***	-1.323***
	(0.130)	(0.00875)	(0.0581)	(0.0783)	(0.0729)	(1.191)	(0.0145)	(0.194)	(0.325)	(0.316)
Conflict	0.491**	0.0141	0.325**	0.530***	0.522***	-0.105	0.000777	-0.00231	-0.0723	-0.0697
	(0.193)	(0.0164)	(0.149)	(0.186)	(0.178)	(0.0933)	(0.00118)	(0.0521)	(0.0668)	(0.0658)
ln(lights)	1.124***	0.0330***	0.203***	0.251***	0.187***	6.462*	0.0341	0.579**	0.918***	0.556**
	(0.274)	(0.0105)	(0.0458)	(0.0641)	(0.0488)	(3.327)	(0.0257)	(0.244)	(0.353)	(0.272)
ln(population)	-10.77**	-0.295*	-3.522**	-2.918*	-2.448*	-91.88***	-0.726**	-9.358***	-11.05***	-9.265***
	(4.729)	(0.165)	(1.381)	(1.600)	(1.331)	(30.73)	(0.307)	(2.482)	(3.528)	(2.731)
Natural resource rents	0.110**	0.000660	0.0103	0.0654***	0.0464***	-0.281	-0.0191***	-0.311***	-0.0917	-0.120
	(0.0524)	(0.00226)	(0.0132)	(0.0213)	(0.0170)	(0.634)	(0.00538)	(0.0892)	(0.133)	(0.110)
Religious tensions	0.967	-0.119**	0.907**	0.746*	0.915**	8.580	0.338***	6.260***	5.533***	6.858***
	(0.999)	(0.0489)	(0.424)	(0.434)	(0.423)	(5.655)	(0.101)	(1.716)	(1.630)	(1.667)
Ethnic tensions	-1.564**	0.0837***	-0.137	-0.561***	-0.353*	-0.638	-0.179***	-0.818	-1.097	-1.057
	(0.755)	(0.0306)	(0.183)	(0.205)	(0.185)	(7.727)	(0.0453)	(0.928)	(1.020)	(0.919)
Military in politics	-0.0345	-0.0389	0.108	-0.199	0.148	-17.29***	-0.0763	-1.028*	-3.483***	-1.169**
	(0.583)	(0.0261)	(0.125)	(0.185)	(0.148)	(6.081)	(0.0518)	(0.559)	(0.719)	(0.574)
Observations	3,095	9,094	8,764	8,159	9,612	1,513	9,264	8,764	8,159	9,612
R-squared	0.180	0.141	0.080	0.137	0.132	0.027	0.014	0.011	0.003	-0.005
Number of id	1,253	3,093	3,080	2,779	3,204	637	3,146	3,080	2,779	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	351.941	402.525	481.459	564.286	503.654	173.048	465.070	481.456	569.042	507.010
Kleibergen-Paap rk Wald F	179.881	210.047	257.060	250.582	258.253	84.165	249.347	259.100	254.455	263.077
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.4916	0.0000	0.0151	0.4394	0.3114	0.6665	0.0000	0.0879	0.9555	0.8907

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

Table 3.5: Further Exploration

VARIABLES	(1) Occurrence First diff.	(2) Fatalities First diff.	(3) Occurrence Low income	(4) Occurrence High income	(5) Fatalities Low income	(6) Fatalities High income
ln(aid)	-0.179***	-3.053	-0.701***	-1.262	-2.402***	-6.832
	(0.0675)	(2.378)	(0.161)	(1.178)	(0.644)	(4.717)
Conflict			0.626**	0.407	0.0641	-0.178*
			(0.287)	(0.256)	(0.0555)	(0.0973)
ln(lights)	0.578***	13.52	0.419**	0.281***	1.067	1.082**
	(0.133)	(9.227)	(0.170)	(0.0881)	(0.757)	(0.488)
ln(population)	1.163	44.00	7.017***	2.395*	27.09***	-5.116
	(1.064)	(37.67)	(2.422)	(1.369)	(8.283)	(6.592)
Natural resource rents	0.0780***	1.299	0.112***	0.101*	0.416***	0.0936
	(0.0195)	(1.565)	(0.0325)	(0.0519)	(0.134)	(0.212)
Religious tensions	0.697**	-0.714	13.32***	0.476	46.05***	7.844
	(0.276)	(7.994)	(3.204)	(1.984)	(13.22)	(7.619)
Ethnic tensions	1.997***	-10.60	-1.138*	-0.117	-5.526**	-0.282
	(0.607)	(6.610)	(0.610)	(0.443)	(2.259)	(1.773)
Military in politics	1.268***	10.45	0.739***	-1.437*	0.899	-7.737**
	(0.305)	(9.121)	(0.275)	(0.788)	(0.772)	(3.232)
Observations	9,615	9,615	2,379	5,703	2,379	5,703
R-squared	0.035	0.001	0.111	0.114	0.011	0.018
Number of id	3,205	3,205	1,004	2,201	1,004	2,201
ADM2 FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0014	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	506.691	506.691	91.884	78.451	93.736	78.328
Kleibergen-Paap rk Wald F	263.675	263.675	93.442	56.222	93.212	54.460
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.7127	0.3631	0.3649	0.0001	0.1191	0.9210

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.6: Conflict by Time Precision

VARIABLES	(1) Day occurrence	(2) Week occurrence	(3) Month occurrence	(4) Day Fatalities	(5) Week Fatalities	(6) Month Fatalities
ln(aid)	-0.220***	-0.0436***	-0.00215	-1.186***	-0.0975	-0.0355
	(0.0634)	(0.0135)	(0.00649)	(0.254)	(0.0956)	(0.0283)
Conflict	0.509***	0.522**	-0.209	-0.0892	-0.0762	-0.240
	(0.147)	(0.262)	(0.135)	(0.0754)	(0.0809)	(0.250)
ln(lights)	0.147***	0.0115	0.0144**	0.485**	-0.00739	0.0721**
	(0.0432)	(0.00768)	(0.00607)	(0.230)	(0.0527)	(0.0347)
ln(population)	-2.442**	-0.0825	-0.0394	-8.959***	-0.373	-0.0791
	(1.239)	(0.113)	(0.0791)	(2.486)	(0.456)	(0.191)
Natural resource rents	0.0380**	0.00927***	0.00326**	-0.106	-0.0235	0.00566
	(0.0150)	(0.00300)	(0.00134)	(0.0900)	(0.0290)	(0.00987)
Religious tensions	0.857**	0.0833*	0.0152	6.534***	0.159	0.162
	(0.392)	(0.0447)	(0.0221)	(1.507)	(0.311)	(0.138)
Ethnic tensions	-0.383**	-0.0534**	0.0184	-0.906	-0.0645	-0.0355
	(0.171)	(0.0246)	(0.0165)	(0.852)	(0.133)	(0.0674)
Military in politics	0.0879	0.0169	-0.0217	-0.986*	-0.0885	-0.124*
	(0.133)	(0.0180)	(0.0150)	(0.514)	(0.0923)	(0.0661)
Observations	9,615	9,615	9,615	9,615	9,615	9,615
R-squared	0.122	0.170	0.068	0.001	0.019	0.088
Number of id	3,205	3,205	3,205	3,205	3,205	3,205
ADM2 FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0034	0.0622
Cragg-Donald Wald F	504.948	506.938	509.039	508.611	506.512	505.947
Kleibergen-Paap rk Wald F	259.045	263.124	265.535	264.250	263.279	263.260
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.1027	0.4368	0.0003	0.8435	0.8249	0.7880

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

Table 3.7: Conflict Occurrences by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.0801***	-6.87e-06	-0.0180**	-0.0151	-0.189***	-0.00533**	-0.0204***
	(0.0199)	(0.00129)	(0.00779)	(0.0259)	(0.0389)	(0.00219)	(0.00654)
Conflict	0.312	0.187	0.110	1.249***	0.267	0.791**	1.154***
	(0.205)	(0.271)	(0.149)	(0.246)	(0.197)	(0.386)	(0.400)
ln(lights)	0.0687***	0.00405***	0.00948**	-0.00123	0.0842***	0.00640**	0.0259***
	(0.0157)	(0.00140)	(0.00463)	(0.0131)	(0.0274)	(0.00302)	(0.00867)
ln(population)	-0.109	0.0279	0.0292	-0.489	-1.468***	0.0376*	-0.183**
	(0.264)	(0.0194)	(0.0632)	(0.782)	(0.405)	(0.0203)	(0.0773)
Natural resource rents	0.0152**	0.000731**	0.00535***	0.00977	0.0158*	0.00180***	0.00760***
	(0.00656)	(0.000329)	(0.00177)	(0.00650)	(0.00877)	(0.000667)	(0.00189)
Religious tensions	0.370***	-0.000722	0.107***	-0.301*	0.742***	0.0216***	0.191***
	(0.0993)	(0.00383)	(0.0335)	(0.159)	(0.214)	(0.00814)	(0.0531)
Ethnic tensions	-0.115**	0.00820**	0.00162	0.101	-0.391***	0.0298*	-0.0615***
	(0.0557)	(0.00374)	(0.0184)	(0.0791)	(0.0955)	(0.0156)	(0.0190)
Military in politics	0.0549	0.00256	0.0133	-0.0941	0.198***	0.0162*	0.00760
	(0.0615)	(0.00279)	(0.0148)	(0.0698)	(0.0678)	(0.00856)	(0.0114)
Observations	9,615	9,615	9,615	9,615	9,615	9,615	9,615
R-squared	0.059	0.041	0.015	0.292	0.017	0.362	0.279
Number of id	3,205	3,205	3,205	3,205	3,205	3,205	3,205
ADM2 FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0062	0.0000	0.0000	0.0000	0.0005	0.0001
Cragg-Donald Wald F	502.969	508.395	505.663	493.850	502.691	506.590	502.943
Kleibergen-Paap rk Wald F	259.131	263.753	262.184	259.650	257.993	263.381	262.629
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.4077	0.0005	0.5750	0.0214	0.1006	0.5577	0.0049

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

Table 3.8: Conflict Fatalities by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.851***	0.000353	-0.00112	-0.0399***	-0.383**	-	-0.0609***
	(0.204)	(0.000305)	(0.00121)	(0.0151)	(0.157)	-	(0.0218)
Conflict	-0.0408	-0.0313	-0.486	0.457	-0.268		-0.0981
	(0.0416)	(0.0439)	(0.365)	(0.281)	(0.178)		(0.116)
ln(lights)	0.436**	-5.22e-06	0.000904	0.00764	0.102	-	0.0152
	(0.189)	(7.61e-05)	(0.000915)	(0.0108)	(0.115)	-	(0.0243)
ln(population)	-5.768***	-0.000496	-0.0116	-0.174	-2.981***	-	-0.300
	(1.930)	(0.000630)	(0.0123)	(0.209)	(1.091)	-	(0.223)
Natural resource rents	0.0408	-9.62e-05	2.42e-05	0.00541	-0.170***	-	-0.00205
	(0.0608)	(9.09e-05)	(0.000209)	(0.00523)	(0.0622)	-	(0.00719)
Religious tensions	5.212***	-0.000819	0.00939	-0.188	1.157*	-	0.549***
	(1.183)	(0.000737)	(0.00869)	(0.143)	(0.696)	-	(0.207)
Ethnic tensions	-0.831	0.000409	-0.00185	-0.0801	0.0894	-	-0.125**
	(0.679)	(0.000355)	(0.00382)	(0.0687)	(0.309)	-	(0.0627)
Military in politics	-0.436	-0.000225	-0.00130	-0.0109	-0.643***	-	-0.0832*
	(0.404)	(0.000217)	(0.00202)	(0.0508)	(0.201)	-	(0.0432)
Observations	9,615	9,615	9,615	9,615	9,615	-	9,615
R-squared	-0.012	0.002	0.063	0.253	0.059	-	0.034
Number of id	3,205	3,205	3,205	3,205	3,205	-	3,205
ADM2 FE	YES	YES	YES	YES	YES	-	YES
Time FE	YES	YES	YES	YES	YES	-	YES
p-value of F	0.0000	0.9993	0.2060	0.0064	0.0000	-	0.0024
Cragg-Donald Wald F	508.440	507.232	506.924	506.500	506.672	-	506.743
Kleibergen-Paap rk Wald F	264.238	263.956	264.104	263.612	263.298	-	263.463
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	-	19.93
Hansen test	0.1320	0.6602	0.1359	0.0059	0.0581	-	0.1141

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

Table 3.9: Restricted Model with Night Lights per capita

VARIABLES	(1) Occurrence	(2) Occurrence	(3) Occurrence	(4) Occurrence	(5) Fatalities	(6) Fatalities	(7) Fatalities	(8) Fatalities
ln(aid)	-0.343***	-0.406***	-0.252***	-0.0127	-1.990***	-2.145***	-1.252***	-0.307**
	(0.101)	(0.111)	(0.0727)	(0.0200)	(0.381)	(0.419)	(0.319)	(0.137)
Conflict	0.563***	0.566***	0.521***	0.339**	-0.109	-0.112	-0.0694	-0.000782
	(0.135)	(0.136)	(0.178)	(0.149)	(0.0673)	(0.0682)	(0.0657)	(0.00310)
ln(lights/population)		19.10***	13.59***	6.755		50.94***	31.94***	-4.881
		(5.581)	(4.806)	(4.441)		(15.80)	(10.82)	(9.918)
Natural resource rents			0.0479***	0.00866			-0.114	-0.348***
			(0.0169)	(0.0112)			(0.110)	(0.0982)
Religious tensions			0.848**	0.270**			6.375***	0.714
			(0.405)	(0.129)			(1.619)	(0.978)
Ethnic tensions			-0.286	0.813***			-0.734	-0.734
			(0.177)	(0.239)			(0.885)	(1.149)
Military in politics			0.169	0.343***			-1.138**	0.0561
			(0.143)	(0.133)			(0.542)	(0.541)
Observations	11,538	11,433	9,612	12,816	11,538	11,433	9,612	12,816
R-squared	0.141	0.130	0.135	0.130	-0.042	-0.052	-0.002	0.008
Number of id	3,846	3,811	3,204	3,204	3,846	3,811	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	281.582	240.625	548.007	-	282.403	241.428	551.395	-
Kleibergen-Paap rk Wald F	146.614	116.632	257.212	-	147.168	117.256	262.451	-
Stock-Yogo 10% value	19.93	19.93	19.93	-	19.93	19.93	19.93	-
Hansen test	0.0030	0.0063	0.3603	-	0.9886	0.8613	0.9130	-

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.10: Restricted Model: Conflict by Time Precision

VARIABLES	(1) Day occurrence	(2) Week occurrence	(3) Month occurrence	(4) Day fatalities	(5) Week fatalities	(6) Month fatalities
ln(aid)	-0.210***	-0.0455***	-0.00193	-1.110***	-0.0955	-0.0397
	(0.0625)	(0.0139)	(0.00644)	(0.252)	(0.0971)	(0.0290)
Conflict	0.508***	0.522**	-0.210	-0.0888	-0.0762	-0.240
	(0.147)	(0.262)	(0.134)	(0.0754)	(0.0809)	(0.250)
ln(lights/population)	12.34***	1.346***	0.0160	27.65***	2.490	1.059
	(4.498)	(0.485)	(0.201)	(8.932)	(2.670)	(0.936)
Natural resource rents	0.0393***	0.00926***	0.00335**	-0.0998	-0.0236	0.00606
	(0.0150)	(0.00300)	(0.00134)	(0.0900)	(0.0287)	(0.00988)
Religious tensions	0.770**	0.0904**	0.0141	6.026***	0.143	0.182
	(0.375)	(0.0439)	(0.0194)	(1.443)	(0.316)	(0.146)
Ethnic tensions	-0.305*	-0.0535**	0.0178	-0.575	-0.0465	-0.0482
	(0.163)	(0.0259)	(0.0144)	(0.815)	(0.129)	(0.0683)
Military in politics	0.0944	0.0191	-0.0170	-0.973**	-0.100	-0.0974
	(0.127)	(0.0180)	(0.0164)	(0.484)	(0.0821)	(0.0613)
Observations	9,612	9,612	9,612	9,612	9,612	9,612
R-squared	0.126	0.167	0.068	0.005	0.019	0.087
Number of id	3,204	3,204	3,204	3,204	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0020	0.1046
Cragg-Donald Wald F	548.486	549.917	552.093	549.836	550.184	549.794
Kleibergen-Paap rk Wald F	257.123	261.468	264.034	262.360	262.236	262.231
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.1227	0.3861	0.0003	0.8373	0.3891	0.8447

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: Restricted Model: Conflict Occurrences by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.0851***	-0.000638	-0.0200***	-0.0104	-0.182***	-0.00670***	-0.0195***
	(0.0215)	(0.00138)	(0.00767)	(0.0235)	(0.0378)	(0.00257)	(0.00594)
Conflict	0.312	0.186	0.110	1.244***	0.267	0.790**	1.155***
	(0.205)	(0.271)	(0.149)	(0.244)	(0.197)	(0.386)	(0.400)
ln(lights/population)	1.807**	0.00568	0.464*	2.374	7.054***	0.184**	0.438**
	(0.727)	(0.0405)	(0.264)	(2.571)	(1.914)	(0.0849)	(0.213)
Natural resource rents	0.0156**	0.000732**	0.00536***	0.00977	0.0166*	0.00180***	0.00786***
	(0.00650)	(0.000326)	(0.00176)	(0.00644)	(0.00882)	(0.000669)	(0.00195)
Religious tensions	0.393***	0.00289	0.117***	-0.332**	0.686***	0.0288***	0.183***
	(0.0983)	(0.00358)	(0.0312)	(0.145)	(0.202)	(0.0105)	(0.0500)
Ethnic tensions	-0.127**	0.00595**	-0.00278	0.125*	-0.343***	0.0261*	-0.0582***
	(0.0607)	(0.00286)	(0.0168)	(0.0733)	(0.0869)	(0.0141)	(0.0172)
Military in politics	0.0793	0.00464	0.0174	-0.106	0.201***	0.0194**	0.0146
	(0.0648)	(0.00326)	(0.0148)	(0.0658)	(0.0625)	(0.00974)	(0.0109)
Observations	9,612	9,612	9,612	9,612	9,612	9,612	9,612
R-squared	0.053	0.037	0.010	0.292	0.024	0.351	0.279
Number of id	3,204	3,204	3,204	3,204	3,204	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0037	0.0000	0.0000	0.0000	0.0004	0.0001
Cragg-Donald Wald F	548.389	551.608	548.818	535.958	544.572	549.928	545.835
Kleibergen-Paap rk Wald F	257.917	262.706	260.784	258.358	255.533	262.392	260.850
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.3776	0.0005	0.6186	0.0197	0.1148	0.6668	0.0053

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

Table 3.12: Restricted Model: Conflict Fatalities by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.817***	0.000382	-0.000996	-0.0381***	-0.353**	-	-0.0579***
	(0.200)	(0.000329)	(0.00110)	(0.0139)	(0.163)	-	(0.0204)
Conflict	-0.0405	-0.0313	-0.486	0.457	-0.268		-0.0981
	(0.0416)	(0.0438)	(0.365)	(0.281)	(0.178)		(0.116)
ln(lights/population)	20.83***	-0.00997	0.0123	0.625	9.970**	-	0.913
	(6.992)	(0.00870)	(0.0232)	(0.652)	(4.759)	-	(1.318)
Natural resource rents	0.0454	-9.50e-05	3.71e-05	0.00544	-0.169***	-	-0.00193
	(0.0610)	(9.01e-05)	(0.000219)	(0.00521)	(0.0619)	-	(0.00719)
Religious tensions	4.955***	-0.000962	0.00863	-0.199	0.967	-	0.530***
	(1.126)	(0.000858)	(0.00802)	(0.133)	(0.707)	-	(0.198)
Ethnic tensions	-0.654	0.000451	-0.00146	-0.0725	0.218	-	-0.113**
	(0.646)	(0.000391)	(0.00346)	(0.0664)	(0.316)	-	(0.0566)
Military in politics	-0.377	-0.000229	-0.00115	-0.0120	-0.667***	-	-0.0836*
	(0.377)	(0.000231)	(0.00206)	(0.0479)	(0.200)	-	(0.0435)
Observations	9,612	9,612	9,612	9,612	9,612	-	9,612
R-squared	-0.009	0.000	0.063	0.254	0.061	-	0.035
Number of id	3,204	3,204	3,204	3,204	3,204	-	3,204
ADM2 FE	YES	YES	YES	YES	YES	-	YES
Time FE	YES	YES	YES	YES	YES	-	YES
p-value of F	0.0000	0.9980	0.1463	0.0281	0.0000	-	0.0029
Cragg-Donald Wald F	551.761	550.205	550.247	549.804	549.935	-	550.006
Kleibergen-Paap rk Wald F	262.725	262.308	262.586	262.117	261.880	-	261.963
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	-	19.93
Hansen test	0.1431	0.6400	0.1345	0.0058	0.0584	-	0.1104

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

Table 3.13: Restricted Model with Squared Aid

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Occurrence	Occurrence	Occurrence	Occurrence	Fatalities	Fatalities	Fatalities	Fatalities
ln(aid)	-0.343***	-0.410***	-0.255***	-0.0130	-1.990***	-2.155***	-1.256***	-0.307**
	(0.101)	(0.112)	(0.0728)	(0.0200)	(0.381)	(0.422)	(0.320)	(0.137)
Conflict	0.563***	0.566***	0.520***	0.339**	-0.109	-0.112	-0.0694	-0.000783
	(0.135)	(0.136)	(0.178)	(0.149)	(0.0673)	(0.0682)	(0.0657)	(0.00310)
ln(lights/population)		20.60***	15.84***	8.475		57.54***	34.63***	-6.986
		(6.377)	(5.530)	(5.187)		(18.68)	(12.02)	(12.21)
$(\ln(\text{lights/population}))^2$		-0.0862	-0.148**	-0.128**		-0.384	-0.177	0.157
		(0.118)	(0.0684)	(0.0651)		(0.320)	(0.155)	(0.182)
Natural resource rents			0.0478***	0.00819			-0.114	-0.347***
			(0.0169)	(0.0112)			(0.110)	(0.0982)
Religious tensions			0.859**	0.272**			6.389***	0.711
			(0.406)	(0.129)			(1.623)	(0.978)
Ethnic tensions			-0.287	0.812***			-0.735	-0.733
			(0.177)	(0.239)			(0.885)	(1.149)
Military in politics			0.166	0.342***			-1.142**	0.0574
			(0.143)	(0.132)			(0.541)	(0.541)
Observations	11,538	11,433	9,612	12,816	11,538	11,433	9,612	12,816
R-squared	0.141	0.129	0.134	0.131	-0.042	-0.053	-0.002	0.008
Number of id	3,846	3,811	3,204	3,204	3,846	3,811	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	281.582	237.378	545.703	-	282.403	238.191	549.147	-
Kleibergen-Paap rk Wald F	146.614	114.548	255.306	-	147.168	115.181	260.612	-
Stock-Yogo 10% value	19.93	19.93	19.93	-	19.93	19.93	19.93	-
Hansen test	0.0030	0.0065	0.3689	-	0.9886	0.8486	0.9156	-

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

Table 3.14: Restricted Model with Squared Aid: Conflict by Time Precision

VARIABLES	(1) Day occurrence	(2) Week occurrence	(3) Month occurrence	(4) Day Fatalities	(5) Week Fatalities	(6) Month Fatalities
ln(aid)	-0.213***	-0.0457***	-0.00192	-1.914***	-0.254	-0.0618
	(0.0627)	(0.0139)	(0.00646)	(0.539)	(0.242)	(0.0477)
Conflict	0.508***	0.522**	-0.210	-0.427	-0.159	-0.0136
	(0.147)	(0.262)	(0.134)	(0.295)	(0.263)	(0.0505)
ln(lights/population)	14.44***	1.514***	0.0154	59.55***	9.618	2.176
	(5.191)	(0.532)	(0.221)	(21.86)	(8.154)	(1.434)
$(\ln(\text{lights/population}))^2$	-0.138**	-0.0110*	1.76e-05	-0.298	-0.0540	-0.0113
	(0.0629)	(0.00663)	(0.00144)	(0.269)	(0.0569)	(0.0110)
Natural resource rents	0.0393***	0.00925***	0.00334**	0.0545	-0.0206	0.00339
	(0.0150)	(0.00300)	(0.00134)	(0.179)	(0.0607)	(0.0169)
Religious tensions	0.780**	0.0912**	0.0140	11.24***	0.360	0.213
	(0.376)	(0.0441)	(0.0195)	(2.733)	(0.744)	(0.160)
Ethnic tensions	-0.306*	-0.0535**	0.0179	-2.147*	-0.151	-0.175**
	(0.163)	(0.0259)	(0.0144)	(1.126)	(0.316)	(0.0878)
Military in politics	0.0911	0.0188	-0.0170	0.726	-0.0320	0.00667
	(0.127)	(0.0180)	(0.0164)	(0.748)	(0.166)	(0.0487)
Observations	9,612	9,612	9,612	9,612	9,612	9,612
R-squared	0.125	0.166	0.068	0.068	0.008	-0.004
Number of id	3,204	3,204	3,204	3,204	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0005	0.1702	0.6669
Cragg-Donald Wald F	546.164	547.676	549.847	549.497	547.526	547.093
Kleibergen-Paap rk Wald F	255.191	259.631	262.173	260.889	259.947	259.961
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.1266	0.3818	0.0003	0.0856	0.2987	0.9490

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.15: Restricted Model with Squared Aid: Conflict Occurrences by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.0852***	-0.000634	-0.0201***	-0.0110	-0.183***	-0.00672***	-0.0196***
	(0.0216)	(0.00138)	(0.00769)	(0.0236)	(0.0380)	(0.00258)	(0.00596)
Conflict	0.312	0.186	0.110	1.243***	0.266	0.790**	1.155***
	(0.205)	(0.271)	(0.149)	(0.244)	(0.196)	(0.386)	(0.400)
ln(lights/population)	1.948**	0.00507	0.514*	2.985	7.963***	0.202**	0.474*
	(0.814)	(0.0442)	(0.293)	(3.026)	(2.145)	(0.0934)	(0.243)
$(\ln(\text{lights/population}))^2$	-0.00925	3.48e-05	-0.00328	-0.0401	-0.0598**	-0.00118	-0.00236
	(0.0104)	(0.000280)	(0.00326)	(0.0331)	(0.0280)	(0.00105)	(0.00280)
Natural resource rents	0.0156**	0.000732**	0.00536***	0.00975	0.0166*	0.00180***	0.00786***
	(0.00650)	(0.000326)	(0.00176)	(0.00644)	(0.00882)	(0.000669)	(0.00195)
Religious tensions	0.394***	0.00287	0.117***	-0.329**	0.691***	0.0289***	0.184***
	(0.0986)	(0.00359)	(0.0313)	(0.145)	(0.203)	(0.0105)	(0.0500)
Ethnic tensions	-0.127**	0.00596**	-0.00280	0.125*	-0.344***	0.0261*	-0.0582***
	(0.0608)	(0.00287)	(0.0168)	(0.0732)	(0.0871)	(0.0141)	(0.0172)
Military in politics	0.0790	0.00464	0.0173	-0.107	0.200***	0.0194**	0.0145
	(0.0647)	(0.00325)	(0.0148)	(0.0659)	(0.0624)	(0.00973)	(0.0109)
Observations	9,612	9,612	9,612	9,612	9,612	9,612	9,612
R-squared	0.053	0.037	0.010	0.293	0.023	0.351	0.279
Number of id	3,204	3,204	3,204	3,204	3,204	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0066	0.0000	0.0000	0.0000	0.0007	0.0001
Cragg-Donald Wald F	546.140	549.362	546.571	534.182	542.312	547.688	543.591
Kleibergen-Paap rk Wald F	256.086	260.856	258.936	256.810	253.686	260.536	258.990
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	19.93	19.93
Hansen test	0.3761	0.0005	0.6206	0.0191	0.1169	0.6705	0.0053

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

Table 3.16: Restricted Model with Squared Aid: Conflict Fatalities by Type

VARIABLES	(1) Battle	(2) Headquarter	(3) Strategic	(4) Riot/protest	(5) Vio. Civil	(6) Transfer	(7) Remote
ln(aid)	-0.819***	0.000383	-0.000997	-0.0381***	-0.354**	-	-0.0579***
	(0.201)	(0.000330)	(0.00110)	(0.0139)	(0.164)	-	(0.0205)
Conflict	-0.0405	-0.0313	-0.486	0.457	-0.268		-0.0981
	(0.0416)	(0.0438)	(0.365)	(0.281)	(0.178)		(0.116)
ln(lights/population)	22.65***	-0.0107	0.0121	0.670	10.82**	-	0.924
	(7.791)	(0.00939)	(0.0245)	(0.749)	(5.202)	-	(1.564)
$(\ln(\text{lights/population}))^2$	-0.119	5.08e-05	1.21e-05	-0.00297	-0.0561	-	-0.000787
	(0.0998)	(6.24e-05)	(0.000123)	(0.00777)	(0.0513)	-	(0.0173)
Natural resource rents	0.0454	-9.50e-05	3.72e-05	0.00544	-0.169***	-	-0.00193
	(0.0610)	(9.00e-05)	(0.000219)	(0.00521)	(0.0619)	-	(0.00719)
Religious tensions	4.965***	-0.000966	0.00863	-0.199	0.970	-	0.530***
	(1.128)	(0.000861)	(0.00803)	(0.133)	(0.708)	-	(0.198)
Ethnic tensions	-0.655	0.000451	-0.00146	-0.0725	0.217	-	-0.113**
	(0.646)	(0.000391)	(0.00346)	(0.0664)	(0.316)	-	(0.0567)
Military in politics	-0.380	-0.000228	-0.00114	-0.0120	-0.668***	-	-0.0836*
	(0.377)	(0.000231)	(0.00206)	(0.0479)	(0.199)	-	(0.0434)
Observations	9,612	9,612	9,612	9,612	9,612	-	9,612
R-squared	-0.009	-0.000	0.063	0.254	0.061	-	0.035
Number of id	3,204	3,204	3,204	3,204	3,204	-	3,204
ADM2 FE	YES	YES	YES	YES	YES	-	YES
Time FE	YES	YES	YES	YES	YES	-	YES
p-value of F	0.0000	0.9993	0.2028	0.0436	0.0000	-	0.0051
Cragg-Donald Wald F	549.509	547.964	548.007	547.566	547.695	-	547.766
Kleibergen-Paap rk Wald F	260.884	260.461	260.736	260.270	260.037	-	260.118
Stock-Yogo 10% value	19.93	19.93	19.93	19.93	19.93	-	19.93
Hansen test	0.1440	0.6391	0.1344	0.0058	0.0581	-	0.1102

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

Table 3.17: Total Conflict Regression with Squared Aid

VARIABLES	(1) Occurrence	(2) Occurrence	(3) Occurrence	(4) Fatalities	(5) Fatalities	(6) Fatalities
ln(aid)	-0.131	-0.123	-0.133	-1.718**	-1.492*	-1.503*
	(0.187)	(0.197)	(0.198)	(0.745)	(0.784)	(0.786)
$(\ln(aid))^2$	-0.00356	-0.00389	-0.00355	0.0523	0.0393	0.0397
	(0.00886)	(0.00911)	(0.00913)	(0.0374)	(0.0383)	(0.0384)
Conflict	0.524***	0.524***	0.524***	-0.0700	-0.0700	-0.0699
	(0.177)	(0.177)	(0.177)	(0.0656)	(0.0656)	(0.0656)
ln(lights)	0.206***			0.717***		
	(0.0473)			(0.272)		
ln(population)	-2.198			-0.206		
	(1.351)			(3.049)		
ln(lights/population)		12.24***	17.19***		13.21	18.47
		(4.523)	(5.689)		(8.276)	(12.27)
Natural resource rents	0.0417**	0.0437***	0.0433***	-0.208*	-0.200*	-0.201*
	(0.0163)	(0.0162)	(0.0162)	(0.113)	(0.114)	(0.114)
Religious tensions	0.653	0.605	0.623	4.771***	4.803***	4.822***
	(0.406)	(0.412)	(0.414)	(1.568)	(1.636)	(1.644)
Ethnic tensions	-0.198	-0.144	-0.150	-0.354	-0.299	-0.306
	(0.203)	(0.218)	(0.218)	(1.038)	(1.085)	(1.086)
Military in politics	0.0579	0.0922	0.0865	-1.479**	-1.326**	-1.332**
	(0.160)	(0.165)	(0.165)	(0.598)	(0.603)	(0.601)
Observations	9,615	9,612	9,612	9,615	9,612	9,612
R-squared	0.143	0.144	0.144	0.014	0.014	0.014
Number of id	3,205	3,204	3,204	3,205	3,204	3,204
ADM2 FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
p-value of F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cragg-Donald Wald F	182.820	159.984	159.704	181.116	158.195	157.954
Kleibergen-Paap rk Wald F	143.396	126.320	126.245	141.606	124.655	124.600
Stock-Yogo 10% value	16.87	16.87	16.87	16.87	16.87	16.87
Hansen test	0.2127	0.2467	0.2418	0.0005	0.0003	0.0003

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

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