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GIS Application in Economic Analyses: Using Aid Effectiveness in Sub-Saharan Africa as an Example

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GIS Applications in Economic Analyses: Using Aid Effectiveness in Sub-Saharan Africa as an Example

Yi Duan

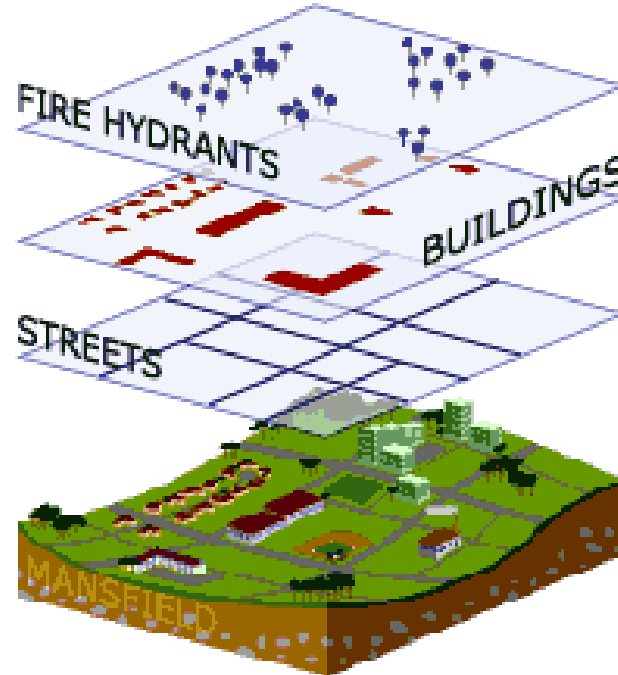
Division of Finance, Economics, and International Business

What is GIS?

- Geographic Information Systems (GIS) is designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data.
- GIS techniques are widely used in many academic disciplines.
- GIS reveals patterns and trends that might otherwise have gone unnoticed without the use of GIS techniques.

How is GIS Used?

- Maps are composed of a series of map layers drawn in a particular order.
- A layer represents geographic data in a particular theme.



Foreign Aid in Sub-Saharan Africa

- Substantial amount of foreign aid to sub-Saharan Africa every year.
- Is aid effective in reducing poverty and promoting economic growth in recipient countries?
- Important for aid allocation decision.
- Previous literature: country level, mixed conclusions.
- But, most aid projects are local activities.

This Paper

- Local aid effectiveness: local aid projects may not help a country's growth.
- Local aid spillovers: regions have more interactions with each other within country than across countries.
- Decomposition of aid effectiveness at different aggregate levels: county, state, country.
- Novel data and novel approach: Geographic information systems (GIS) and spatial analysis.

Unit of Analysis: ADM2

The U.S. as an example

- Country: the U.S.
- ADM1 (First Order Administrative Division): States
- ADM2 (Second Order Administrative Division): Counties

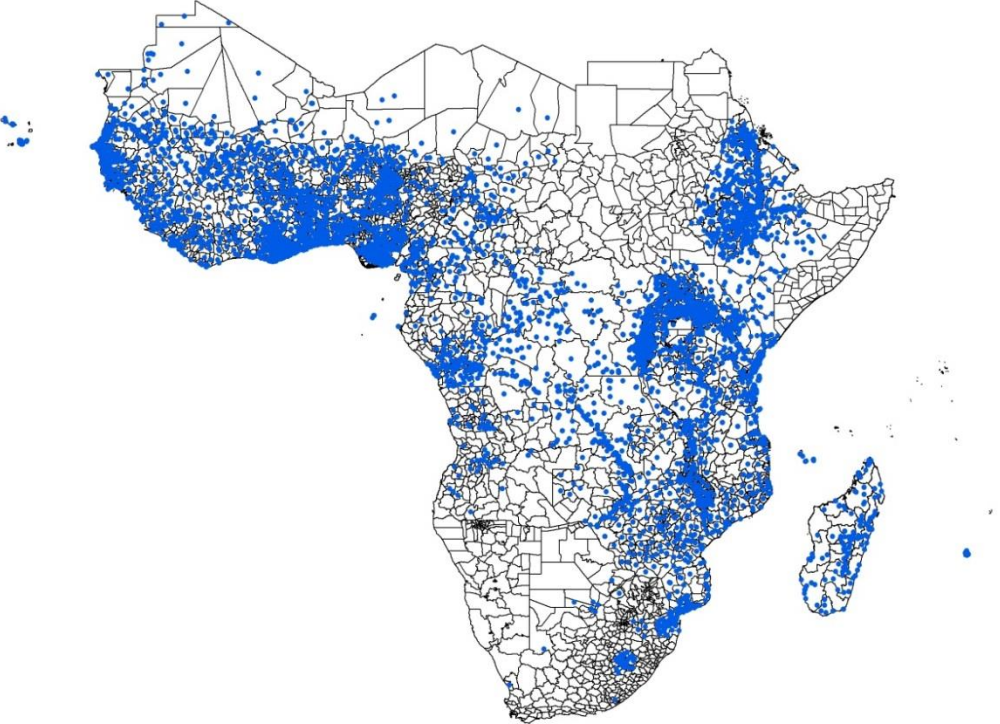
Aid Data: AidData.org (1995-2014)

- World Bank Geocoded Research Release, Level 1, Version 1.3
- 5881 aid projects
- 61243 locations
- Each aid project has a precision code

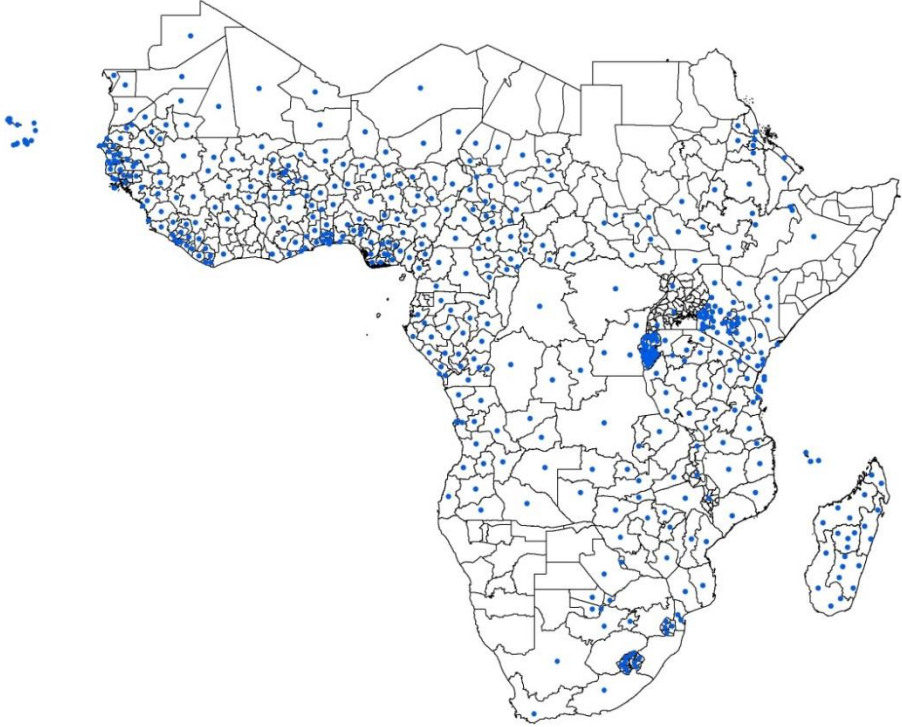
Aid Data: AidData.org (1995-2014)

Precision Code	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

Aid Projects at ADM2 Level



Aid Projects at ADM1 Level



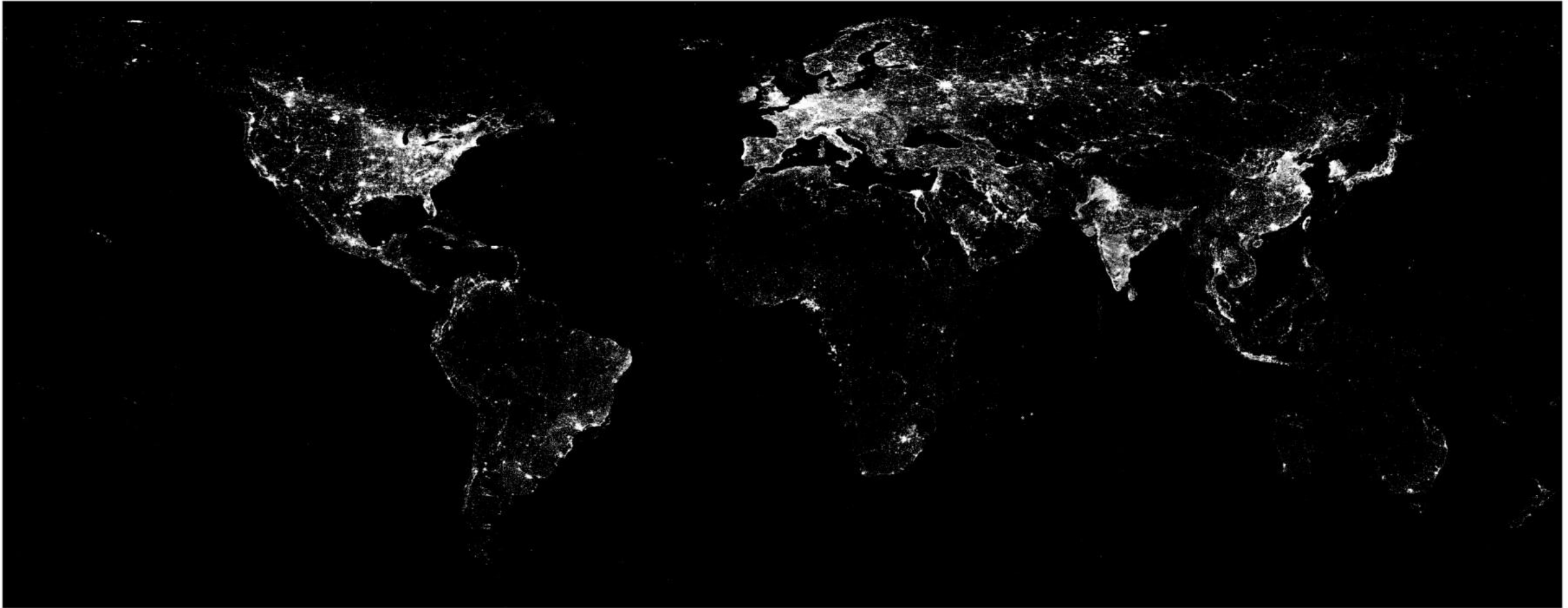
Aid Projects at Country Level



Night Lights Data: NOAA (1992-2013)

- Satellites from the United States Air Force Defense Meteorological Satellite Program (DMSP) have been circling the earth 14 times per day recording the intensity of Earth-based lights with their Operational Linescan System (OLS).
- Measure light intensity on earth between 65 degree South and 75 degree North.
- Elvidge *et al.* (2001), Elvidge *et al.* (2009), Sutton and Costanza (2002), Henderson *et al.* (2012): night lights are good proxy for economics activities.

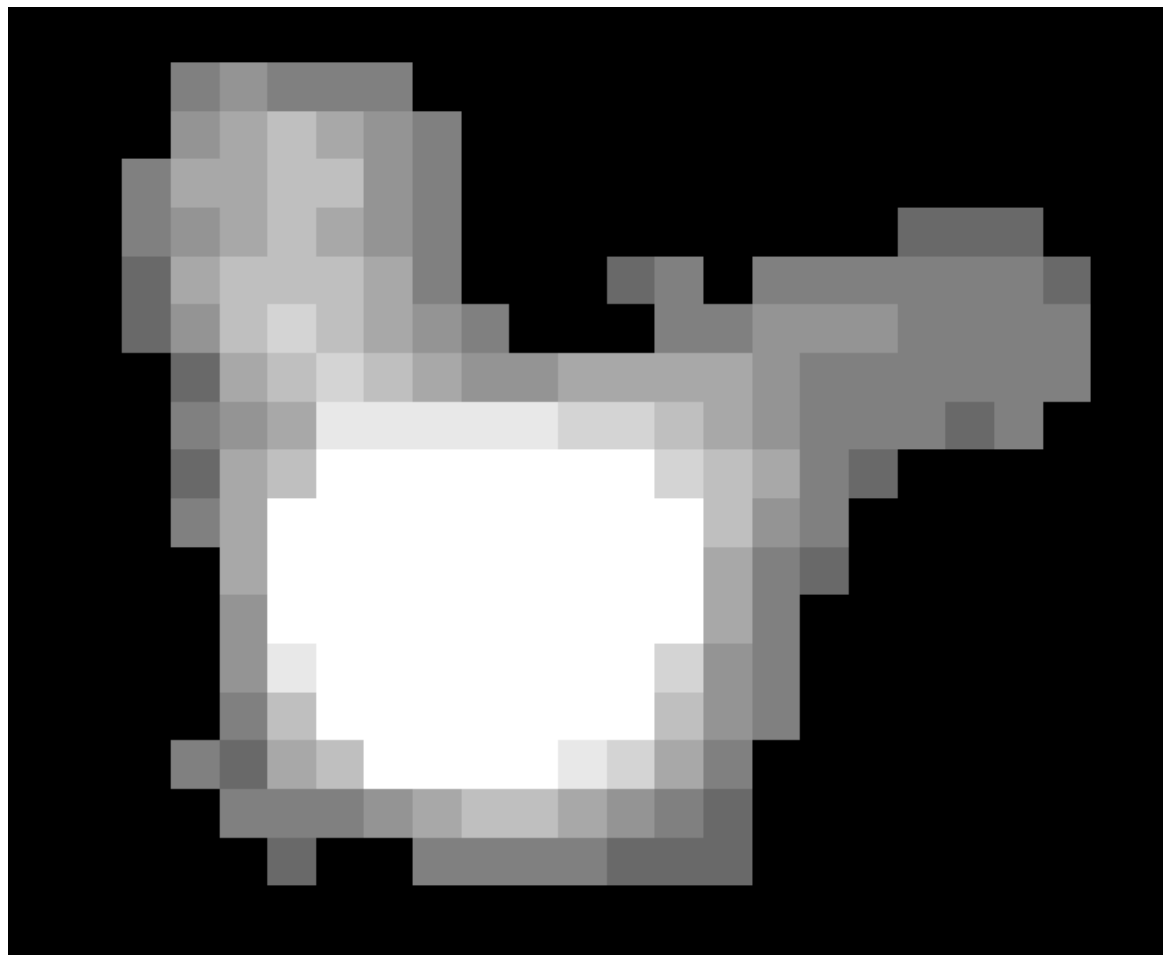
Night Lights Data: 2013



Night Lights Data

- Raster.
- 30 arc-second pixel ($1/120^{\text{th}}$ of a degree of latitude and longitude, approximately 0.86 square kilometers at the equator).
- On a scale from 0 to 63 (highest lights intensity).

Night Lights Data



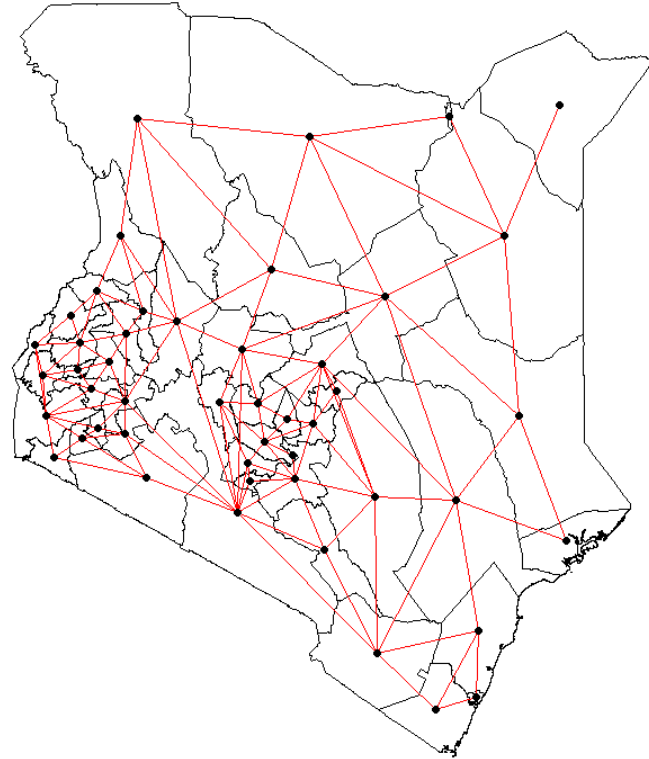
Population Data: CIESIN and CIAT

- Raster.
- 2.5 arc-minutes resolution (about 4.625 kilometers times 4.625 kilometers at the equator).
- In 1990, 1995 and 2000, also the estimated data in 2005, 2010 and 2015.

Population: 1995



Spillover Effects: Adjacent Neighbors (Kenya)



Future Work: Inverse Distance Weighting (IDW); weights by population, income (lights), and income per capita (lights per capita).

Model Specification

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

- $growth_{i,t}$ is the growth rate of income per capita in ADM2 i at t .
- $\ln(1 + lightspc_{i,t-1})$ represents the logarithm of lagged income per capita level in ADM2 i .
- $aid_{i,t-1}^{ADM2}$ is the amount of aid received by ADM2 i at $t-1$.
- $aid_{-i,t-1}^{ADM2}$ is the amount of aid received by i 's neighbors.
- $aid_{i,t-1}^{ADM1}$ 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.
- $aid_{i,t-1}^{country}$ is the fair share of total amount of aid received by the country where ADM2 i locates at $t-1$, excluding the amount of aid received at ADM2 and ADM1 levels.
- 4 year average to smooth business cycles.

Baseline Regression Results

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	OLS
$aid_{i,t-1}^{ADM2}$	0.979*** (0.116)	0.861*** (0.107)		0.667*** (0.077)		0.649*** (0.074)	-0.0004 (0.001)
$aid_{-i,t-1}^{ADM2}$		0.405*** (0.052)		0.611*** (0.071)		0.606*** (0.069)	-0.0003 (0.001)
$aid_{i,t-1}^{ADM1}$			-0.790*** (0.081)	-1.042*** (0.115)		-0.945*** (0.104)	-0.009*** (0.002)
$aid_{i,t-1}^{country}$					-0.680*** (0.067)	-0.234*** (0.031)	-0.006*** (0.002)
$\ln(1 + lightspc_{i,t-1})$	-17.660*** (3.519)	-16.430*** (3.866)	-28.010*** (3.314)	-28.910*** (3.477)	-25.540*** (2.991)	-30.280*** (3.482)	-18.280*** (2.425)
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	-

Conclusions

- 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.
- Another possibility is that aid targeted at more specific level is more economically motivated and less politically motivated.
- A third reason is that local aid projects tend to stimulate local participation.
- There exist positive spillovers of aid across adjacent neighbors at the local level. That can be explained by knowledge and technology spillovers.

Policy Implications

- Justifies Easterly's argument that "bottom-up" approach may work better than "top-down" approach in some development policy designs.
- 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.
- We should reduce barriers to resource movements and knowledge dissemination within the country to promote positive spillover effects.

Data Processing Details

Spatial Data Processing Details

Descriptions	Computer Programs and Commands
Country boundary merge	QGIS: MMQGIS
Neighbor weights matrix building	R: poly2nb (“spdep” package)
Aid calculation	R
Night lights calculation	ArcGIS: Model Builder, Zonal Statistics as Table
Population calculation	ArcGIS: Model Builder, Zonal Statistics as Table
Conflict intensity calculation	ArcGIS: Kernel Density
Air temperature calculation	R: extract (“raster” package)
Precipitation calculation	R: extract (“raster” package)

Non-Spatial Data Processing Details

Descriptions	Computer Programs and Commands
Population liner interpolation	Stata: ipolate
Regression	Stata: xtivreg2

Thank You!

Simultaneity: Brückner (2013)

- Aid variables = exogenous part + endogenous part
IV for aid variables explained by growth

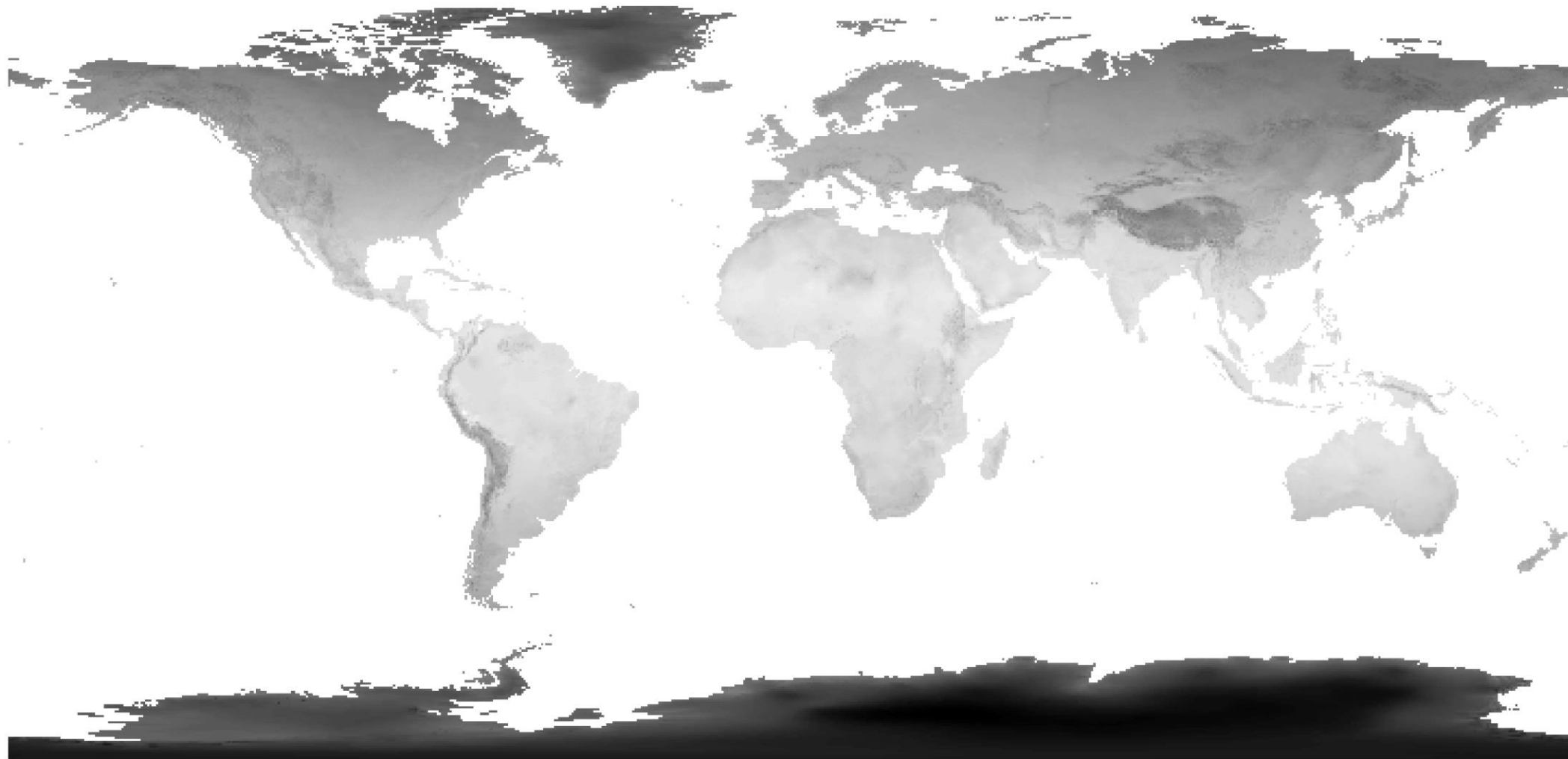
$$\ln(1 + aid_{t-1}) = a_i + b_t + c * growth_{i,t} + \epsilon_{i,t} \quad (2)$$

- $\ln(1 + aid_{t-1})$ 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 in region i at time t as instruments for $growth_{i,t}$

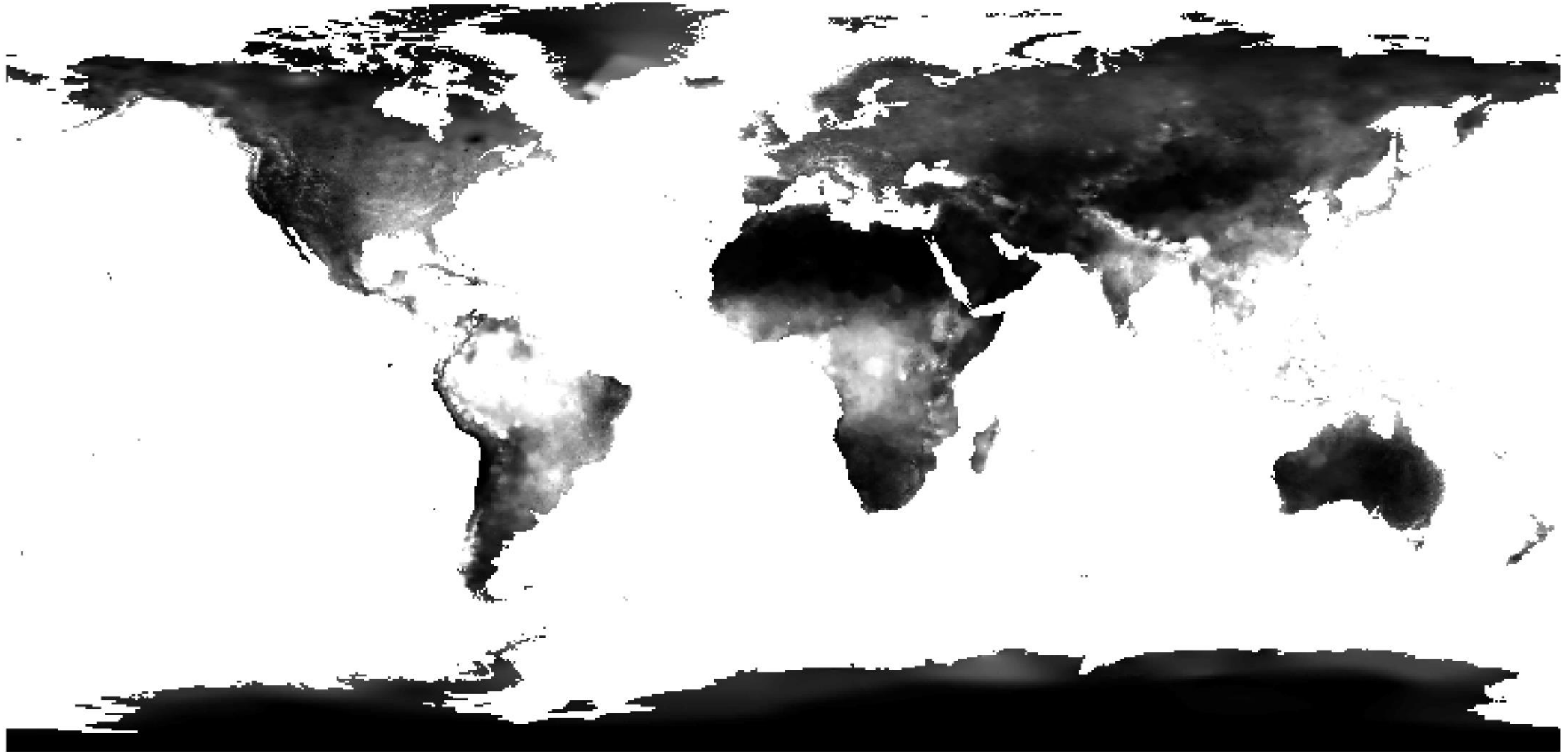
$$\ln(1 + aid_{t-1}^*) = \ln(1 + aid_{t-1}) - c * growth_{i,t} \quad (3)$$

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).

Air Temperature (in Celsius): 2013



Precipitation (in mm): 2013



Data Sources

	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)

Summary Statistics of the Data

	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
$\ln(1 + lightspc_{i,t-1})$	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