Appendix Figure 1

We combine data from satellite images of night lights in 2013, obtained from the National Oceanic and Atmospheric Administration's Defense Meteorologi-cal Satellite Program–Operational Line Scan (NOAA DMSP-OLS), with data from the Gridded Population of the World, Version 4 (GPWv4), provided by the Centerfor International Earth Science Information Network (CIESIN) at Columbia Uni-versity, to predict where the largest gains in nighttime brightness would occur if everyone were able to enjoy the same levels of brightness as OECD countries. The simple procedure is as follows:

Step1: Estimating the relationship between night lights and population for OECD Countries

- We download and merge the nightlights and population raster files. We make the adjustment for difference in file origin of the two raster files by resampling the nighlights file based on nearest neighborhood method.
- We then stack the new nighlights file and the origin population file and create a new merged dataset

```
#Importing the nighlights and population file
nl=raster("nl.tif")
pop <-raster("pop/pop.tif")

# Re-sampling Nighlights Data based on nearest neighborhood because the file
origin is different
d1<-resample(nl,pop,method="ngb")

# Stacking the resampled and population raster file
new=stack(d1,pop)

#Converting stacked file to a spatial data frame after filtering the NAs
p1 = rasterToPoints(new)
newdata = data.frame(p1)
newdata<- newdata %>% dplyr::filter(!is.na(pop) & !is.na(nl)) %>%
filter(pop>1)
coordinates(newdata) <- ~x+y
proj4string(newdata) <- CRS("+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84
+towgs84=0,0,0")
```

- We then downlod the shapefile for world countries borders from thematic mapping.org and subset the OECD countries.
- We then extract the nighlights and population data for OECD countries from the previously merged file. At this step we filter out nighlight values of zero's and population less than 100.

```r
# Read this shape file with the rgdal library.
my_spdf=readOGR("/Users/world_shape_file", layer="TM_WORLD_BORDERS_SIMPL-0.3")

oecd <- read_excel("/Users/OECD.xlsx")
r<-oecd$Country1
oecd.sf=subset(my_spdf,my_spdf@data$NAME %in% r)

# Spatial Join: Spatial Data frame and OECD Shapefile
pts_in<-over(newdata,oecd.sf)
newdata_oecd <- spCbind(newdata, pts_in)

# Filter data points from the OECD nightlights and population file
n1<-data.frame(newdata_oecd) %>% filter(!is.na(NAME))
n1<- n1 %>% filter(pop>100) %>% filter(nl>0) %>%  mutate(lpop=log(pop), lnl=log(nl))
```

- We plot the scatter for actual and logs of population and nighlights

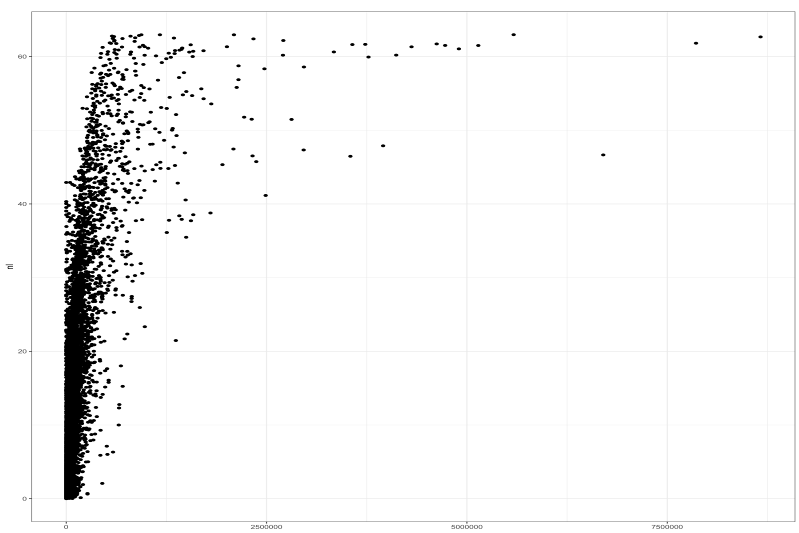

Fig1: actual values of population and nighlights

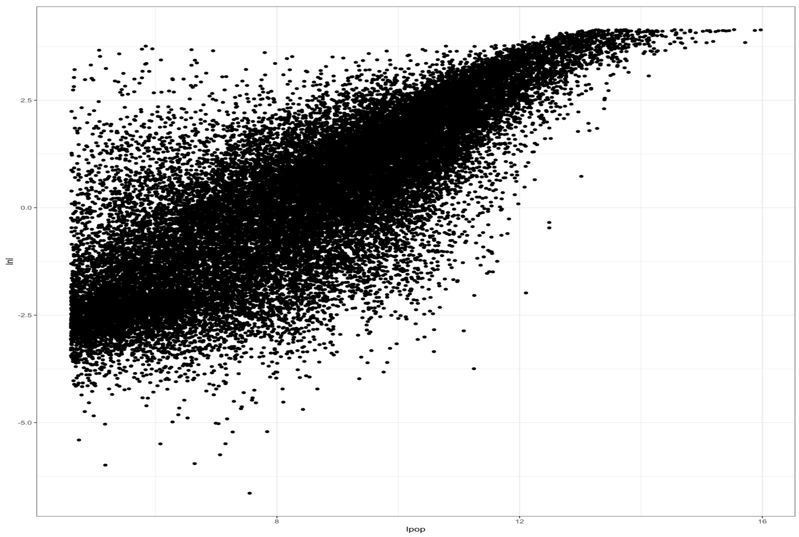

Fig2: log values of population and nighlights

- We run the linear regression of Nighlights and Population for OECD Countries

```
linearMod1 <- lm(lnl ~ lpop, data=n1)
summary(linearMod1)
```

Step2: Projecting the missing lights for Africa

- At first we spatially join the nightLight and population data with the Africa shapefile.
- Then we project the night lights using the results from the OECD regression. We then cap the projected values of night lights at 63. (which is the maximum value in the original night light data)
- We then calculate "missing night lights" by taking the difference between projected and original value.
- We replaced the negative missing night lights with zeros.

```
# Subset Africa countries from World Map
africa=my_spdf[my_spdf@data$REGION==2, ]

#Spatial Join with NightLight and Population Data
af_pts_in<-over(newdata,africa)
af_data <- spCbind(newdata, af_pts_in)

# Filter NAs and create log values
n2<-data.frame(af_data) %>% filter(!is.na(NAME))
n2<-n2 %>% mutate(lpop=log(pop), lnl=log(nl))

# -- Step 5: Projection of OECD on Africa and Create Missing Night Lights
```

```
Database
africa_nl<-n2 %>%
  mutate(nl_proj=(-5.386709)+0.950176*lpop) %>% #Projection using alpha-hat
and beta-hat from OECD regression (5km)
  mutate(nl_proj_ul= exp(nl_proj), #Unlog projected night lights
         nl_proj_ul_x=if_else(nl_proj_ul>63,63,nl_proj_ul), #cap at max
         miss_nl_ul= nl_proj_ul_x-nl, #Missing night lights (unlogged)
         miss_nl_ul_nw=if_else(miss_nl_ul<0,0,miss_nl_ul)) #replace negatives
```

Step3: Plotting the missing lights Africa Map

```
# -- Step 6: Rasterizing the Projected Data set

new_coords <- cbind(africa_nl$x, africa_nl$y)
new_pts <- SpatialPointsDataFrame(coords=new_coords,
data=data.frame(africa_nl$miss_nl_ul_nw))
names(new_pts) <- "miss_nl"

cell_size <- 0.1
lat_min <- -39.822; lat_max <- 42.34041; lon_min <- -25.36055; lon_max <-
63.49576
ncols <- ((lon_max - lon_min)/cell_size)+1; nrows <- ((lat_max -
lat_min)/cell_size)+1
af.dt<- raster(nrows=nrows, ncols=ncols, xmn=lon_min, xmx=lon_max,
ymn=lat_min, ymx=lat_max, res=0.1, crs="+proj=longlat +datum=WGS84")
af.dt<- rasterize(new_pts,af.dt,fun=mean)

# Converting raster into dataframe for GGPlot
af<-rasterToPoints(af.dt)
af2<-data.frame(af)

# Extract Africa country shape file and convert it to a dataframe
africa1=my_spdf[my_spdf@data$REGION==2, ]
africa1@data$id = rownames(africa1@data)
africa.points = fortify(africa1, region="id")
africa.df = join(africa.points, africa1@data, by="id")

finalMap <- ggplot(data=af2, aes(x=x, y=y)) +
  geom_polygon(data=africa.df, aes(x=long,y=lat,group=group),color="white",
lwd=0.01, fill="white", bg="white") +
  geom_raster(aes(fill = miss_nl)) +
  labs(fill = "miss_nl") +
  scale_fill_gradient(low ="white", high = "black") +
  guides(fill = FALSE) +
  geom_polygon(data=africa.df,
aes(x=long,y=lat,group=group),color="black",lwd=0.1,fill="NA",bg="NA")+
  theme_void() +
  xlim(-19,53) +
```

```
  ylim(-36,38)
finalMap
```

Appendix Figure 1: Distribution of "missing" night lights in Africa