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# Content

# It never rains but it pours: weather shocks on sectoral wage in US counties

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**Abstract**

The paper explores the effect of weather shocks on wage growth, using quarterly data on a large sample of US counties for the 1990-2006 period. We find a robust and significant effect of extreme weather events on private wages, a result not previously established for a developed country. The effect of weather on wages also varies depending on the type of shock considered: whereas extreme cold events and rainfall shocks have a negative impact on wages, extreme warm temperatures appear to have the opposite effect. In order to shed light on this peculiar pattern we exploits differences across sectors and also study to what extent weather shocks are linked to the agricultural dependence and the financial development of a given county. Weather shocks affect positively wages only in sectors with non-tradable goods. Agricultural dependence is an important factor to explain the negative impact of cold events, whereas financial development fuels wage-growth in case of warm events.

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## 1. Introduction

According to IPCC (2013), during the last decade extreme weather events were more and more frequent and the period 1983-2012 was the warmest 30-years period of the last 14 centuries. This phenomenon obviously determined a growing interest on climate-related issues.[1]In this framework, the literature started to investigate the future cost of climate change for the human society. The first studies on growth and climate were focusing on the link between weather and income employing cross-sectional dataset, such as Sachs and Warner (1997), Gallup *et al.* (1999) and Dell *et al.* (2009). However, works such as Acemoglu *et al.* (2002) and Rodrik *et al.* (2004) argued that the correlation between weather realizations and income is spurious and driven by omitted controls, as for example the missing identification of the institutional framework or other social norms. Reconciling the literature through a panel dataset at country-level, Dell *et al.* (2012) recently reopened the debate demonstrating that year-to-year fluctuations in temperature and precipitation have a large negative effect on growth but only in poor countries, suggesting that being poor is highly correlated with a substantial negative temperature effect. Dell *et al.* (2012) explain that in these countries weather's effect is consistent and broad and it affects also agricultural output, industrial output and political stability. The authors, however, do not establish any significant result for developed countries. Several positive or negative factors could drive this non-finding, as for example an higher level of resilience and adaptation typical of developed countries but also the type of weather data employed, the temporal dimension of the observations, and the specification used. This is why this paper provides an analysis on the effect of weather focusing on daily extreme events.

In this framework, the final purpose of this study is to investigate the effect of weather shocks on intra-county labor income growth in US during the period 1990-2006 using quarterly data. Exploiting daily weather observations, and combining them with quarterly labor wage in private sector, it is shown that weather influences significantly average daily wage. Differently from previous studies, which usually focused only on temperature and precipitation trends[2], this paper shows that increasing the frequency of observation (daily for weather and quarterly for wage), it is possible to demonstrate that climate effectively interacts with the economic environment. This result is not in contradiction with previous studies, conversely it supplies evidence of the effect of extreme realizations against the common used average yearly values of temperature as in Dell *et al.* (2012). This finding is obtained concentrating on a smaller geographical level (county) than previous ones in the literature (i.e. country-level) also in order to reduce the dispersion of weather-related

[1] As defined in works such as Dell *et al.* (2014), climate refers to the overall distribution of outcomes such as temperature and rainfall, while weather describes the realizations from the climate distribution.

[2] Also because of the complexity of finding weather data with high frequency.

information caused by the high spatial variability of the phenomenon itself. In addition, as IPCC (2013) points out, apart from a trend effect, climate change is also determining an increase in the likelihood of weather shocks, defined in this paper as extreme events outside the historical distribution in a particular geographical zone. Thus, it would be necessary to extend the knowledge of climate change outside the classical trend effect, in order also to capture all the complexity of the phenomenon that we are facing. For example, average precipitation during a year is not informative of the intra-year distribution of the precipitation itself, and the same mean value could be determined both by a linear homogeneous distribution or by few and localized extreme events alternated with a long period of drought. Employment of average data disregards the possibility to depict all the effects of weather and this, added to the increasing likelihood of weather shocks, could determine an underestimation of the cost of climate change in the future. This paper finds an heterogeneity behind the effect of weather and, exploiting sectoral data, it shows that the general result hides a story of winners and losers, where some industries with a higher degree of climate-sensitiveness are negative correlated with the shocks and, contrary, fewer industries are gaining from the increasing variability. This is compatible with Graff Zivin and Neidell (2014) who suggest that the effect of weather on time-allocation is heterogeneous depending on whether the sector is climate-exposed or not. We obtain all these estimates using average daily sectoral labor wage supplied by the US Bureau of Economic Analysis and defining weather shocks as the occurrence of a two-days weather record outside the 99.9% historical confidence band of weather realizations in the county[3]. To be consistent with the adopted definition of extreme events, We calculate shocks on maximum/minimum temperature and on total precipitation. The need of daily data observations for weather realization during the historical period (1980q1-1989q4), combined with the high-propensity of switching-off weather stations as explained by Auffhammer *et al.* (2013), reduce the base sample to an unbalanced panel of 1935 US counties and weather stations, 12 sectors, for a total of 720,196 observations. In spite of this, different tests have been conducted considering only a balanced sub-sample and in general the results can be considered consistent and robust.

Following the cross-country literature, the study then supplies one of the first within-country evidence, especially for a developed country, that weather shocks affect significantly and heterogeneously daily wages and thus labor productivity. We test the estimates obtained focusing on some channels of heterogeneity considered relevant in the development and climate-related literature. Particularly, this study focuses on three dimensions that could affect the heterogeneity of the shocks: agricultural-dependence, level of tradability of the sectors and financial development of the county. Agricultural-dependence

[3]The historical period refers to the decade 1980q1-1989q4.

has a role only in case of shocks on minimum temperature, while it does not appear to drive elasticities of income to weather in case of rainfall or maximum temperature shocks. The level of tradability of the goods in the sectors seems to be a primary factor of the propagation of weather shocks, indeed all the negative effects of extreme events are concentrated on the industries defined as more tradable. Finally, contrary to the development literature, financial development appears to fuel wage growth during shock on maximum temperature but it has no role in mitigating the effect of negative shocks. This could mean that even if agents have the possibility to smooth they actually do not follow this strategy. The paper is organized as follows: section 2 introduces the related literature; section 3 includes data description with their methodology and sources; section 4 presents summary statistics; section 5 shows the results of the empirical analysis and discusses it; section 6 addresses the heterogeneity of these effects; section 7 develops some robustness check; section 8 outlines conclusions and section 9 contains Appendix and tables.

## 2. Related Literature

The main contribution of the present study is related to the climate-economics literature, as recently defined by Dell *et al.* (2014). Part of this literature addresses the question whether income is affected by climate environment using cross-sectional samples. Their general finding is that warm countries and regions are less rich than cold ones. This is the case, for example, of Gallup *et al.* (1999), who show how countries located between the two tropics have on average a 1% smaller yearly growth-rate with respect to other countries. From a panel data perspective, Dell *et al.* (2012) demonstrate that poor countries experience a drop in per capita income of 1.4% when their temperature increases of 1°C. Additionally, they show that climate has an influence also on the agricultural, industrial and political output[4]. They conclude that while it is plausible that this negative shift is driven by an agricultural channel, it is also possible that temperature plays its role through other dimensions, such as political stability. Their findings are not significant for rich countries, and this is compatible with the hypothesis that advanced economies are less vulnerable or more resilient to weather trends. Narrowing the time-dimensional and geographical-dimensional level of the analysis, we add novel evidence on the effect of weather on wage in US, which is one of the richest country in the world.
Other works investigate the effect of weather events on income realization for single sectors, focusing on the labor productivity channel. As demonstrated in the medical litera-

[4] Other paper studies the weather effects on several output, for analysis on agricultural the impact of weather, gdp loss and farmers behavior see De Giorgi and Pistaferri (2013), Deschenes and Greenstone (2007), Fisher *et al.* (2012), Schlenker and Lobell (2010); for evidence on aggregate outputs see Jones and Olken (2010).

ture, extreme daily temperature and rainfall cause fatigue[5] and thus weather could have an important role in determining labor productivity. This is usually shown employing observational and experimental data, conducted through experiments on productivity of factory, call center and office workers. For example, Niemela *et al.* (2002) show that an increase in temperature by 1° C outside the normal temperature zone cause a reduction of about 1.8% on workers' labor productivity. Other laboratory experiments emphasize that productivity of individuals could decline when the temperature passes 25-30 C° or goes above a certain threshold. Our findings are compatible with this literature, but they adds novel evidence about the heterogeneity of the effect on 12 different sectors.

Finally, this paper gives empirical support on the possible channels and mechanism hidden behind the effect of weather on average income. A recent study by Graff Zivin and Neidell (2014) shows that during an extreme hot or cold day, a worker could prefer to allocate time to leisure activity instead of working, to stay at home or to work instead of enjoying outside activities. Their results display a negative effect of extreme heat on time allocated to labor in climate-exposed industries (defined as high risk), with the occurrence of temperature over 37 C° associated to a statistically significant drop of 59 minutes in labor activity. Graff Zivin and Neidell (2014) thus give a first insight on the heterogeneous effect of weather depending on the exposition to climate of the sector considered. The present paper, after disentangling by sectors, investigates the role of agriculture, tradability and financial development in fostering the shocks' propagation to overall economy.

To the best of our knowledge, in the literature there is not a comprehensive study that estimates the cost of happening of extreme weather events in terms of wage for several sectors at sub-national level in case of developed country.

## 3. Data source

### 3.1 Weather data

The analysis employs records of climate variables from weather stations data drawn from the National Climatic Data Center (NCDC) Global Historical Climatology Network-Daily (GHCN-Daily). This platform provides one of the most complete database of daily climate summaries from land surface stations located all over the world. Following Barreca *et al.* (2013), we select as explanatory variables the daily maximum/minimum temperature and total daily precipitation. Using both maximum and minimum temperature is necessary for identifying eventual shocks on the extreme of temperature records. Indeed, in case of employment of average values it would be challenging to capture the occurrence

[5]For evidence on cognitive and productivity performance see Epstein *et al.* (1980), Ramsey (1995), Hancock, Ross, and Szalma (2007), Pilcher, Nadler, and Busch (2002).

of extreme events because they could moderately affect the overall average, especially if measured during long periods of time (such as years). In this sense, we propose a different identification of climate fluctuations using daily data and exploiting an alternative dimension of weather. Once excluded weather stations with missing daily values for the historical period (1980q1-1989q4), remaining stations are merged with counties that contain them. Realization of this one-to-one match between counties and stations is necessary for several reasons. Firstly, the study needs daily records in order to be consistent with the definition of weather shock adopted, that is the occurrence of minimum two-day lasting climate records outside the 99.9% confidence interval of historical counties' average. Employing station data allows to avoid interpolation of more than 10 millions of records from different stations that have few records for each year. A recent survey on the usage of climate data from Auffhammer *et al.* (2013) suggests deriving data for missing stations regressing their records from non-missing stations. However, because of the extreme spatial variability of weather data and the quantity of stations missing in the dataset, predicting missing records from other stations could bias the results at least as not including them. Furthermore, being this analysis focused on the intra-county variation of labor income in response to weather shocks, the temporal dimension should be the priority, and in order to verify a possible bias we test the results in the robustness section.

The methodology requires the identification of the occurrence of record outliers. Once identified, we use the outliers to generate quarterly dummies on positive maximum temperature shocks, negative minimum temperature shocks, and precipitation shocks. The identification of weather shocks is based on the calculation, for each county, of the average and standard deviations of maximum/minimum temperature and total precipitation in each season for the historical period (1980q1-1989q4), where the seasons are set as coincident to 1st quarter, 2nd quarter, 3rd quarter, 4th quarter. For example, we define the average of maximum temperature during the first season in a county as the county's historical maximum temperature of all the first quarters in the historical sample (1980q1-1989q1). Then, we set a dummy equal to one for that county if during a first quarter of the period under analysis there are two consecutive observations outside the 99.9% confidence interval of its seasonal historical average.

Thus, in order to set the shock at county-quarter level, we set a different confidence interval for each quarter (season) and each county in order to identify quarter's outliers. This helps also in avoiding to consider as shocks just, for example, extremely high realizations during summer and extremely low realizations during winter. In addition, we consider the county's average because each geographical unit has its own experience with the local weather. It is straightforward that an extreme event in San Diego is totally different from another event in New York, where usually negative weather events are more severe. This methodology accounts for this difference, creating a county-specific measure for the shock.

### 3.2 Labor income data

Data on quarterly labor wage are delivered by the U.S. Bureau of Economic Analysis (BEA) on county and quarterly basis starting from 1990q1 for public and private sectors. Data are available for twelve industry supersectors following NAICS 1992 classification (North American Industry Classification System). For each quarter, BEA supplies total labor wage, employment, and average weekly labor wage in a quarter. This paper keeps only data from private industries and it hypothesizes that each day contributes equivalently to the average weekly labor wage. Thus, we derive the average daily labor wage in a quarter dividing the average weekly labor wage by seven. Finally, data on wages are deflated using BEA Consumer Price Index.

### 3.3 Other data

Data on population are available at year level from BEA. We impute a linear population growth rate within the year in order to predict the value at quarterly level. This is done in order to maintain the original time-period of the wage for the final-sample. Dummies on the occurrence of hurricanes are created at state-year level for all the hurricanes listed by Strobl (2011). We decide to create this variable at state-year level for two reasons: first, because of the difficulty of finding an entire list of counties hit by hurricanes and, second, because the happening of an hurricane in a small group of counties could however influence the economy of the whole state, through aid for recovering from the damages.

In the second part of the paper we explore the heterogeneity of shocks' effects, focusing also on some dimensions considered significant by the climate-economics literature. First, the analysis tests the level of agricultural-dependence of the county itself as a mechanism of shock propagation. As Dell *et al.* (2012) emphasize in case of developing countries, if agriculture has a crucial role in the economy of a county it would be possible that the weather would affect more the income of that county. For this reason we employ a variable that reports the fraction of area covered by cropland in each county. This value is provided by Ramankutty and Foley (1999), it is extracted using GIS (Geographical Information System) and it is employed to explore whether the effect of shocks changes increasing the agricultural area inside a county.

A second channel is the tradability of the goods in the sectors. As Graff Zivin and Neidell (2014) point out, the level of exposure to climate could influence the effect of weather on the individual time-allocation choice. For this reason, we exploit the concept of tradabilty of goods dividing the sample in two clusters [6]: non-tradable industries (or low-tradable) and high-tradable industries. High-tradable cluster includes Construction, Good-Producing, Manufacturing, Trade and Transportation, while the non-tradable one comprises Education and Health, Financial Activities, Other Services, Professional Services, Service Providing.

The third channel explored is the level of financial development of the county during the whole period (1990q1-2006q4). The intuition is that in counties with higher financial development we expect that shocks will be smoothed by the higher possibility of borrowing. For this purpose, data on the number of banks and saving institutions are extracted for each year from Censtats, that is a platform supplying also records at county level collected by the US Census Bureau. The number of banks and saving institutions are then divided by the population and thus the final sample is treated at year-level, and not at quarterly-level as in the previous analysis.

## 4. Summary and descriptive statistics

Figure 1 displays the spatial distribution of weather stations selected from NCDC's dataset that have non-missing values for the historical period (1980q1-1989q4). It is possible to notice a higher concentration of weather stations on the east coast than on the west one, mainly because there are more missing values (station switched off) in the last one. Therefore, the final sample contains only 1935 counties out of the 3143 of which US is composed. As Auffhammer *et al.* (2013) explain in their work, it is common that stations are switched off after brief periods or that frequently they do not record all the climate variables. This is however not correlated with the weather-shock events, even because it is unlikely that shocks constrain stations to be switched off and so the analysis can proceed without any issue of sample selection. Table 1 shows summary statistics for historical and sample's weather variables. While during 1980q1-1989q4 maximum temperature was on average 18.48° C, the mean value of the period 1990q1-2006q1 is 18.66° C, with an increase of 0.18° C between the two periods. There was a slight positive shift also in average tmin, passing from 5.92° C degree during 1980q1-1989q4 to 6.34° C during 1990q1-2006q4. This occurred also in average daily precipitation during a quarter, that passed from 2.55 average mm of precipitation to 2.67 mm. Standard deviation for all the variables reported is also higher during the period in analysis than in the historical one, highlighting once again the higher volatility of the weather during last decade. Table 2 reports the main weather explanatory variables, i.e. the frequency of climate shocks with the associated

[6]Here I exclude some sector because of the unknown tradabilty of the goods and services produced.

standard deviation. Quarters with negative temperature show the higher frequency, equal to 0.28, followed by rainfall shocks with 0.16 and positive temperature shocks with 0.03. These results indicate that weather shocks in US are more frequent on the occurrence of extreme negative events, such as cold temperature and extreme days of rainfall, and this is coherent with Lobell *et al.* (2011). Note that, applying this methodology, counties that received a shock in a certain quarter are considered as treated, and thus previous statistics represent the fraction of the sample hit by the shocks. These differences in frequencies among the weather realizations, especially the high value of negative and rainfall shocks, are explained both by the changing climate during last thirty years[7], as well as the uncertain distribution of climate, which is an open debate in the literature. This is the reason why the robustness section addresses this issue using different specifications for the weather variable. The final part of Table 2 displays summary statistics for total shocks per quarter. The maximum number of tmax shocks inside a quarter is 30, while for tmin and rainfall they are respectively 42 and 10.

[Insert Table 1 and Table 2 here]

Table 3 shows summary statistics for average daily real-wage in the 12 sectors under study. Wage is deflated using CPI 2006 for the purpose of comparing data from 1990 to 2006. Sectoral real wage is higher in Manufacturing, characterized also by the second-higher standard deviation. Information and Good Producing are the second and the third more remunerative sectors. Conversely, Leisure and Hospitality experiences the lower average labor income during all the period. Figure 2 shows the spatial distribution of daily wages averaged by all the sector and quarters. Labor wage is highly concentrated in counties belonging to big cities, as New York and Boston in north-east, Houston in the south, Los Angeles and Las Vegas in the south-west, and Chicago in the north-east. A zone of low labor income can be identified in the center of US, where big cities are few and industrial activities are less developed.

Lower panel of Table 3 shows the summary statistics for the variable employed in the heterogeneity section and other controls. Mean fraction of area harvested in all the sample is equal to 0.35, indicating that on average 35% of each county's territory is covered by cropland, while the index of bank per capita (multiplied by 100 for calculation purpose) is available only for 180,415 observations, with a mean of 0.042 and standard deviation equal to 0.025. Finally, log of population has an average of 10.60, while the average for the hurricane dummy is 0.03, meaning that 3% of the sample experienced an hurricane during the period under analysis.

[7] As explained by Lobell *et al.* (2011) for the period 1980-2008

Figure 3 reports an example of the method employed for identifying the shock for a random county during 2000q3. The green line represents the mean value of maximum temperature for the 3rd quarter during 1980q1-1989q4 for that county, while the red line is the upper bound of the confidence interval at 99.9% level. Notice that for the maximum temperature we consider only the upper bound while for negative temperature we use only the lower bound. Red dots are two couples of consecutive records outside the 99.9% confidence interval that are classified as shock, while blue dots are observations inside the confidence bands. Therefore, in this case the dummy variable on maximum temperature will take value 1 for the study of the extensive margin. In addition, a second variable identifying the total positive temperature shocks will assume value 2 for the study of the intensive margin. Note that, independently from the classification criteria chosen, during the third quarter in figure an anomaly in the weather distribution is identifiable around the daily observations that here are classified as a shock. This can be determined only using this non-linear methodology, that captures the occurrence of such events under dummy variables.

[Insert Table 3 here]

In figure 4 we exploit average daily temperature excursion, calculated as the difference between the average maximum temperature and the average minimum temperature in each county for the period 1990q1-2006q4. This measure is plot in the figure with the natural logarithm of average labor income. Figure 4 shows that counties with higher daily temperature excursion experience the lower labor income. An increase of 1 degree in daily excursion is associated to a decline of 4% on average quarterly income and the correlation is significant at 1% level. Obviously the correlation could be spurious, also for his cross-county dimension, and several factors could determine it, as for instance property right institutions[8].

## 5. Empirical analysis

To capture the effect of weather shocks on intra-county labor income growth, and following convergence theory as in Strobl (2011), the main model fitted is a county, sector, and quarterly fixed effects OLS model with standard errors clustered at state-industry level. We cluster the errors at state-industry level because of two reasons. First, sectoral wage needs to be correlated because of global demand and supply factors. Indeed without

[8] For evidence on the debate about the importance of geographic or institutional factors see Acemoglu *et al.* (2002) and Sach (2003)

clustering, an increase in global demand or supply for an industry could bias the estimates of the standard errors. Second, considering that climate has a high spatial dimension, it is necessary to correct standard errors for eventual spatial correlation. The sample is an unbalanced panel and the correlation matrix for the spatial-error model should vary togheter with the variation of the number of counties during each quarter. However, this is computational demanding. Thus, in order to partially address this issue, we cluster errors also at state level so that this spatial correlation could be taken into account at least for the counties not located on the border. Fixed effects are another relevant instrument for the analysis of intra-county variation since they capture latitude, longitude, elevation and other spatial controls used in the cross-sectional literature[9]. In addition, since characteristics such as race, education or gender-ratio have small variability between-quarters, the likelihood that their variation corresponds to the occurrence of weather shocks is extremely low. The empirical model is tested using quarterly dummies because, together with the sector fixed-effects, they capture the intra-year cyclicality of labor wage for specific sectors (for instance in the sector of Leisure and Hospitality). Furthermore, they address the effect of business cycle, including economic shocks that could impact on the whole sample at the same time. Finally, we employ the natural logarithm of labor wage in order to estimate the coefficients as percentage changes in wage. The following model of county's income process encompasses all these characteristics:

$$\begin{aligned} lnw_{c,s,q} = \beta_0 + \beta_1 lnw_{c,s,q-1} + \beta_2 \delta tmax_{c,q} + \beta_3 \delta tmin_{c,q} + \beta_4 \delta prec_{c,q} + \\ \pi_q + \mu_c + \zeta_s + \gamma X_{c,q} + \epsilon_{s,i} \end{aligned} \tag{1}$$

Where $\beta_0$ is the constant, $lnw_{c,s,q}$ is the natural logarithm of average daily labor wage in sector $s$, for county $c$, during quarter $q$; $lnw_{c,s,q-1}$ is the natural logarithm of previous quarter labor wage for the same county; $\delta tmax$, $\delta tmin$, and $\delta prec$ are dummies taking value 1 if in that quarter there are *minimum* two consecutive records outside the 99.9% confidence interval of their historical average; $X_{c,q}$ is a matrix of controls (i.e. population growth rate and hurricane dummy); $\pi_q$ are quarterly dummies; $\zeta_s$ sector fixed-effects; $\mu_c$ are counties fixed-effects; $\epsilon$ is an error term clustered at sector $s$ by state $i$ level. Before introducing the results, one caveat should be made. Regressing on a lagged variable could bias the estimation of the coefficients, as established by Nickell (1981). The author points out, however, that the bias goes to zero as the time dimension increases. Our panel contains on average more than 29 observations per group (and a maximum of 67).

[9] As the controls employed in Dell *et al.* (2009).

Additionally, in the robustness section the analysis is conducted reducing the panel to a balanced one and keeping only counties with the larger number of consecutive observations.

### 5.1 Extensive margin: shock or not?

Table 4 reports the results on the extensive margin, where we control only for the effect of the presence of weather shocks independently from the number of the events itself. The baseline specification includes sector, counties and quarterly FE. In column 1, wage is regressed only on positive/negative temperature and precipitation shocks, and the result is that average daily wage in a quarter decrease by -0.2% when rainfall shocks are present during the quarter. We calculate these estimates without fitting any control and they are significant at 1%. In column 2 we include the first lag of daily wage for the same id. The result of the presence of rainfall shocks is quite consistent with previous estimation. The extreme events on precipitation influences the average daily wage in a quarter by -0.1%. Interestingly, in column 2 extreme events on maximum temperature have also an effect on wages, but this effect is positive and equal to +0.4%. In column 3 the total dimension of the population in the county is added among the controls, but it is lagged in order to avoid any correlation with the change in employment. The estimates in column 3 remain quite consistent with previous ones: a quarter with positive shocks experiences, on average, an increase in wages equal to +0.4%, with a significant coefficient at 1% level. Also in case of rainfall shocks in a quarter the coefficient is stable and significant at 10% level, with an effect of -0.1% on wage. Finally, in column 4 we fit the same model adding a dummy that controls for the happening of hurricanes at state-level for a certain year. The consistency of the estimate is not affected by this control, and the coefficient remains significant and stable, with a small increase on the effect of positive shocks, that reaches a value of +0.5%. Summarizing, in the extensive margin it is evident that positive temperature and rainfall shocks have an effect on wage growth, but while this effect is positive for maximum temperature, it is negative in case of precipitation shocks. Minimum temperature does not appear to influence the wage growth path of the overall economy. However, from Table 4 it is not possible to exclude that weather variables have an heterogeneous impact on different industries, hitting differently each sector depending on their climate exposure. Analyzing only the extensive margin could determine a good estimation for a study that aims to sum-up the effect of climate, but it would underestimate the actual role of the shocks, that could be to exacerbate inter-sectoral differences. This is the reason why, after studying the intensive margin, we proceed investigating the role of weather shocks in affecting wage growth sector by sector.

[Insert Table 4 here]

### 5.2 Intensive margin: the effect of one more shock

Table 5 displays the intensive margin of the effect of weather shocks in the data, where the main covariates are the total number of shocks in a county for each quarter and the dependent variable is the average daily wage in a quarter. As in Table 4, column 1 reports the effect of weather shocks without fitting any controls. The result is that when there is an increase of one shock on tmax, the average daily wage in that quarter has a positive growth equal to +0.1%. The same effect in magnitude, but different in sign (-0.1%), takes place when there is one more shock in precipitation in a quarter with respect to the quarter before. In column 2 we report the results obtained adding the lagged value of wage to the specification of column 1. While previous estimates for rainfall and maximum temperature remain consistent, it is interesting to note that also minimum temperature appears to have a small effect on wages, with a coefficient equal to -0.03% significant at 10 % level. In column 3 we add also the lagged value of the population in the county and the coefficients of the three shock variables remain consistent. Finally, adding a dummy on the hurricanes does not modify the estimation, with the coefficients of maximum temperature shocks (+0.1%), minimum temperature (-0.04%), and rainfall shocks (-0.1%) remaining stable and significant. Note that the value of the daily wage derives from the BEA's calculation of average weekly wage in a quarter, which is divided by 7 assuming that each day contributes equally to the average daily wage. Furthermore, also BEA calculates the original average weekly wage by averaging total quarterly wage on the number of weeks present in a quarter. Thus, considering that on average a quarter is composed by 64 working days, we can assume that each day contributes to the quarterly realization in a percentage of around 1.56%. Then, if the hypothesis is correct, the occurrence of one shock on maximum temperature in a quarter has the effect of increasing the labor wage by 0.1%/1.56%, corresponding to a shift of +6.41% on the daily productivity. For the same reason, in case of an increase of one shock on rainfall the daily productivity diminish by -6.41%. Finally, the presence of one more shock in minimum temperature causes a negative shift on labor productivity of -2.56%. This estimate supplies evidence of the potential role that climate change could have in influencing average productivity in a developed country, but does not gives insights about the potential heterogeneous effect that weather may have on different sectors of the economy.

[Insert Table 5 here]

### 5.3 Sectoral Analysis: winners and losers?

Understanding which is the sector more affected by weather in terms of private wage could provide insights for implementing specific policies to tackle its higher vulnerability, measured as entity of the shock over average wage. For this reason Table 6 disentangles the effect of weather shocks at sectoral level. The sectoral daily wage in a quarter is regressed using specification 4 of Table 5. Thus, the model includes counties FE, quarterly FE, the lagged natural log of wages, the lagged level of population and a dummy at state-year level if an hurricane hit the state in that year. The main covariates are once again the total number of shocks in the quarter, thus the estimates reported in Table 6 refer to the effect of the increase of 1 shock in the total number of shocks during the quarter for which average daily wage is reported.

According to Graff Zivin and Neidell (2014), the sectors that are more exposed to weather should be also the more negatively affected by the occurrence of extreme events. This is the case of Construction, where the increase of 1 shock on minimum temperature or in rainfall causes a decrease on average daily wages of -0.2%, with the the coefficients significant at 1%. Also the super-sector including Education and Health has a decline in private wage in case of one rainfall shock, with the entity of the negative shift equal to -0.2% and significant at 1% level. This decline could correspond to the so-called "snow-day", term that is used by the municipalities in US when the schools and the public offices closed during extreme precipitation events. A third sector exposed with severity to weather shocks is Leisure and Hospitality, which experiences both a positive and a negative effect. Indeed its wage increases by +0.5% when there is one more shock on positive temperature, and it declines by -0.1% when the shock is on minimum temperature. We conjecture that the positive effect of a shock on maximum temperature could be driven by an increase in the demand of good and services for Leisure and Hospitality. Graff Zivin and Neidell (2014) demonstrate that in case of a positive shift in temperature the individuals tend to allocate more time to the external activities and this could be connected with an increase in the demand for good and services and in the wages of workers in the private sector. Other sectors such as Manufacturing[10] and Natural Resources are affected by extreme events, with the first one experiencing a decrease of -0.1% in wage in case of shock on minimum temperature, and the second one having a negative shift of -0.4% in case of shock on rainfall. Furthermore, the occurrence of a shock on negative temperature seems to affect negatively also Other Services (-0.05%) and Trade and Transportation (-0.1%), while rainfall shock has a negative effect also on Service Providing (-0.1%).

All results reported here could be expected because of the degree of exposition to weather of each sector itself. However, there is a surprising result that gives new insight on the effect of

[10]This sector could be considered as climate exposed because of some external operation.

weather on wages, evident in Table 6. Indeed, two sectors, which are not climate exposed, are positively correlated with extreme events. This is the case of the Financial Activities and Professional Services. In the first one the occurrence of a positive or negative shock on temperature brings an increase of respectively +0.02% and +0.01% in wage. In the second one the presence of one shock on maximum temperature determines a positive shift on wages equal to +0.1%. The result on Financial Activities could be explained because this sector includes also insurance activities, which are likely to increase revenues during periods with extreme events since people tend to cope with risk buying more insurance. Conversely, a conjecture for the effect of shocks on maximum temperature in these sectors is the increase in demand in Leisure and Hospitality, which could have a spillover effects on Financial Activities (e.g. more insurance for traveling, more bank movements) and on Professional Services.

[Insert Table 6 here]

Summing up, while from an overall perspective only maximum temperature and rainfall shocks appear to have an influence on wages (as in Table 4), once the analysis is conducted in each sector, 10 sectors out of 12 are influenced heterogeneously by the occurrence of extreme events, included shocks on minimum temperature. The heterogeneity of the effect of weather shocks create small winners (such as Financial Activities, Professional Services and Leisure and Hospitality in case of positive temperature shocks) and big losers (as Construction, Education and Health, Manufacturing, Natural Resources, Other Services, Services Providing, and Trade and Transportation).

### 5.4 Sectoral daily impact of shocks

Table 7 gives an insight of the monetary cost of weather shocks in US economy. Indeed, Table 7 displays the effect of a shocks on weather as % of daily wage for each sector (column 1) and it focuses on the value of the event expressed in real USD 2006 (column 2). Then, in column 3 we calculate the maximum predicted cost/revenue from shocks for the county with the largest number of shocks. As in section 5.2, I apply the following methodology:

$$\%dailywage = \beta_s * \frac{1}{totdays_q} * 100 \tag{2}$$

where $\beta$ is the coefficient calculated in Table 6 for sector $s$ and $totdays$ is the number of working days in a quarter, which is assumed to be equal to 64. In column 2, using the sectoral average daily wage, we determine for each sector the value in dollar of the percentage in column 1. In column 3 we multiply the value in dollars for the maximum number of shocks (and by type of shock) in a quarter for all the dataset.

As Table 7 shows, the highest cost of the happening of a rainfall shock is associated to Natural Resource, which experiences a drop of -25.64% in daily productivity, equal to 10.63 dollars. In this case, the highest predicted value of shocks for the quarter with more extreme events is equal to 308.27 USD. The second sector most affected is Construction, with drops equal to 12.82% in daily wage both for a shock on minimum temperature and in rainfall, and where the maximum predicted cost of these shocks is equal respectively to 231 and 159.5 USD. Also Education and Health and Manufacturing have consistent losses and in the worst case they are above 130 USD per quarters.
Turning to the positive effects of the shocks, which are listed in the last part of Table 6, Leisure and Hospitality is the sector with the highest positive elasticity to the occurrence of extreme events on maximum temperature. Indeed, the occurrence of a shock on positive temperature increases the daily wage on average of 32.05%, with a maximum predicted net effect equal to 149.1 USD which compensates largely the negative effect of a shock on minimum temperature in the same sector (which has a maximum predicted value of -41.75 USD). Financial Activities and Professional Services are the other sectors receiving a positive effect from shocks on weather, but these impacts are restrained to less than 20 dollars per quarter in case of maximum predicted value (column 3). However, Financial Activities and Professional services could be strengthened by weather shocks because the occurrence of extreme events will increase the differential between their average wage and that of the other sectors, pushing up the wage inequality among sectors.

## 6. Heterogeneity

This section investigates the heterogeneity of the effect of weather shocks and the mechanisms of transmission of these to the economy. Collecting data from different sources, we focus in particular on the role of agricultural-dependence of the county in influencing the effect of extreme events on private wage of the county itself; on the tradable and non-tradable nature of the sectors and on the financial development level of the county.

### 6.1 Agricultural-dependence

During the occurrence of an extreme event, several dimensions could determine a shift in the normal growth path of wages in private sector. A factor could be the presence of a strong agricultural sector. This, being the most directly interested by weather shocks, would facilitate the impact on average income. Such channel has been hypothesized also by Dell *et al.* (2012) who have found a strong effect of climate on GDP's of developing countries with a large agricultural value added. On this purpose, after having averaged the variable on fraction of area harvested at county level for the period 1990q1-2006q4, this work tests if the effect of weather shocks changes when the area dedicated to cropland increases. In Figure 5 we fit a specification similar to column 4 of Table 5, with only state FE in place of the county FE, using a rolling strategy. As it is possible to notice from Figure 5, moving toward a sample with more area harvested does not influence the impact of shocks on wage, which is positively influenced by a shift of tmax shocks only in the middle of the graph. Thus, for what concerns maximum temperature the result confirms that there is not a direct link between cropland (i.e. agriculture) and private wages growth. In Figure 6 we conduct the same exercise with a different result. Indeed, in this case a variation of shocks on minimum temperature decreases wage when the fraction of area harvested passes the threshold of 0.6-0.7. This implies that the effect of shocks on minimum temperature is negative and significant when the fraction of area harvested is high. Thus, we establish a link between minimum temperature, agriculture and average private wage that is new in the literature for developed countries. In case of extreme events, also in developed countries (minimum) temperature shocks pass plausibly through the agricultural sector and affect the rest of the economy. In Figure 7 the same analysis is conducted for the precipitation shocks but in this case the result is not pointing towards an agricultural channel, considered that the effect of shocks on income is significant only at low level of fraction or area harvested (area<0.2).

### 6.2 Tradable vs non-tradable

The nature of the goods produced and sold in the market could also increase the likelihood that an extreme weather realization would affect the wages in private sector. In case of sector producing tradable goods, they should be more exposed to climate in general and thus to shocks. The concept of tradable and non-tradable goods is not far from the classification of climate-exposed developed by Graff Zivin and Neidell (2014). Differently from them, we exclude some sectors such as Leisure and Hospitality and Natural Resource because they are heavily climate-exposed but not easily identifiable as tradable. Consequently, the definition of sectors with tradable goods includes Construction, Good-Producing, Manufacturing, Trade and Transportation, while the non-tradable sectors are Education and Health, Financial Activities, Other Services, Professional Services, Service Providing. We employ the specification in column 4 of Table 5, therefore the main weather-covariates are the number of shocks during a quarter. Table 8 displays the result for tradable goods (column 1) and non-tradable ones (column 2). Interestingly, negative effects of minimum temperature and rainfall shocks are all concentrated on industries with tradable goods and they are consistent with the analysis in Table 4 and Table 5. The value of shocks on maximum temperature is positive but only for sector with non-tradable goods.

This estimate identifies a net-role of the nature of the goods in determining an effect of climate on income, thus establishing that the more an industry is engaged in trade the higher will be its exposition to weather shocks.

### 6.3 Financial development

This section investigates the role of financial development and savings in determining the effect of weather shocks. Intuitively, in counties where there is a higher concentration of banks activities one would expect that extreme events would affect less private wages. The reason behind this intuition is that banks could allow firms and individuals to borrow for paying wages in private sector during catastrophic events. This induces a mitigation of the effect of extreme events, as suggested by Jayachandran (2006) in case of developing countries. Data on total number of banks and saving institutions have been extracted at county level from the Censtat database of US. They are supplied on an annual basis for the period 1990-2006. We divide total number of banks and saving institutions by the average yearly population in each county to obtain a county-year panel with the average number of banks per capita. Then, we merge the resulting panel with the original dataset of weather shocks, which are averaged also at year level.
Table 9 shows results obtained adding to the usual specification the new variable on bank density and its interaction with the average number of weather shocks in the year. In Table 9 shocks on maximum temperature have a negative effect on wage-growth which is more than compensated by the interaction of the extreme event with the bank density, indicating that the larger is the number of banks per capita in a county, the higher will be the positive effect of maximum temperature shocks on wage growth. Surprisingly, financial development does not appear to mitigate the effects of minimum temperature or rainfall shocks on wage growth. However, only rainfall shocks have a significant effect on wage and this is probably due to the redefinition of the panel on annual basis, which is likely to reduce the variation of the main covariates determining non-significant results similar to the standard ones in the climate-economic literature.

## 7. Robustness

In Table 10 we conduct the same analyses of Table 4 and Table 5 but we reduce the sample in a balanced panel one, following Nickell (1981) who suggests that the number of observations needs to be large to avoid biases in the estimates of the standard errors. Table 10 shows the results for two balanced sub-samples, for the period 1990-2000 and

1990-2002, where observations per id are respectively 44 and 52. The first two columns report the extensive margin (corresponding to column 4 of Table 4), while the last two display the intensive margin (where I fit specification 4 of Table 5). For what concerns the extensive margin, the positive effect of maximum temperature is confirmed and the coefficient associated to shocked quarters is slightly higher than the one in Table 4. Rainfall shocked quarters show more variability in the coefficient, while the extensive margin analysis for the period 1990-2000 confirms the results of the main section. When turning to the sample 1990q1-2002q4 statistical significance decreases but the coefficient remains negative. In addition, minimum temperature is not significant as in the main results, giving consistency to the analysis. Moving to the intensive margin, both sub-panels are coherent with the estimation in Table 5. An increase of one shock in the total maximum temperature causes an increase of 0.3% in average daily wage both for the panel 1990-2000 and for the panel 1990-2002. Furthermore, an increase of one shock in the total rainfall ones during the quarter induces a decrease on average daily private wages of 0.1-0.2%, again consistent with Table 5.

A second test consists in varying the level of the confidence interval for the shock's definition. For this purpose, in Table 11 shocks are defined differently from the main part of the analysis. In column 1-2 we reduce the level of the confidence band and observations are identified as shocks if their value is outside the 99.0% confidence interval. In column 3-4 we increase the level so that the observations need to have a value larger than 99.95% in order to be defined as shocks. Table 11 reports the results for the intensive margin. Both in column 1-2 and 3-4 a shock on maximum temperature has a positive and significant effect on income, confirming the estimates of the main part of the paper. Minimum temperature shocks have a small, negative and non-significant effect as evident in column 1-2 and gains statistical significance in column 3-4, where the shocks are extremely high (value>99.95%). The opposite happens with rainfall shocks. As Table 11 shows the effect of rainfall on private wage remains the same but the statistical power decreases when we define as shocks only observations outside the 99.5%. While this result could arise some doubt on the right level of the shock definition, it should be noticed that income is affected by extreme weather events heterogeneously, as showed in the main part of the study, and the extreme events themselves need to be identified at local level. Indeed, the sign of the coefficients in Table 11 is the same of the main analysis and the loss of statistical power is probably due to the exclusion from the treated group of observations that are effectively influencing the private wage. Thus, following this interpretation, the test instead of hindering the overall result of the paper supports the idea that each weather variable has a different effect on income even in a developed country and that this needs to be taken into account when investigating the interaction between weather and income.

## 8. Conclusion

This paper studies the effect of extreme weather events on average daily private wages in US counties, contributing to the recent climate-economics literature. This is a new result for a developed country. We demonstrate that the occurrence of short but intense extreme events during a quarter has a significant and heterogeneous effect on wages. Shocks on maximum temperature have a positive effect on the salary level. The occurrence of a single shock increases average daily private wage by 0.1% in a quarter, corresponding to an increase of 6.41% of daily productivity. Conversely, both cold and rainfall events affect negatively private wage and their elasticities are respectively equal to -0.04% and -0.1%. In the second part of the paper we focus on sectoral wage and we show that large part of the economy is influenced by extreme events. Both wage in climate-sensitive sectors[11] such as Construction, or non-climate-sensitive industries, as for instance Manufacturing, are altered by the happening of extreme events. Finally, we exploits differences across sectors to shed light on this peculiar pattern.We explore three different dimensions: the agricultural dependence of the county, the tradability of the goods in the sector and the level of financial development of the counties. Agriculture has a role only in the propagation of cold events and this probably indicates that the level of resilience to the other types of shocks is high for a developed country such as US. Tradability, which differs from the climate-sensitive definition of Graff Zivin and Neidell (2014) mainly by the inclusion of Good-Producing and Manufacturing in the tradable cluster, is one of the main channels of propagation of weather shocks. The cluster of tradable-goods sectors is the only affected negatively by cold and rainfall events. Warm events fuels sensibly the growth of private income in the non-tradable sectors. Thus, while previously the exposition itself to climate during the productive cycle was considered as the main factor easing weather influence on income, this result points out that all the income-realization process, from the production to the moment in which demand matches supply, is strongly affected by weather. Finally, financial development fuels wage's growth in case of positive temperature shocks but does not helps in smoothing consumption during cold or rainfall events. Still many mechanisms hidden behind the role of weather on daily life remain unexplored. This is mainly caused by the absence of complete weather series and individual daily observations and decisions. This study provides empirical evidence on the heterogeneity that characterizes a complex phenomenon such as climate change, which needs to be addressed with more resources and specific policies depending on the sector considered.

[11] as defined by Graff Zivin and Neidell (2014)

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## 9. Appendix and tables

Dummies identifying quarter with positive temperature shocks ($\delta tmax_{c,q}$), negative temperature shocks ($\delta tmin_{c,q}$), and rainfall shocks ($\delta prec_{c,q}$) are defined as follows:

$$\delta tmax_{c,q} = \begin{cases} 1 & \text{if } tmax_{d,c,q} > t\bar{m}ax_{c,\bar{q}} + 3.09\sigma tmax_{c,\bar{q}} \;\&\; tmax_{d-1,c,q} > t\bar{m}ax_{c,\bar{q}} + 3.09\sigma tmax_{c,\bar{q}} \\ 0 & \text{otherwhise} \end{cases}$$

$$\delta tmin_{c,q} = \begin{cases} 1 & \text{if } tmin_{d,c,q} < t\bar{m}in_{c,\bar{q}} - 3.09\sigma tmin_{c,\bar{q}} \;\&\; tmin_{d-1,c,q} < t\bar{m}in_{c,\bar{q}} - 3.09\sigma tmin_{c,\bar{q}} \\ 0 & \text{otherwhise} \end{cases}$$

$$\delta prec_{c,q} = \begin{cases} 1 & \text{if } prec_{d,c,q} > pr\bar{e}c_{c,\bar{q}} + 3.09\sigma prec_{c,\bar{q}} \;\&\; prec_{d-1,c,q} > pr\bar{e}c_{c,\bar{q}} + 3.09\sigma prec_{c,\bar{q}} \\ 0 & \text{otherwhise} \end{cases}$$

Table 1: Historical (1980-1989) and sample (1990-2006) weather statistics

| | Mean | SD |
|---|---|---|
| Historical tmax (C°) | 18.48 | 4.78 |
| Sample tmax (C°) | 18.66 | 9.46 |
| Historical tmin(C°) | 5.92 | 4.57 |
| Sample tmin (C°) | 6.34 | 8.81 |
| Historical precipitation (mm) | 2.55 | 0.97 |
| Sample precipitation (mm) | 2.67 | 1.65 |
| Total observations (N) | 720,196 | |

Table 2: weather shock statistics

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| dummy tmax shock | 0.03 | 0.17 | 0 | 1 |
| dummy tmin shock | 0.28 | 0.45 | 0 | 1 |
| dummy rainfall shock | 0.16 | 0.365 | 0 | 1 |
| Total tmax shocks per quarter | 0.86 | 0.658 | 0 | 30 |
| Total tmin shocks per quarter | 1.07 | 2.61 | 0 | 42 |
| Total rainfall shocks per quarter | 0.20 | 0.537 | 0 | 29 |
| Total observations (N) 720,196 | | | | |

Table 3: Daily real wage statistics by sector (USD deflated using CPI in 2006) and other data

| | N | Mean | S. D. |
|---|---|---|---|
| Construction | 56,476 | 44.10 | 13.02 |
| Education and Health Services | 61,134 | 37.13 | 11.80 |
| Financial Activities | 61,464 | 44.32 | 17.04 |
| Goods-Producing | 64,336 | 48.51 | 14.85 |
| Information | 47,788 | 48.88 | 18.76 |
| Leisure and Hospitality | 63,432 | 15.56 | 5.36 |
| Manufacturing | 56,407 | 50.57 | 15.69 |
| Natural Resources and Mining | 55,428 | 42.66 | 19.67 |
| Other Services | 55,642 | 26.86 | 7.73 |
| Professional and Business Services | 57,549 | 41.41 | 16.18 |
| Service-Providing | 64,558 | 34.30 | 11.31 |
| Trade, Transportation, and Utilities | 65,071 | 35.58 | 8.97 |
| Data for heterogeneity and other data | | | |
| Mean fraction of area harvested | 673,349 | 0.35 | 0.26 |
| Bank per capita *100 | 180,415 | 0.042 | 0.025 |
| Ln population | 720,196 | 10.60 | 1.45 |
| Dummy Hurricane | 720,196 | .03 | 0.17 |

Table 4: Extensive margin analysis, FE model on the effect of weather shocks (dummies) on natural log of average daily wage

| Dependent variable: natural log of daily labor income | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| dummy tmax shock | 0.003 | 0.004** | 0.004** | 0.005** |
| | (0.002) | (0.002) | (0.002) | (0.001) |
| dummy tmin shock | 0.000 | -0.002 | -0.001 | -0.001 |
| | (0.000) | (0.001) | (0.001) | (0.001) |
| dummy rainfall shock | -0.002*** | -0.001* | -0.001* | -0.001* |
| | (0.0006) | (0.0005) | (0.0005) | (0.0005) |
| log of initial income (lag 1) | | 0.456*** | 0.453 *** | 0.45 *** |
| | | (0.011) | (0.011) | (0.012) |
| Log of population (lag 1) | N | N | Y | Y |
| Dummy Hurricane | N | N | N | Y |
| Counties FE | Y | Y | Y | Y |
| Sector FE | Y | Y | Y | Y |
| Quarterly FE | Y | Y | Y | Y |
| R-squared | 0.02 | 0.89 | 0.76 | 0.66 |
| Observations | 709,285 | 649,416 | 649,416 | 649,416 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model. The dependent variable is the natural log of daily labor income. All the specifications (columns 1 to 4) include county, sector, and quarterly FE. Standard errors are clustered at State by Sector level.

Table 5: Intensive margin: FE model on the effect of an increase in the numbers of weather shocks on natural log of average daily wage

| Dependent variable: natural log of daily labor wage in a quarter | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Total tmax shocks | 0.001** | 0.001*** | 0.001*** | 0.001*** |
| | (0.0004) | (0.0004) | (0.0005) | (0.0005) |
| Total tmin shocks | -0.000 | -0.0003* | -0.0004* | -0.0004* |
| | (0.0000) | (0.0002) | (0.0002) | (0.0002) |
| Total rainfall shocks | - 0.001*** | -0.001** | -0.001** | -0.001** |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| log of initial wage (lag 1) | | 0.456*** | 0.453*** | 0.453*** |
| | | (0.011) | (0.011) | (0.011) |
| Log of population (lag 1) | N | N | Y | Y |
| Dummy Hurricane | N | N | N | Y |
| Counties FE | Y | Y | Y | Y |
| Sector FE | Y | Y | Y | Y |
| Quarterly FE | Y | Y | Y | Y |
| R-squared | 0.02 | 0.90 | 0.88 | 0.76 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model. The dependent variable is the natural log of daily labor income. All the specifications (columns 1 to 4) include county, sector, and quarterly FE. Standard errors are clustered at State by Sector level.

Table 6: Intensive margin of the effect of weather shocks on natural log of sectoral daily wage using specification 4 of Table 5

| | Construction | Education & Health | Financial Activities | Good-Prod. | Information | Leisure & Hospitality |
|---|---|---|---|---|---|---|
| Total tmax shocks | 0.002 | -0.0005 | 0.0002* | 0.001 | -0.001 | 0.005*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Total tmin shocks | -0.002*** | 0.005 | 0.0001** | -0.004 | -0.001 | -0.001*** |
| | (0.000) | (0.0004) | (0.0000) | (0.0005) | (0.001) | (0.000) |
| Total rainfall shocks | -0.002** | -0.002*** | -0.001 | -0.001 | - 0.002 | 0.000 |
| | (0.000) | (0.0005) | (0.001) | (0.001) | (0.001) | (0.000) |
| R-squared | 0.75 | 0.87 | 0.55 | 0.77 | 0.76 | 0.76 |
| | Manufact. | Natural Res. | Oth. Services | Profess. Serv. | Serv. provid. | Trade & Transp |
| Total tmax shocks | 0.001 | 0.001 | 0.002 | 0.002* | 0.001 | 0.001 |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| Total tmin shocks | -0.001** | 0.001 | -0.0005* | 0.002 | -0.000 | -0.001*** |
| | (0.000) | (0.001) | (0.000) | (0.001) | (0.000) | (0.001) |
| Total rainfall shocks | -0.000 | -0.004*** | -0.001 | 0.001 | -0.001* | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.0007) | (0.001) |
| R-squared | 0.79 | 0.38 | 0.68 | 0.72 | 0.81 | 0.75 |

State robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model with all the controls of specification 4 in Table 5. The dependent variable is the sectorial natural log of daily labor income. Standard errors are clustered at State level.

Table 7: Impact of shocks by sector expressed in percentage of daily income, dollars for the year 2006, and maximum predicted value in the sample

| | Negative effect of shocks | | |
|---|---|---|---|
| | % of daily wage | vaule in real USD 2006 | Predicted max net effect |
| Construction (tmin) | -12.82% | 5.50 | 231 |
| Construction (rainfall) | -12.82% | 5.50 | 159.5 |
| Education and Health (rainfall) | -12.82% | 4.71 | 136.59 |
| Leisure and Hospitality (tmin) | -6.41% | 0.99 | 41.75 |
| Manufacturing (tmin) | -6.41% | 3.23 | 132.3 |
| Natural Resource (rainfall) | -25.64% | 10.63 | 308.27 |
| Other Services (tmin) | -3.20% | 0.84 | 35.28 |
| Service Providing (rainfall) | -6.41% | 2.19 | 63.51 |
| Trade and Transportation (tmin) | -6.41% | 2.27 | 93.34 |
| | Positive effect of shocks | | |
| | % of dalily wage | value in real USD 2006 | Predicted max net effect |
| Leisure and Hospitality (tmax) | +32.05% | 4.97 | 149.1 |
| Financial Activities (tmax) | +1.28% | 0.56 | 16.8 |
| Financial Activities (tmin) | +0.64% | 0.28 | 11.76 |
| Professional Services (tmax) | +12.82% | 0.26 | 7.8 |

Table 8: Intensive margin of the effect of weather shocks on natural log of sectoral daily wage by type of tradable and non-tradable sectors, using specification 4 of Table 5

| | Tradable | Non-tradable |
|---|---|---|
| Total tmax shocks | 0.001 | 0.001*** |
| | (0.001) | (0.001) |
| Total tmin shocks | -0.001*** | 0.000 |
| | (0.000) | (0.000) |
| Total rainfall shocks | -0.001** | -0.001 |
| | (0.000) | (0.001) |
| Log of population (lag 1) | Y | Y |
| Dummy Hurricane | Y | Y |
| Counties FE | Y | Y |
| Sector FE | Y | Y |
| Quarterly FE | Y | Y |
| R-squared | 0.77 | 0.73 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model with all the controls of specification 4 in Table 5. The dependent variable is the natural log of daily labor income. Standard errors are clustered at State by Sector level.

Table 9: Intensive margin of the effect of weather shocks on natural log of sectoral daily wage considering bank density for the period 1990-2006, using specification 4 of Table 5

| | (1) | (2) |
|---|---|---|
| Total tmax shocks | -0.01** | -0.01** |
| | (0.000) | (0.000) |
| Total tmin shocks | -0.000 | -0.000 |
| | (0.000) | (0.000) |
| Total rainfall shocks | -0.004* | -0.004* |
| | (0.001) | (0.000) |
| bank density | -0.01 | -0.01 |
| | (0.05) | (0.000) |
| bank density x Total tmax shock | 0.12* | 0.12* |
| | (0.06) | (0.06) |
| bank density x Total tmin shock | 0.003 | -0.003 |
| | (0.009) | (0.009) |
| bank density x Total rainfall shock | 0.003 | -0.001 |
| | (0.04) | (0.04) |
| Controls | N | Y |
| Counties FE | Y | Y |
| Sector FE | Y | Y |
| Year FE | Y | Y |
| R-squared | 0.96 | 0.91 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model with all the controls of specification 4 in Table 5. The dependent variable is the natural log of daily labor income. Standard errors are clustered at State by Sector level.

Table 10: Robustness on intensive and extensive margin with balanced panel, effects of weather shocks on private wage

| | EM | EM | IM | IM |
|---|---|---|---|---|
| dummy tmax shock | 0.006** | 0.006** | | |
| | (0.003) | (0.003) | | |
| dummy tmin shock | 0.002 | -0.001 | | |
| | (0.002) | (0.001) | | |
| dummy rainfall shock | -0.002*** | -0.001 | | |
| | (0.000) | (0.0001) | | |
| Total tmax shocks | | | 0.003*** | 0.003*** |
| | | | (0.001) | (0.001) |
| Total tmin shocks | | | 0.000 | -0.000 |
| | | | (0.000) | (0.000) |
| Total rainfall shocks | | | -0.002*** | -0.001* |
| | | | (0.000) | (0.001) |
| Coverage of the balanced panel | 1990-2000 | 1990-2002 | 1990-2000 | 1990-2002 |
| Log of initial income (lag 1) | Y | Y | Y | Y |
| Log of population (lag 1) | Y | Y | Y | Y |
| Dummy Hurricane | Y | Y | Y | Y |
| Counties FE | Y | Y | Y | Y |
| Sector FE | Y | Y | Y | Y |
| Quarterly FE | Y | Y | Y | Y |
| Observations | 104,368 | 99627 | 104,368 | 99627 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model. The dependent variable is the natural log of daily labor income. All the specifications (columns 1 to 4) include county, sector, and quarterly FE, lagged population and lagged wage. Standard errors are clustered at State by Sector level.

Table 11: Robustness test on the intensive margin defining as shock observations outside 99% confidence band (column 1-2) and observations outside 99.95% (column 3-4).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Total tmax shocks | 0.000** | 0.000** | 0.002*** | 0.002*** |
| | (0.0000) | (0.002) | (0.001) | (0.001) |
| Total tmin shocks | - 0.000 | -0.000 | -0.001** | -0.001** |
| | (0.000) | (0.000) | (0.000) | (0.001) |
| Total rainfall shocks | -0.001*** | -0.001*** | -0.001 | -0.001 |
| | (0.000) | (0.0000) | (0.000) | (0.0005) |
| Definition of the shock | obs>99.0% | obs>99.0% | obs>99.95% | obs>99.95% |
| Log of initial income (lag 1) | Y | Y | Y | Y |
| Log of population (lag 1) | Y | Y | Y | Y |
| Dummy Hurricane | N | Y | N | Y |
| Counties FE | Y | Y | Y | Y |
| Sector FE | Y | Y | Y | Y |
| Quarterly FE | Y | Y | Y | Y |
| R-squared | 0.76 | 0.76 | 0.76 | 0.76 |

State-sector clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports estimates obtained fitting an OLS Fixed-effect model. The dependent variable is the natural log of daily labor income. All the specifications (columns 1 to 4) include county, sector, and quarterly FE, lagged population and lagged wage. Standard errors are clustered at State by Sector level.

Figure 1: Spatial distribution of NCDC's meteorological station in analysis

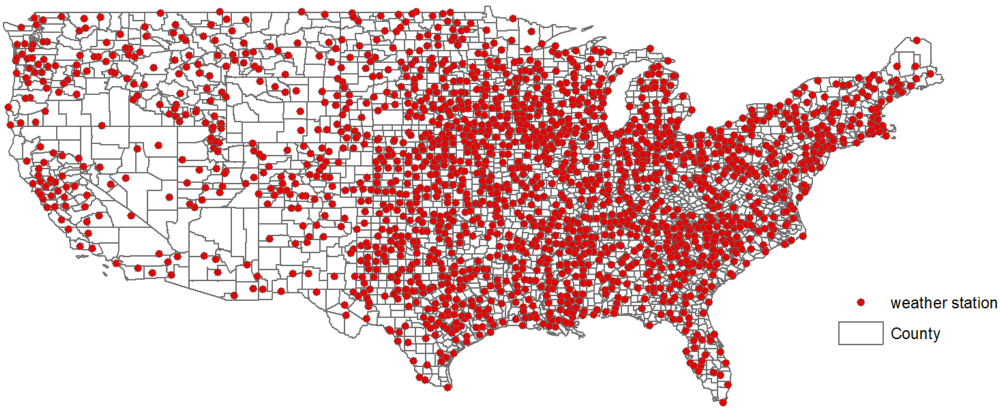



Figure 2: Spatial distribution of average daily wage 1990-2006 (2006 USD)

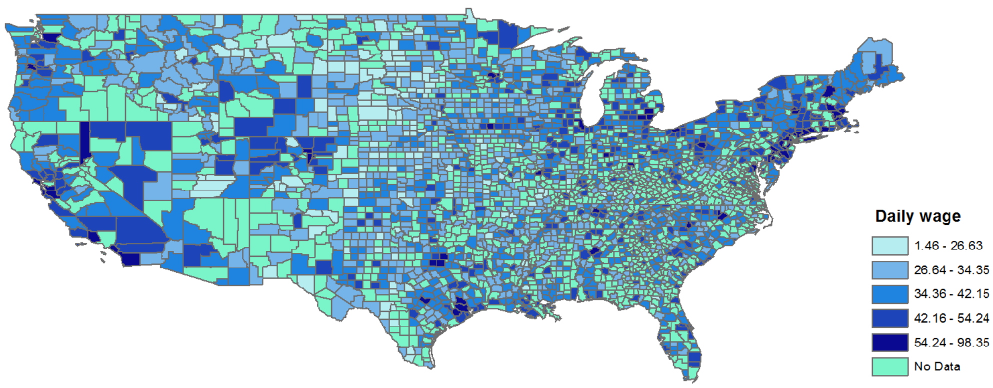


Figure 3: Example of shock identification for tmax, red dots are two couples of observations that are defined as shocks in the empirical strategy

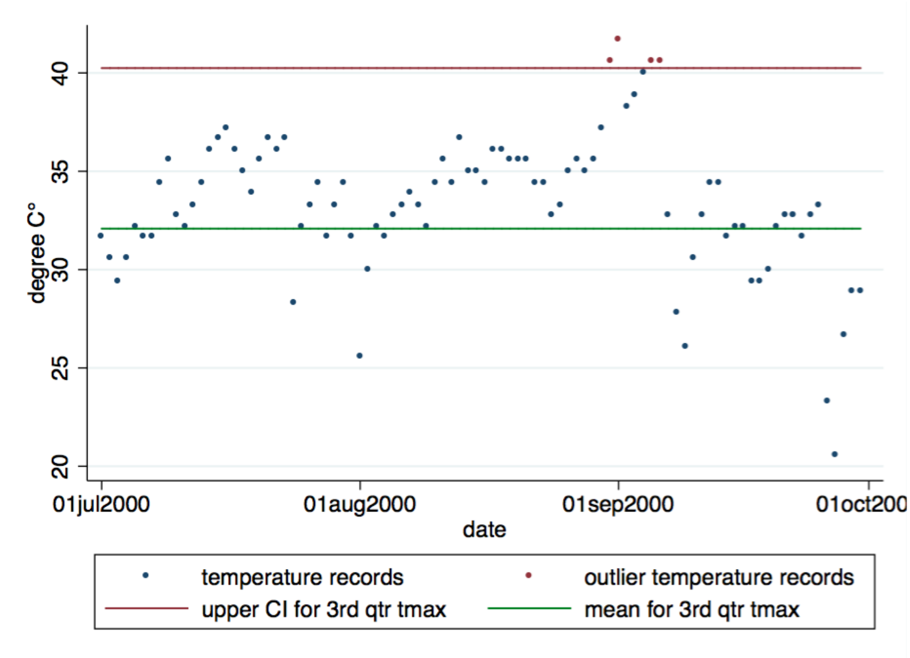



Figure 4: Negative correlation between daily temperature excursion and ln of average income by county

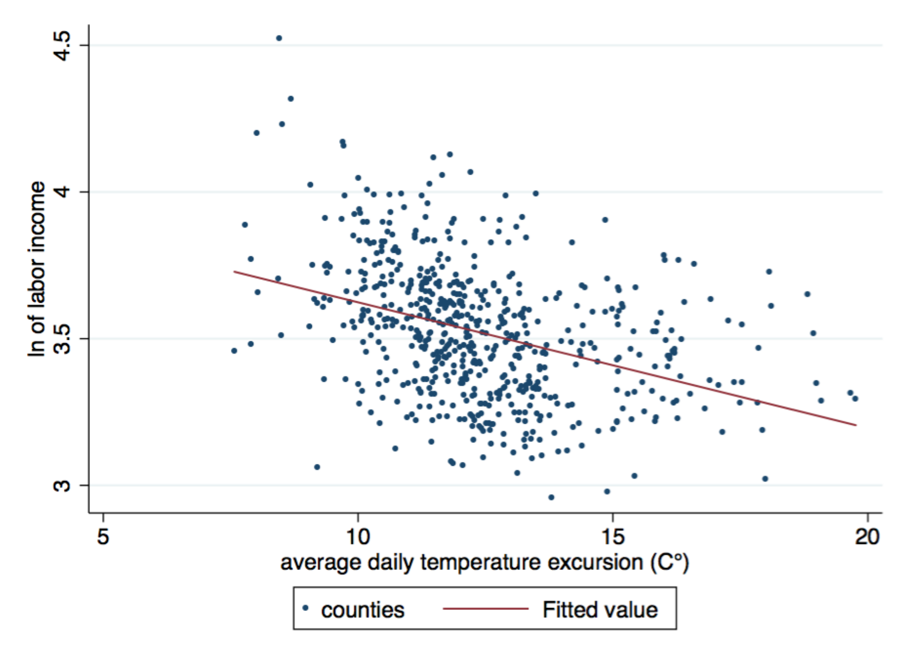
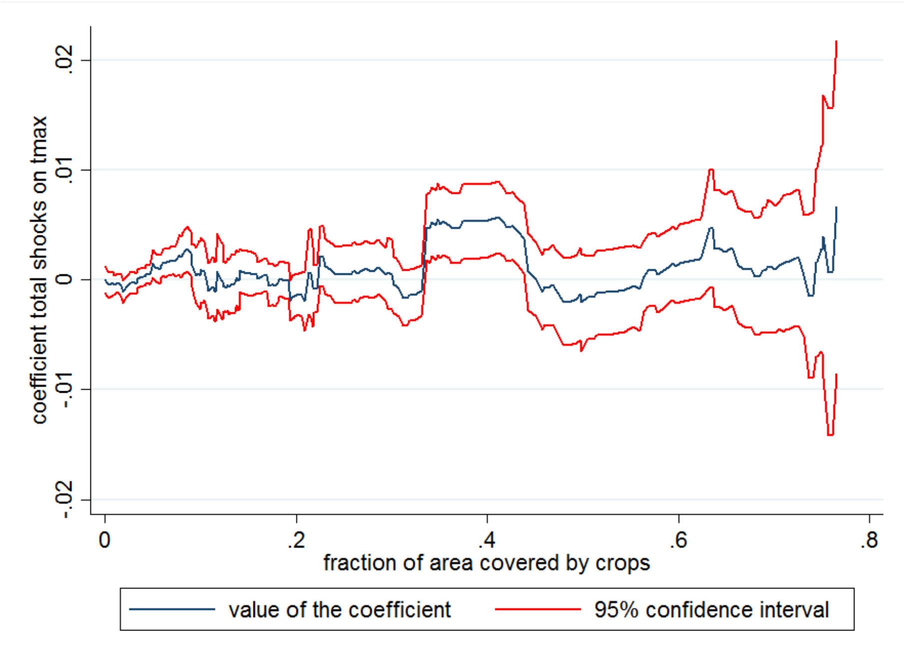
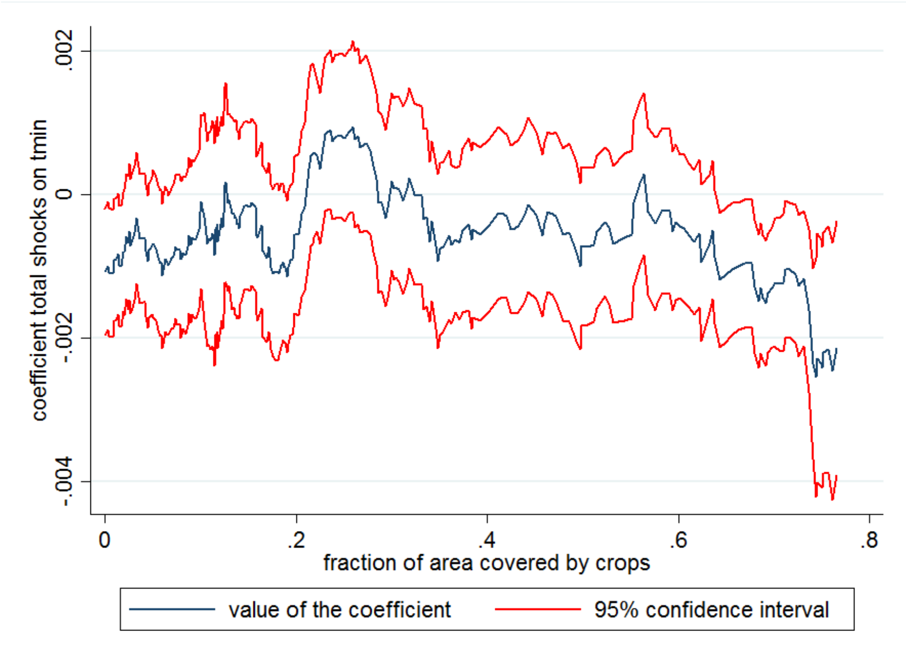


Figure 5: The effect of total tmax shocks on wage rolling on fraction of area harvested



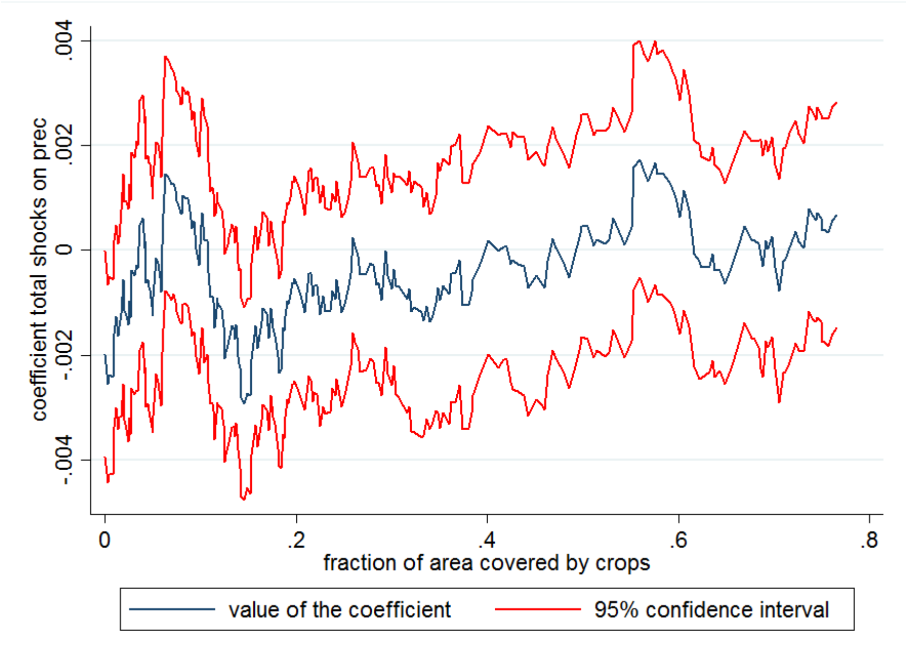

*Note*: the figure reports the result from the rolling-windows regressions using the main specification with FE on States instead of counties, where the window is of 60,000 observations and proceed with step equal to 2,500 observations. Rolling is on the average fraction of area harvested by county. The blue line shows the coefficient estimates for the total number of shocks on maximum temperature and the red lines the 5-percent confidence intervals.

Figure 6: The effect of total tmin shocks on wage rolling on fraction of area harvested




*Note*: the figure reports the result from the rolling-windows regressions using the main specification with FE on States instead of counties, where the window is of 60,000 observations and proceed with step equal to 2,500 observations. Rolling is on the average fraction of area harvested by county. The blue line shows the coefficient estimates for the total number of shocks on minimum temperature and the red lines the 5-percent confidence intervals.

Figure 7: The effect of total prec shocks on wage rolling on fraction of area harvested




*Note*: the figure reports the result from the rolling-windows regressions using the main specification with FE on States instead of counties, where the window is of 60,000 observations and proceed with step equal to 2,500 observations. Rolling is on the average fraction of area harvested by county. The blue line shows the coefficient estimates for the total number of shocks on precipitation and the red lines the 5-percent confidence intervals.

# Does foreign aid fuel trust?

Alexandra D'Onofrio* Giuseppe Maggio†

March 26, 2015

**Abstract**

What are the socioeconomic effects of foreign aid in developing countries? How effective is aid in promoting social capital? The paper focuses on these questions from an empirical perspective and assesses the casual effect of foreign aid on trust in Uganda. Individuals living in counties that received more aid exhibit up to 13.3% higher probability to trust others with respect to those living in counties with no aid. The same finding holds when taking into account the intensive margin, i.e. an increase of 1% in foreign aid induces an increase of 1.1% in the probability of trusting other people. We use also an instrumental strategy based on the enforcement of Non Governmental Organizations (Amendment) Act and we show that the link from aid to trust is robust to different estimation strategies. Finally, we find that a channel is operating through lowering inequality. We demonstrate that foreign aid has a stronger effect in counties where there is a lower level of perceived inequality.

*JEL Classification*: D63; O12; O22; O55; C31
*Keywords*: foreign aid; social capital; trust; Africa; geo-referenced data; inequality.

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# 1 Introduction

The effectiveness of foreign aid is an old debated issue among economists and development experts. In this paper, we depart from the traditional focus on the pure economic outcome of aid and look at the potential effect on trust. A recent strand of the growth literature has stressed the importance of the role of cultural values in economic development. In particular, trust, broadly defined as cooperative attitude outside the family circle and usually taken as a proxy for social capital, is considered a key element of many economic and social outcomes by social scientists and increasingly also by economists.[1]

Combining individual-level survey data on trust with georeferenced county-level data on aid, we ask whether aid flows affected how generalized trust changed over time. We hypothesize that large disbursements of aid funds in a county contribute to increase the generalized trust (i.e. trust on other people) of individuals living in that county or, equivalently, to reduce the trust deficit over time. Since a trust deficit may hinder the effectiveness of aid in furthering development outcomes, a direct effect of aid in recovering trust represents an important feature to consider while planning how to foster long lasting development.

We contribute to the empirical literature on foreign aid by adding novel evidence about the socioeconomic effects of aid from a microeconomic perspective. Given the important policy implications, it is therefore surprising that there is little direct evidence on the relationship between foreign aid and population attitudes - in particular, trust - in the extant literature. By contrast, there is a large debated literature on how effective is foreign aid in reducing poverty, enhancing governance or other economic outcomes.

The paper focuses on Uganda due to its status of developing country and because it has an experience of disruption of capital due to violent conflicts occurred during the last decade. Although Uganda has been studied for social capital, allowing useful comparisons in the field, the importance of the building-effect of external funding is still unexplored. For example, Rohner et al. [29] study the influence of civil conflict on social capital, focusing on Uganda's experience during the last decade and highlight how such a large disruptive contemporaneous shock changes beliefs and social capital by reducing generalized trust. Conversely, in this study we hypothesize that the disbursement of funds through the financing of foreign aid initiatives by donors, represents a positive contemporaneous shock that changes beliefs and social

[1] See Algan and Cahuc [5] for an extensive review of the recent research on trust, institutions and growth.

capital, and increases trust.

To test our hypothesis, we use data from the 2012 Afrobarometer survey and from AidData and examine whether individuals living in counties that received more aid in the last decade are more trusting of others today. We find that individuals living in counties that received more aid exhibit higher levels of generalized trust today. This finding holds both for the extensive margin (whether the county received or not aid) and the intensive margin (how many funds the county received). Particularly, the more funds the county received, the higher is the level of trust of individuals living in that county.

An alternative explanation for our finding is that more aid has been directed to counties that initially were more trusting, and that these higher levels of trust simply remain unchanged today. Alternatively, there might be other factors, such as individual and county specific characteristics, that are correlated with the amount of aid flows and subsequent levels of trust. In our methodological approach, we consider a number of ways to determine whether the correlations we uncover are indeed causal.

Our first strategy is to study the shift in individual trust with respect to the previous survey, by controlling for the county-average level of trust in the previous period. Moreover, we use predetermined independent variables, i.e. we do not use contemporaneous values of aid and trust. A second check is to control for a number of county and district level characteristics - such as, among others, urbanization, number of micro-enterprises, unemployment rate. The intuition is that by controlling for this extensive set of covariates, we capture any potential effects other than aid on trust.

Our alternative approach is the use of instrumental variables. This requires an instrument that is correlated with the presence of aid in the county but uncorrelated with any characteristics that may affect the level of trust of the individuals in that county. We use the distance of each county from the committee belonging to the same district of the county itself. The introduction of the particularly restrictive legislation that disciplines the ordinary activity of NGOs in Uganda (the NGO Registration Act) provides a basis for the instrument's exogeneity. The IV regressions produce estimates that are qualitatively consistent with the OLS estimates.

In section 2, we begin our study by first describing the historical and conceptual background. We discuss the traditional literature on foreign aid and its effectiveness, we summarize the recent economic performance of Uganda and we give a broader macroeconomic perspective on the relationship between aid and trust. In section 3, we turn to a presentation of the data sources, before describing the methodology and the empirics in section 4. In section 5 we study the relationship between aid, inequality and trust. section 6 describes robustness checks while section 7 concludes.

## 2 Literature and background

The Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD) defines foreign aid as financial flows, technical assistance, and commodities that are designed to promote economic development and welfare as their main objective, i.e. aid for military or other non-development purposes is excluded, and are provided as either grants or subsidized loans.[2] Based on this definition, aid represents one of the largest components of foreign capital flows to low-income countries, while for most middle-income countries private capital flows are more important. On average, between 2000 and 2012, Uganda, classified by the World Bank as a low income country, received foreign aid worth 13 percent of its GNI, that sum up to almost 75% of central government expense.[3]

One of the most debated issues in development economics is whether foreign aid promotes economic growth in aid recipient countries. The topic is relevant to both donors, given the difficulty of keeping up with the same level of aid as in the past in the current global economic crisis, and recipients countries, given their difficulty, among others, to meet the goal set by the United Nations of reducing poverty to half the 1990 level by 2015.[4]

The academic research on aid has traditionally focused on the effects of aid inflows on growth rates, as well as on determining which socio-political, institutional and economic factors undermine or enhance the effectiveness of aid. Mosley [24] suggested that while aid seems to be effective at the microeconomic level, any positive aggregate impact of aid is much harder to identify, and pointed out the presence of a "micro-macro paradox".

Bourguignon and Sundberg [8] refer to a 'black box' to describe the relationship between aid and development, given that the empirical literature on aid effectiveness has yielded unclear and ambiguous results, due to the heterogeneity of aid motives, the limitations of the tools of analysis, and the complex

[2] See for example Radelet [27].

[3] Data are taken from World Development Indicators. According to the World Bank classification, economies are divided according to 2012 GNI per capita, calculated using the World Bank Atlas method. The groups are: low income, $1,035 or less; lower middle income, $1,036 - $4,085; upper middle income, $4,086 - $12,615; and high income,$12,616 or more. In Uganda GNI per capita in 2012 is $480.

[4] This is one of the eight Millennium Development Goals.

causality chain linking external aid to final outcomes. Rajan and Subramanian [28] conclude how difficult it is to find any systematic effect of aid on growth, at a macroeconomic level.

The impact of aid on growth is an empirical question and has been extensively studied in the macro literature in the last four decades.[5] The quantitative cross-country analyses of the macroeconomic impact of foreign aid on growth has seen three different stages. The first wave of the literature on aid and growth can be traced back to the so called "gap-models" where the emphasis was on the effects of financing constraints on growth in low income countries and how aid could alleviate them ( Chenery and Strout [12]; Domar [15]; Bacha [6]). A second wave of the literature focused on a direct investigation of the aid-growth relationship, instead of addressing the topic only indirectly through the aid-savings link and produced contradictory results ( Levy [22]). A third generation of panel based econometric studies started in the '90s with the aim of assessing whether the impact of aid on growth was unconditionally positive and what are the necessary conditions to make aid effective in recipient countries ( Burnside and Dollar [9]; Alesina and Dollar [3]; Collier and Dollar [13]; Dalgaard et al. [14]). More recently, Chatterjee et al. [11] study the effectiveness of aid on the growth performance of recipient countries by looking at indirect mechanisms through which aid affects growth. In particular, by looking at linkages between the composition of foreign aid and the composition of government-spending, they find that the fungibility of aid matters and that the composition of aid is important in determining and affecting the economic outcomes.

From a microeconomic perspective, besides the impact evaluation of specific projects, there is lack of any systematic academic evidence on the impact of aid on growth.[6] The main difficulty in producing microeconomic evidence on the topic is data availability. If AidData provides localized data about the aid projects at the county level, at the same time there are no localized data to measure local development, i.e. there are not reliable statistics about each county's GDP. If, on one hand, it is not possible to measure economic development at the county level, on the other hand, there are survey data on trust at the individual level that can be used as county-level proxy of development. Data on trust in the economic literature are usually used as proxy for social capital.[7] Social capital refers to the institutions, relationships,

[5]See Hansen and Tarp [20] for a comprehensive review of the aid literature.

[6]The Independent Evaluation Group (IEG) evaluates the activities of the International Bank for Reconstruction and Development (IBRD) and International Development Association (inside the World Bank), the work of International Finance Corporation (IFC) in private sector development, and Multilateral Investment Guarantee Agency's (MIGA) guarantee projects and services. They generally report positive assessment when looking at individual specific initiatives.

[7]See, among others, Butler et al. [10], Giuliano and Spilimbergo [19].

and norms that shape the quality and quantity of a society's social interactions. Academics interested on African development issues used survey data on trust in many instances. Relying on Afrobarometer and historical data, Nunn and Wantchekon [26] find that individuals in sub-Saharan African countries whose ancestors' ethnicities were subject to a high intensity of enslavement report lower trust levels today.

Milner et al. [23] document additional evidence on aid and beliefs in Uganda and highlight how aid effectiveness should be not studied per se but compared to other domestic programs and by looking at recipients' beliefs about foreign aid. In particular, they provide evidence that in Uganda citizens view aid as less prone to political manipulation and does more efficient than government activities.

The Global Humanitarian Assistance (2014) ranks the country as the 16th largest ODA recipient country in the world in 2011. Total aid received were 1.5 billions of dollars, including 80 millions of humanitarian assistance. The high need for external funding in Uganda is also emphasized by the fact that the country is classified as 'fragile state', and it shows the highest level of vulnerability index score.According to Global Humanitarian Assistance (2014), such rankings largely depend on the fact that the country experienced a number of conflicts during the last decade. Regarding the contribution of aid in improving the country's situation, the US Department of State (2013) documents how: "the assistance enhances social and economic well-being throughout the country, and U.S. support improves the lives of hundreds of thousands of Ugandans."

In general, countries assistance programs aim at promoting good governance and human rights, the strengthening of democracy, the conduct of free and fair elections. They also aim at addressing health threats, as well as improving maternal and child health and coping with Ugandan fast population growth through family planning, agricultural productivity, food security, and nutrition, besides several other environmental issues, such as global warming and climate change. The way the programs are implemented and their final goals may have different impacts on population, both from a physical and from a social perspective. For example, in 2012 US Centers for Disease Control and Prevention (CDC) provided antiretroviral therapy (ART) to more than 228,000 people and care for 400,000 HIV-infected patients, we can trivially hypothesize that these individuals not only experienced a direct benefit from the occurrence of the event - receiving foreign aid - in terms of increased life expectancy, but they also changed their believes on external agents, increased their generalized trust on other people, and these all together led to better average living conditions in the country. Thus, following our premises, the underlying mechanism that we have in mind should work through the direct interaction of inhabitants with other people. Hence, in our study we select funds delivered from 25 agencies that addresses ten primary sectors (listed in Appendix 2), for a total of 1315 projects [8].

## 3 Data Sources and Description

Data for this study come from two different databases: AidData 3.0 and Afrobarometer.[9]

AidData is managed by the AidData Center for Development Policy. It is a huge geospatial dataset that contains data on more than $5.5 trillion dollars in development finance from 90 bilateral and multilateral agencies at the project level. By specifying the precise detail of the geographic locations of development projects, the dataset allows to analyze where aid funds are going at the sub-national level. Therefore, it represents the most accessible and complete database to study and evaluate foreign aid. [10]

Afrobarometer is a research project that measures the social, political, and economic environment in Africa through a series of national public attitude surveys on democracy and governance. Afrobarometer surveys are conducted in 35 African countries and are repeated on a regular cycle. Each survey contains a standard set of questions, thus making possible comparisons across countries and over time.

In our analysis we employ the most recently issued Afrobarometer survey for Uganda, i.e. Round 5 that covers year 2012 ( AfrobarometerData [2]). Among other questions, respondent answer the following question:

- Generally speaking, would you say that most people can be trusted or that you must be very careful in dealing with people?

  a] Most people can be trusted

  b] Must be very careful

The answer given to this question represents our main dependent variable, that takes value 1 if the individual answer "Most people can be trusted", 0 otherwise. Thus, we build a cross-sectional dataset at the individual level, where for each individual we have a set of information on individual characteristics, including the county of residence.

[8] We do not report the list of projects due to limited space, but it is available upon request.

[9] See Tierney et al. [30] and AfrobarometerData [1]

[10] Findley et al. [16] and Fleck and Kilby [17], among others, have used AidData to study implications of aid and conflicts.

Our main explanatory variable is a dummy on the presence of funds in a specific county. We employ data from the Uganda Aid Management Platform, a new dataset release that includes all foreign aid disbursed in Uganda since 1996. For each project, the dataset includes information about donors, quantity disbursed, project category, project objective, signature and starting date, completion date, and the chronology of the disbursement. We consider 1315 projects, sponsored by 25 different agencies and involving more than 10 different sectors of activity (for an extensive list of sectors financed by each agency please refer to Appendix 2). We build a dummy variable taking value 1, if at least one project delivered aid in that county for the period 2008-2010, 0 otherwise. We limit the time sample to 2008-2010 because Afrobarometer survey has been delivered in 2012 but it refers to a fieldwork that started in 2011 so we cannot consider funds that arrived in 2011.

The timing of the analysis is displayed in Figure 1, where we plot the time series of foreign aid in Uganda and the waves of Afrobarometer that we employ in the analysis. Foreign aid have a huge increase during 2006-2011, mainly associated with the end of the conflicts in the north of the country and the presence of Uganda in the security council of UN during 2009-2010[11]. Wave 4 of Afrobarometer was delivered in 2008, and we use it here mainly to correct our estimates by taking into account the previous level of county's average trust. Afrobarometer's wave 5 is our dataset of interest for the individual analysis.

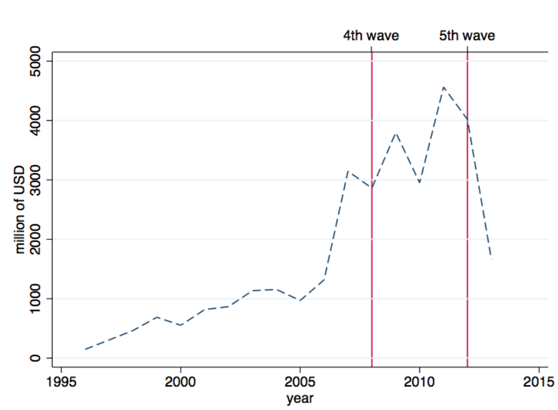


**Fig. 1.** Level of foreign aid (USD) and waves from Afrobarometer

Figure 2 shows the localization of aid in Uganda according to AidData. While the distribution of funds seems homogeneous all over the country, there is evidence of high concentration of projects at the boarder with Kenya and Rwanda (east and south-west). Furthermore, some counties in the middle of the

[11]For an in depth discussion of the correlation of foreign aid with presence in UN's security council, see Kuziemko and Werker [21]

country do not receive foreign aid at all, and we use them as a control sample in the rest of the study.

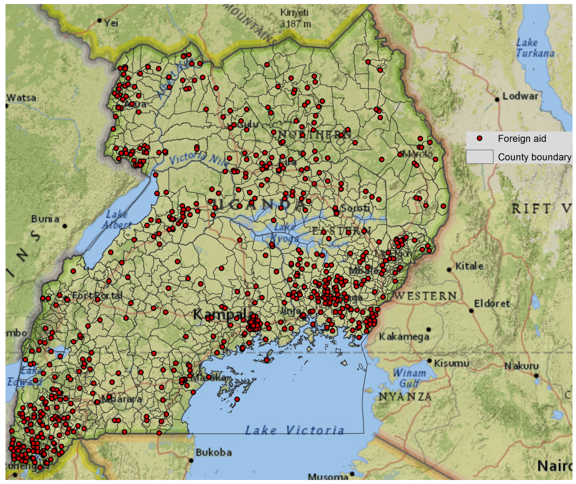


**Fig. 2.** Geolocalized foreign aid in Uganda.

Table 1 lists summary statistics for individuals in our sample, clustered depending on whether their county of residence received foreign aid between 2008 and 2010. Column 2 to 7 of Table 1 report number of observations, mean and standard deviation for all the variables divided into the two groups.

According to those statistics, large part of the sample received external aid over the period considered, while around 20 percent of the sample did not receive any funding. Furthermore, that fraction remains constant when dropping those observations that are perfectly predicted by adding counties, ethnic or agency fixed effects. For what concerns individual level variables, people in counties that received aid are on average more rural, the average of the dummy is 0.82 against 0.92 of the control group, they are younger and report different access to services (more access to piped water system but less access to cell phone services); they show more variance in the educational level (more individual with high and low education). Considering county and district-level variables, there are strong differences between the two groups. Almost all the variables considered, with the exception of the average trust in relatives in 2008, are significantly different between the two clusters. Trust in 2008 is higher in counties that did not receive fund (as trust in other people and in known people). Furthermore, counties that did not receive aid are characterized by a smaller unemployment rate, lower level of subsistence by farms, lower number of micro-enterprises and higher ethnic fragmentation. All those dimensions are negatively correlated with trust suggesting that if it were the case that our result would be determined only by cross sectional differences in counties' characteristics, the regression sign should be the opposite of what we find.

A commonly used proxy for per capita income, satellite nightlights are lower in the control group, however this is extremely correlated to the lower degree of urbanization in the same group and somehow compensated by the higher level of urban population. Finally, as ethnic-level variable we consider the traditional ethnic-group specific dependence on some activity (such as hunting, fishing, agriculture or animal husbandry) that we take from the Ethnographic Atlas of Murdoch [25].

[Insert Table 1 and Table 2 here]

## 4 Empirics

We begin by estimating the relationship between the presence of a fund in a county over the period 2008-2010 and the level of trust in that county as surveyed in 2012. Following Rohner et al. [29], our baseline estimating equation is a standard probit-model as follows:

$$\begin{aligned} Pr(trust_{i,c}^{2012} = 1) = &\Phi[\beta_0 + \beta_1 dummy\_funds_c + \beta_2 trust_c^{2008} + \alpha \mathbf{X}_i + \lambda_r + \\ &agency_j + project_k + ethnic_m + \mu_{i,c}] \end{aligned} \tag{1}$$

where $trust_{i,c}^{2012}$ is a dummy which varies across individuals and takes value 1 if in county $c$ the person $i$ answers in the survey that most people can be trusted, 0 otherwise; $trust_c^{2008}$ denotes the county-average level of trust from the previous wave of the survey; $dummy\_funds_c$ is a binary variable assuming value 1 if funding occurred in 2008-2010 in that county. $\lambda_r$ are region fixed-effects, which are included to capture region-specific factors that may affect trust; *agency* and *projects* are donors and project destinations fixed-effects; *ethnic* are fixed effect on ethnicity and $\mu_{i,c}$ are county-clustered individual errors. The use of region and ethnic fixed effects, as well as county-clustered errors is a standard methodology to allow for common effects and spatial correlation among individuals belonging to the same county, while the use of agency and project fixed effects is peculiar and crucial to the purpose of the analysis. Given the heterogeneity that characterizes projects and agencies implementing them, such fixed effects capture the *singularity* of each agency and of each type of project, helping us in identifying the *net effect* of funding, independently of who is actually implementing it and how it is developed.

$\mathbf{X}_i$ denotes a matrix of individual-level covariates, which include the respondent's demographic characteristics, such as age, age squared, employment status, and educational level. [12] Other individual level covariates considered ares possession of radio, television, and vehicles, an indicator variable that equals one if the respondent lives in an urban location instead or a rural ones. The matrix also includes a set of variables designed to capture the composition and characteristics of the county in which the respondent lives, which include population size, diffusion of mobile phone services, availability of schools, access to electricity, piped water and sewage system, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate, unemployment rate, ethnic fractionalization and nightlight.

When considering our cross-sectional dataset, we need to deal with the issue of potential reverse causality. Foreign aid could be allocated according to several dimensions, such as a higher or lower level of trust or corruption, or according to allocation parameters and decisions possibly correlated with them. Therefore, in order to partially avoid reverse causality, we focus the analysis on the shift with respect to the previous level of trust, as in Rohner et al. [29]. In this way, we can partially overcome the problem of reverse causality, and for this purpose we consider three different variables of trust - in other people, in neighbors and in family - and compute the county-average level of generalized trust in the previous period ($trust_c^{2008}$).

### 4.1 Extensive margin

Table 2 reports Probit estimates of Equation 1. The estimates show that the presence of aid is positive correlated with the subsequent level of trust. The coefficient of the dummy for the presence of foreign aid (Dummy Fund) is positive and significant throughout all the specification considered. All the specifications fitted include dummies for each agency, in order to capture the net effect of aid on trust, independently from differences among agencies, as, for instance, efficiency in implementation.[13]

Table 2 reports the results from the baseline model as marginal effects at mean value of other control variables. We interpret results in column 1 as showing that respondents living in a county that received

[12] Occupation and education may be important determinant of trust themselves, as underlined in Nunn and Wantchekon [26] and Francois et al. [18], who, in particular, provide evidence of higher levels of trust for individuals working in more competitive sectors within the United States.

[13] In our dataset we have 25 different agencies.

aid, have 11.4 percent higher probability of trusting other people - i.e. trust taking value 1 - than people living in a county that did not receive aid, given that all the control variables take their mean value. Such estimate is significant at one percent level, and robust to a set of individual, county and district level controls, regional and agency fixed effects.

In column 2 and 3 we increase model's complexity, controlling for sectoral and ethnic fixed effects. The inclusion of sectoral fixed effects determines an higher probability of trusting other people of 13.3 percent, meaning that people living in a county that received foreign aid show a positive effect on trust. The result holds also in case of ethnic fixed effects, where the coefficient associated to presence of fund is equal to 13.2 percent and still significant at one percent level.

Finally, in column 4 we control for religion fixed effects and the coefficient remains significant and equal to 11.3 percent.

[Insert Table 2 here]

In Table 3 we report the marginal effect of the increase in one unity of other control variables in order to compare our result on trust. In each column are reported the results obtained with the same specification of the corresponding column in Table 2. The first variable reported is the natural log of population, which seems to be negative correlated with trust in other people, but the coefficient associated is significant only in column 3-4. Urban-rural dummy does not appear to be correlated with trust in other people while the unemployement level is positively correlated with trust. This result could be driven by the fact that in counties with higher level of unemployment individuals should rely more on the social environment in order to find alternative resources to labor income. In addition, the result is coherent with the dummy on the employment at individual level, that has a negative and significant coefficient equal to -0.04. Finally, satellite nightlight is positively associated with trust, indicating that an increase of one unit in satellite nightlight increase the probability of trusting other people of 17.5% in column 1, and up to +26.9% in column 4. Thus, the presence of foreign aid in a county has a coefficient associated that on average is equal to half of the one of satellite nightlight, but higher both of the unemployment and more significant, in general, of the one linked to the natural log of population. This give us a first indication of the magnitude that the presence of foreign aid could have on individuals believes, sometimes stronger that the common demographic controls employed.

[Insert Table 3 here]

### 4.2 Intensive margin

We now turn to a different dimension of aid. Table 4 reports Probit estimates for the intensive margin of aid. The main difference with respect to Equation 1 and Table 2 is the independent variable Ln fund used instead of Dummy Fund. Ln fund is the level of aid received in each county. Table 4 shows the effects on trust of an increase of one percent in the amount of aid. Similarly to Equation 1 we regress individual trust on the logarithm of foreign aid disbursed, and we control for the same set of characteristics considered in Table 2. Results in Table 4 show that individual trust is highly correlated with foreign aid. An increase of one percent in the quantity of aid is associated with an increase of 0.8 percent of the probability of trusting other people, and the estimated coefficient is significant at one percent level (column 1).

In column 2 and 3 we add sectoral fixed effect and ethnic fixed effects. The coefficient estimates are thus robust, do not change much, and stay significant, to different specifications. Indeed, both in column 2 and 3, an increase of one percent of foreign aid determines an increase of 1.1 percent of trust, given that all the other explanatory variables take their mean value.

In column 4, where we fit a model with a set of 22 religion fixed effects, we find that the coefficient on Ln fund is equal to 0.7 percent and significant at one percent level. Hence, our estimates are also robust to the introduction of a bigger set of controls.

[Insert Table 4 here]

Both in Table 4 and in Table 2, when we control for the type of project and the type of agency, the estimated coefficient increases significantly. We believe that this happens because of the heterogeneity of projects and because of the number of agencies that implemented them. As showed by Alesina and Dollar [3] from a macro perspective, donors give foreign aid is disbursed for different reasons, that may be even completely unrelated to developing issues. There are countries that have more propensity to finance countries that share similar international political preferences. For example, Alesina and Dollar [3] show that there is evidence that the United States have given more aid to countries active in fighting terrorism, and that France has financed mainly former French colonies. Such allocation patterns somehow show that the goal of supporting development and social capital is not considered as the primary determinant of foreign aid. Following a similar reasoning, some type of projects or some agencies could end up delivering aid *less efficiently* than we would expect. Hence, our estimates for the coefficient on aid might actually be lower than we would hypothesize if aid were delivered only according to development considerations, although still positive. Controlling for project and agency type allow us to get rid of the influence of the specific characteristics of single donors or sectors, and to detect the actual correlation between aid and trust.

### 4.3 Instrumental strategy: the NGO Registraction Act

The findings reported in section 4 of a positive correlation between the presence and level of aid in a county and the subsequent level of trust are consistent with our hypothesis about the positive impact of aid on trust. However, an alternative explanation for our findings is that more aid has been directed to counties that initially were more trusting, and that these higher levels of trust simply remain unchanged, or there might be other factors, such as individual and county specific characteristics, that are correlated with the amount of aid flows and subsequent levels of trust. In this section, we address the endogeneity concerns through the use of instrumental variables. This strategy requires an instrument that is correlated with the presence of aid in the county but uncorrelated with any characteristics that may affect the level of trust of the individuals in that county.

In Uganda, a non governmental organization can operate and deliver aid funds to a county after obtaining a specific authorization from the competent district committee. If the NGO is not authorized by the district committee, it cannot carry out any activity and so no aid fund would arrive in Uganda. Since 2006, NGOs started to operate in counties where there were district committees. The more an agency is located far away from the district committee, the more difficult it is to get the authorization, the lower is the incentive for NGOs to engage in aid activities in that county, the less aid the county receives.

The legal source of the provisions on the activity of NGOs comes from a particularly restrictive legislation that regulates the course of their ordinary activities (the NGO Registration Act). The introduction of this law provides a basis for the instrument's exogeneity.

The Non Governmental Organizations (Amendment) Act, passed in 2006, has undermined the productivity of NGOs, by erecting barriers to entry, activity, funding and assembly within the sector.

Among other factors, the precondition that all foreign funds have to be passed through the Bank of Uganda is severely limiting the output of the NGO sector. Among others, the ICNL (International Center for Not-for-Profit Law) has recognized how the fact that all foreign funding must be received in the Bank of Uganda, a government bank, represents a huge barrier to resources' disbursement. [14] The law establishes mandatory registration procedures, including recommendations from governmental representatives, and penalties for conducting activities through unregistered organizations. I.e., NGOs must cooperate with local councils and relevant district committees to be able to carry on their ordinary duties. Regulation 13 of the NGO Registration Regulations 2009 states that an organization in carrying out its operations shall comply with the requirement of not having any direct contact with the people in the area of operation unless it has given seven days' notice in writing of its intention to the local councils and Resident District Commissioners of the area.

We instrument the presence of aid in a specific county with the distance of the county from the district committee.

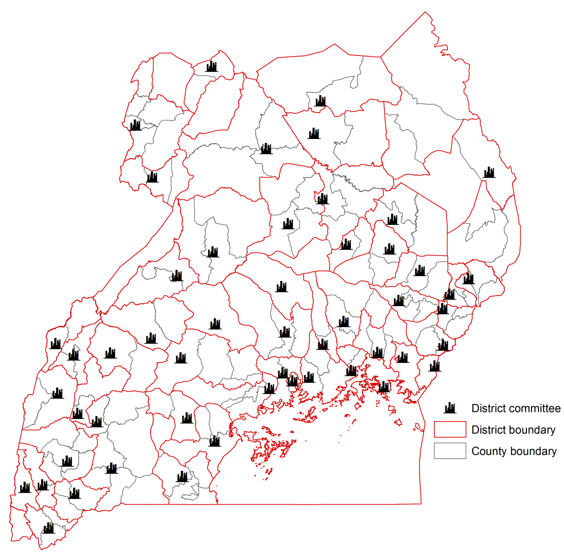


**Fig. 3.** Geolocalized District committee in Uganda.

*Notes:* In the map we draw only the district committees of the counties included in our dataset.

In particular, we employ as instrument the logarithm of the distance of each county from the committee belonging to the same district of the county itself. We impose that if the county contains the district committee the instrument takes value 0, otherwise it equals the logarithm of the distance

[14] See http://www.icnl.org/research/monitor/uganda.html.

plus one. To be consistent, we need to exclude from the dataset all individuals that live in counties that received funds committed before 2006. We thus select only foreign aid projects committed after the 2006 amendment to the legislation and compare trust of respondents in this specific sub-sample with trust of those who did not receive funds. The selection reduces the sample to 985 observations.

Table 5 shows the results of the first and second stage of the instrumental variables estimation. Throughout all the specifications, the distance from the district committee is significant in predicting the effect of foreign aid on trust on other people. In line with our conjecture, the sign of the coefficient on the distance from the district committee is negative, i.e. the more a county is distant from the committee the lower is the probability that the NGO belonging to that county obtains funds for their activities. Column 1 shows the result of the baseline regression, where we fit a two stage least square model with individual controls, county and district level controls and fixed effects for ethnicity. The marginal coefficient on distance is equal to -3.23 and significant at five percent level. The second stage results, reported in the bottom panel of Table 5, are also in line with our conjecture: the sign on the variable dummy fund is positive, as expected. Furthermore, the component of the dummy fund variable predicted by the distance is equal to 0.379 and significant at one percent level. In column 2 and 3, we increase the complexity of the model, adding region fixed effects (column 2) and religion fixed effects (column 3). In both cases, an increase in the logarithm of the distance from the district committee is associated with a negative probability of receiving foreign aid, corresponding to a marginal coefficient of -3.74, significant at the one percent level. The second stage results show again a positive causal effect of the component of the dummy fund variable predicted by the distance on trust in other people. The coefficients estimates are quite stable (0.340 in column 2 and 0.374 in column 3) and significant at the one percent level. Estimates in the last two columns of Table 5 pass the F-test for exogeneity. Overall, the instrumental variables analysis confirms that foreign aid represents a positive shock on individual trust on other people.

## 5 Foreign aid, inequality and trust

A number of papers studied the correlation between social capital, as measured by trust, and various measures of inequality, finding a significant linkage between them. According to Alesina and Ferrara [4], living in a community with a high degree of income disparity, i.e. high level of Gini coefficient, is strongly associated with low trust. They find evidence of this effect in a sample of individuals from American

localities. Uslaner and Brown [31] explain the linkage between trust and inequality. According to the authors, where inequality is high, people are less likely to believe that the future looks bright, and this is reflected also in trust in other people. Thus, a possible explanation to our finding is that receiving foreign aid induces a decrease in the level of inequality inside the county and this in turn affects trust in other people. This could happen given that one of the objectives of foreign aid is to provide or improve public goods, such as roads, or public services. Living in an improved environment could then have an effect on perceived inequality and on trust.
In this section we follow this strand of the literature and study whether inequality could be a channel through which aid affects trust. We exploit a question from Afrobarometer, where individuals are asked to compare their living condition with respect to other Ugandans. Using individuals' answer to this question, we create a dummy measure of perceived equality. The variable in the survey can assume 5 values, depending on whether the individual feels that his living condition are "much worse", "worse", "same", "better", "much better" than that of other Ugandans. We code the variable as 1 if the individual feels his living condition equal to other Ugandans, and zero in all the other cases. We control for the same variable estimated in 2008 averaged at county level to measure the shift from the average perceived inequality during previous wave. Results in Table 6 show that when a county received foreign aid, the likelihood that residents in that county feel more equal increase of 11% (column 1). This result is significant at 1% level and robust to several demographic and fixed-effect controls on region and agency. It is interesting to notice that the magnitude of the coefficient is similar to the one associated to trust in column 1 of Table 2. Columns 2-4 fit different fixed effects on sectors, ethnic origin and religion, and the result is always positive and significant at least at 5% level.

Figure 4 reports the results from the rolling-window regressions using the main specification and where we control for past level of trust, individual and geographic controls, and sectorial fixed effects. The x-axis shows the difference between individual perceived equality and the county's average of perceived equality from Afrobarometer 4. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. The blue line shows the coefficient estimates for the natural log of foreign aid received (ln fund) by the county while the red lines are the 5-percent confidence intervals. As it is possible to notice, when the equality perceived with respect to previous wave is low, the coefficients estimated are not significative. Increasing the equality perceived with respect to previous wave, the

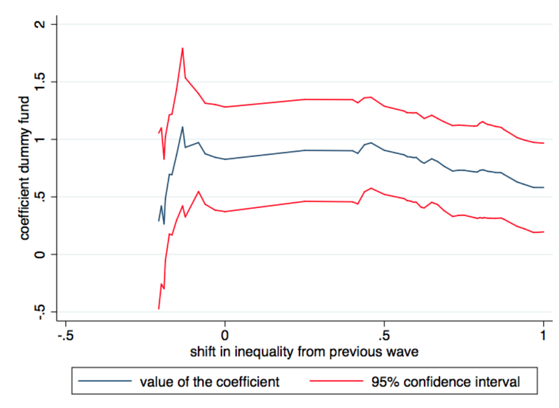


**Fig. 4.** Evolution of the coefficients on the presence of aid (dummy fund) in rolling regressions (probit model) ordered by increasing equality perceived with respect to previous wave

*Note*: The figure reports the result from the rolling-windows regressions, where the window includes 900 observations. The x-axis shows the difference between individual perceived equality and the county's average of perceived equality from Afrobarometer 4. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. The blue line shows the coefficient estimates for the presence of fund (dummy fund) in the county while the red lines are the 5-percent confdence intervals.

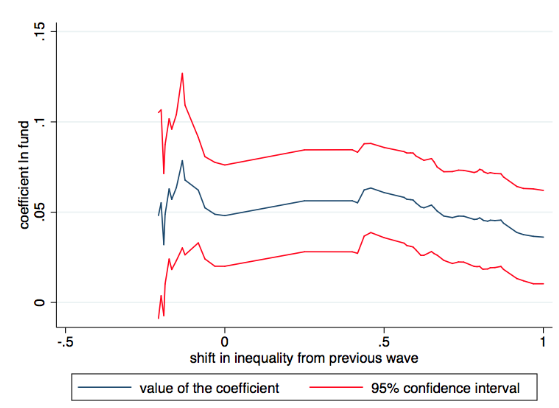


**Fig. 5.** Evolution of the coefficients on the quantity of aid (ln fund) in rolling regressions (probit model) ordered by increasing equality perceived with respect to previous wave

*Note*: The figure reports the result from the rolling-windows regressions, where the window includes 850 observations. The x-axis shows the difference between individual perceived equality and the county's average of perceived equality from Afrobarometer 4. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. The blue line shows the coefficient estimates for the natural log of foreign aid received (ln fund) by the county while the red lines are the 5-percent confdence intervals.

coefficient associated to the presence of fund becomes positive and significant.[15] This gives support to the hypothesis that trust and inequality are strictly linked, and the last one could be a channel for the effect of foreign aid on trust. Figure 5 shows the result of the same type of analysis when the rolling estimation is conducted using the natural log of foreign aid received in the county. Also in this case, for lower level of equality perceived with respect to previous wave the coefficients estimated are not significative. Then, for higher level of equality perceived, an increase in 1% in foreign aid seems to contribute linearly to the trust in other people. The findings of this section confirm the close link among aid, inequality, and trust.

## 6 Robustness check

Up to this point, we have studied whether large disbursement of aid contributed to reduce the trust deficit over time using different specification and addressing exogeneity issues through an appropriate instrument. In this section, we run some empirical tests to check the robustness of our hypothesis. In Table 9, we conduct the same instrumental strategy investigation as in Table 5 using the sample of aid committed before 2006. We test whether distance predicts foreign aid committed prior to the enforcement of the NGO's registration act, to check for spurious correlation between foreign aid and distance in general. Based on the results in Table 9, we can easily dismiss the possibility of having detected a spurious correlation: distance has a positive effect on foreign aid committed before 2006, unlike what we have detected in Table 5. We might infer that 2006 represented a breaking point in our analysis, mainly due to the enforcement of the NGO's registration act. Looking at the F test, we can exclude that distance is a good instrument for predicting foreign aid committed before 2006 and this supports once more our conjecture.

In Table 10, we run different instrumental probit models and the results are robust and in line with those in Table 5. As Table 10 shows, higher distance from the district committee is always associated with higher probability of getting aid, and the probability of obtaining aid is positively associated with higher trust in other people. In column 1 to 3 of Table 10, we include the same controls employed in Table 5: results are consistent and independent from the model's specification.

In Table 11, we collapse the data at county level and run a probit model employing only county and district levels' regressors. Although the number of observations in this case is extremely low and thus

[15]we identify a cut-off point when the value of the shift in equality is equal to -0.17.

any inference must be drawn with caution, the presence of aid in a county (dummy fund) remains again statistically significant. The positive and significant marginal coefficient reported in column 1 of Table 11 comes from a model in which we control for the average level of trust in 2008. In column 2, we control for other demographic and economic characteristics of the county, such as nightlight, unemployment and all the other county level controls included in Table 2. The effect of the main explanatory variable becomes stronger when we include additional controls: the coefficient now takes a value of 0.711 and is significant at five percent level. Finally, in column 3 we control for ethnic fragmentation and for slave trade, employing the variables developed by Nunn and Wantchekon [26]. Again, the coefficient on aid is positive and significant, with a marginal value equal to 0.865.

In Table 12, we study the effect of foreign aid on other dimensions of trust, in particular trust on relatives, on neighbors, and on other known people. The presence of foreign aid has almost no effect on other dimensions of trust, with the exception of a slightly positive effect in the two stage least squares regression with trust on neighbors. In general, we conclude that foreign aid has an extremely significant effect only on generalized trust, without affecting the other dimensions of trust.

Considering the recent history of Uganda, there is an additional possible explanation to our results on aid and trust, that is related to the occurrence of civil conflicts. Both aid and trust might be correlated with the past experience of fighting in a specific county. In their recent work Rohner et al. [29] highlight the importance of civil conflict in determining the level of social capital and trust in Uganda from a long term perspective. They show how people living in counties that experienced conflicts report lower levels of trust, compared to people that never experienced conflicts. Following this reasoning, it might be interesting to study whether and how foreign aid mitigate the legacy of past conflicts on today levels of trust. Indeed, if the availability of aid resources on a number of projects has also the potential to reduce the disrupting effects on trust of past conflicts thus accelerating the process of rebuilding trust, we could conclude that foreign aid has a wider role in similar situations than just enhancing economic growth. As an extension of the core analysis of the paper, in Table 7 we fit the same specification of Table 2 adding as regressor the variable *All fighting*, taken from Rohner et al. [29]. This variable counts all the conflicts that occurred in a county from 2000 to 2008, a period characterized by a high incidence of conflict in Uganda, especially in the north of the country, where a rebel movement called Lord's Resistance Army was operating.[16]

[16]See Rohner et al. [29] for an extensive overview of the situation of conflict in Uganda.

In column 1 of Table 7, we fit the baseline model using *All fighting* as explanatory variable and excluding the dummy on the presence of foreign aid. The number of fighting that occurred until 2008 has a negative effect on long-term trust, but this effect is statistically significant at ten percent level only in column 2 where we control for ethnic fixed effects. When we include in the model the dummy for aid, we find that *All fighting* continues to be barely significant and the sign becomes quite unstable (see column 3-6). Conversely, the dummy on the presence of fund is significant at one percent level and the estimates are similar to those in Table 2 in terms of magnitude.

The results in Table 7 could be driven by a high correlation between the localization of foreign aid and that of conflict. Indeed, it might happen that NGOs develop projects in counties with records of violent conflicts and such eventuality would drive our result, delivering non significant coefficients for the proxy of conflicts. In order to test this hypothesis, in Table 8 we collapse the data at county level and fit a probit model in which we regress the dummy for the presence of foreign aid on the number of conflicts that occurred between 2000 and 2008 (column 1). In column 2, we add several county and district level controls, and in column 3 we include controls on ethnic fractionalizations and the logarithm of the quantity of slaves exported historically. Throughout all the specifications, we find no relevant effect of fighting on the presence of foreign aid (dummy fund).

## 7 Conclusion

Is there a linkage between foreign aid and trust? In this study we hypothesize that the disbursement of funds through the financing of foreign aid initiatives by donors, represents a positive contemporaneous shock that changes beliefs and social capital, and increases trust on other people. To test our hypothesis, we use data from two waves of Afrobarometer survey and from AidData to examine whether individuals living in counties that received more aid in the last decade are more trusting of others today.

In the first part of the analysis we implement a probit model and we find that an individual who lives in a county recipient of foreign aid, has an higher probability of trusting other people compared to one living in a county that did not receive foreign aid. The coefficient associated with the presence of a project tells us that the marginal probability at mean value of the other variables is equal to 13 percent and significant at one percent level. Our finding holds also at the extensive margin, where a rise of one percent in foreign aid is associated with an increase of one percent in the probability of trusting other people. The findings are robust to controlling for the previous level of trust in the county, individual, local, ethnic, and religion characteristics. However, an agency could decide to allocate foreign aid in a county where there is more probability of success for the project, and in this case our result could be driven by reverse causality. In order to overcome the reverse causality issue, we implement an instrumental variable strategy exploiting the NGO Registration Act of 2006, a restrictive legislation that disciplines the ordinary activity of NGOs in Uganda and that entered into force in 2006. Excluding the aid committed before 2006 and employing as instrument the logarithm of the distance between a county and its district committee, we assess the causal effect of foreign aid on trust. The magnitude of the result is higher than in the previous case, an individual living in a county recipient of foreign aid has a 37.9% higher probability of trusting other people than someone living in a county not recipient of foreign aid. However, the shift in magnitude could be caused by the implementation of a linear probability 2SLS model.

Following Bourdieu [7], social capital is an attribute of an individual in a social context; one can acquire social capital through purposeful action and can transform social capital into conventional economic gains.' Our study supports the hypothesis that, independently from the long-debated issue between foreign aid and growth, foreign aid has an impact on trust, that is commonly considered as a proxy of social capital. Previous literature on aid was not able to capture the short-term growth effect, and in some cases, as Burnside and Dollar [9], found a positive relationship between foreign aid and growth conditional on good policies. Conversely, our analysis is the first that suggests how foreign aid has a significant effect on social dimensions that, following Bourdieu [7] definition, could be converted into conventional economic gains in the future.

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# Appendix 1

**Table 1.** Summary Statistics

| | Foreign aid=0 | | | Foreign aid=1 | | |
|---|---|---|---|---|---|---|
| | N | mean | sd | N | mean | sd |
| **Individual-level** | | | | | | |
| Urban/Rural dummy | 413 | 0.920 | 0.268 | 1699 | 0.822 | 0.383 |
| Access to electricity | 413 | 0.445 | 0.498 | 1699 | 0.427 | 0.495 |
| Access to piped water system | 413 | 0.290 | 0.455 | 1699 | 0.313 | 0.464 |
| Access to sewage system | 413 | 0.058 | 0.234 | 1699 | 0.174 | 0.380 |
| Cell phone service | 413 | 0.961 | 0.193 | 1699 | 0.896 | 0.305 |
| Access to school | 413 | 0.903 | 0.296 | 1699 | 0.883 | 0.322 |
| Radio | 413 | 0.789 | 0.408 | 1698 | 0.813 | 0.390 |
| Television | 412 | 0.085 | 0.279 | 1696 | 0.163 | 0.369 |
| Vehicle | 413 | 0.082 | 0.275 | 1699 | 0.101 | 0.302 |
| Age | 408 | 36.74 | 13.60 | 1693 | 34.88 | 12.76 |
| $Age^2$ | 408 | 1534.6 | 1222.4 | 1693 | 1379.4 | 1080.8 |
| No and not looking for employment | 413 | 0.301 | 0.463 | 1699 | 0.257 | 0.437 |
| Unemployed | 413 | 0.225 | 0.418 | 1699 | 0.247 | 0.431 |
| Part-time employed | 413 | 0.230 | 0.421 | 1699 | 0.232 | 0.422 |
| Full-time employed | 413 | 0.235 | 0.424 | 1699 | 0.263 | 0.440 |
| High education | 413 | 0.092 | 0.289 | 1699 | 0.131 | 0.338 |
| Medium education | 413 | 0.494 | 0.500 | 1699 | 0.505 | 0.500 |
| Low education | 413 | 0.414 | 0.493 | 1699 | 0.363 | 0.481 |
| Sex | 413 | 0.499 | 0.500 | 1699 | 0.501 | 0.500 |
| **County and district-level** | | | | | | |
| Trust relatives 2008 | 413 | 0.843 | 0.110 | 1699 | 0.844 | 0.119 |
| Trust in known people 2008 | 413 | 0.575 | 0.216 | 1699 | 0.529 | 0.190 |
| Trust in others 2008 | 413 | 0.356 | 0.252 | 1699 | 0.312 | 0.219 |
| Population size (2002) | 413 | 506735 | 223645 | 1699 | 558819 | 298867 |
| Urbanization | 413 | 7.301 | 4.902 | 1699 | 15.01 | 26.23 |
| Net Migration (in 1000) | 413 | -2.197 | 5.07 | 1699 | 0.155 | 5.61 |
| Age dependency ratio | 413 | 116.48 | 10.40 | 1699 | 109.69 | 16.17 |
| Adjusted Fertility Rate | 413 | 7.312 | 0.628 | 1699 | 6.923 | 1.02 |
| Manufacturing Share | 413 | 2.034 | 1.742 | 1699 | 2.38 | 2.01 |
| Subsistence farming | 413 | 24.84 | 10.47 | 1699 | 31.143 | 23.15 |
| Unemployment share | 413 | 4.085 | 1.639 | 1699 | 4.628 | 3.379 |
| Number of Micro Enterprise | 413 | 22590 | 11680 | 1699 | 30382 | 25134 |
| Ethnic fragmentation | 413 | 0.202 | 0.237 | 1699 | 0.116 | 0.173 |
| Satellite nightlight per capita | 413 | 0.131 | 0.183 | 1699 | 0.812 | 1.880 |
| **Ethnic-level** | | | | | | |
| Slave export area (ln) | 413 | 0.0319 | 0.042 | 1699 | 0.031 | 0.052 |
| Hunting | 377 | .692 | 0.615 | 1595 | 0.869 | 0.470 |
| Fishing | 377 | 0.745 | 0.818 | 1595 | 0.727 | 0.835 |
| Animal Husbandry | 377 | 2.541 | 1.093 | 1595 | 2.515 | 1.168 |
| Agriculture | 377 | 5.94 | 0.682 | 1595 | 5.774 | 0.823 |

**Table 2.** Foreign aid and trust - extensive margin

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dummy Fund | 0.114*** | 0.133*** | 0.132*** | 0.113** |
| | (0.029) | (0.037) | (0.045) | (0.045) |
| Agency FE | Y | Y | Y | Y |
| Sector FE | N | Y | Y | Y |
| Ethnic FE | N | N | Y | Y |
| Religion FE | N | N | N | Y |
| Region FE | Y | Y | Y | Y |
| Pseudo-$R^2$ | 0.1335 | 0.1432 | 0.1461 | 0.1589 |
| Observations | 1,845 | 1,845 | 1,721 | 1,697 |

County-religion clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports marginal effects obtained through a Probit model. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. All the specifications (columns 1 to 4) include the following set of controls: a vector of demographic characteristics (age and its square, employment status, and educational level), a vector of social characteristics (population size, possession of radio, television, and vehicles, whether the county is rural or urban, access to electricity, piped water, sewage system, cell phone services and availability of schools), the average level generalized trust in 2008 by county, the previous level of trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate, unemployment rate, and county characteristics (ethnic fractionalization, nightlight), fixed-effects on agencies and regions.

**Table 3.** Other control variables and trust - marginal coefficients.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| ln of Population | -0.054 | -0.025 | -0.232*** | -236*** |
| | (0.039) | (0.042) | (0.066) | (0.066) |
| Urban dummy | -0.033 | -0.031 | -0.07 | -0.07 |
| | (0.042) | (0.044) | (0.048) | (0.048) |
| Unemployment level 2008 | 0.018*** | 0.019*** | 0.023*** | 0.023*** |
| | (0.005) | (0.005) | (0.007) | (0.007) |
| Dummy employment | -0.040** | -0.041** | -0.042** | -0.039** |
| | (0.017) | (0.017) | (0.017) | (0.018) |
| Satellite nightlight percapita 2008 | 0.175*** | 0.219*** | 0.263*** | 0.269*** |
| | (0.040) | (0.046) | (0.054) | (0.053) |

County-religion clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Notes*: The table reports the marginal effects of other control variables from the specification reported in Table 2. Specifications in column 1-4 correspond to those fitted in column 1-4 of Table 2. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. All the specifications (columns 1 to 4) include the following set of controls: a vector of demographic characteristics (age and its square, employment status, and educational level), a vector of social characteristics (population size, possession of radio, television, and vehicles, whether the county is rural or urban, access to electricity, piped water, sewage system, cell phone services and availability of schools), the average level generalized trust in 2008, the previous level of trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate, unemployment rate, and county characteristics (ethnic fractionalization, nightlight), fixed-effects on agencies and regions.

**Table 4.** Foreign aid and trust - intensive margin

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Ln fund | 0.008*** | 0.011*** | 0.011*** | 0.0076*** |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Agency FE | Y | Y | Y | Y |
| Sector FE | N | Y | Y | Y |
| Ethnic FE | N | N | Y | Y |
| Religion FE | N | N | N | Y |
| Region FE | Y | Y | Y | Y |
| Pseudo-$R^2$ | 0.1340 | 0.1446 | 0.1470 | 0.1485 |
| Observations | 1,845 | 1,845 | 1,721 | 1,697 |

County-religion clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Notes*: The table reports marginal effects obtained through a Probit model. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. For the set of controls see note below Table 2.

**Table 5.** Two stage least square estimation using ln of the distance from district committee as instrument for the presence of fund

| First stage regression | | | |
|---|---|---|---|
| ln(distance+1) from district committee | -3.23** | -3.74*** | -3.74*** |
| | (1.21) | (1.13) | (1.11) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Kleibergen-Paap F statistic | 7.09 | 10.93 | 11.29 |
| $R^2$ | 0.49 | 0.54 | 0.54 |
| **Second stage regression** | | | |
| Dummy fund | 0.379*** | 0.340*** | 0.374*** |
| | (0.134) | (0.091) | (0.098) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Errors clustered | County & Religion | County & Religion | County & Religion |
| $R^2$ | 0.07 | 0.09 | 0.09 |
| Observations | 985 | 985 | 985 |

*** p<0.01, ** p<0.05, * p<0.10

*Notes*: model applied is a a 2 stage least square with trust (dummy 0-1) as dependent variable at individual level and the ratio between average county's distance from all the offices of Bank of Uganda on the county's area. All the specifications include demographic controls (age and age-squared, employment status, and educational level) social controls (population size radio/television/vehicle possession, urban/rural dummy, access to electricity, piped water, sewage system, cell phone services and school); generalized trust in 2008 by county, past trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate,unemployment rate), and county characteristics, fixed-effects on agency.

**Table 6.** Foreign aid and perceived equality - extensive margin

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dummy Fund | 0.111*** | 0.099*** | 0.064** | 0.058** |
| | (0.042) | (0.035) | (0.026) | (0.026) |
| Agency FE | Y | N | N | N |
| Sector FE | N | Y | N | N |
| Ethnic FE | N | N | Y | N |
| Religion FE | N | N | N | Y |
| Region FE | Y | Y | Y | Y |
| Pseudo-$R^2$ | 0.063 | 0.053 | 0.048 | 0.058 |
| Observations | 1,647 | 1,657 | 1,657 | 1,638 |

County-religion clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Notes*: The table reports the marginal effects obtained through a Probit model. The dependent variable is a dummy taking value 1 if the individual feels equal with others in term of living condition, and 0 otherwise. All the specifications (columns 1 to 4) include the following set of controls: a vector of demographic characteristics (age and its square, employment status, and educational level), a vector of social characteristics (population size, possession of radio, television, and vehicles, whether the county is rural or urban, access to electricity, piped water, sewage system, cell phone services and availability of schools), the average level of perceived equality in 2008 averaged by county, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate, unemployment rate, and county characteristics (ethnic fractionalization, nightlight), fixed-effects on agencies and regions.

**Table 7.** Foreign aid, trust and conflict- Extensive Margin robustness check

| | (1) | (2) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|---|
| All fighting | -1.903 | -3.667* | -0.212 | 1.371 | 2.047 | - 0.460 |
| | (1.885) | (2.231) | (1.548) | (1.538) | (1.067) | (0.762) |
| Dummy Fund | | | 0.572*** | 0.728*** | 0.685*** | 0.536*** |
| | | | (0.089) | (0.146) | (0.232) | (0.150) |
| Agency FE | N | N | Y | Y | Y | Y |
| Sector FE | N | N | N | Y | Y | Y |
| Ethnic FE | N Y | N | N | Y | Y | |
| Religion FE | N | N | N | N | N | Y |
| Region FE | Y | N | Y | Y | Y | Y |
| Observations | 1,979 | 1,853 | 1,877 | 1,877 | 1,721 | 1,825 |

Region-clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Note*: The table reports Probit estimates. The dependent variable is a dummy taking value 1 if the individual shows generalized trust, and 0 otherwise. All the specifications (columns 1 to 4) include the following set of controls: a vector of demographic characteristics (age and its square, employment status, and educational level), a vector of social characteristics (population size, possession of radio, television, and vehicles, whether the county is rural or urban, access to electricity, piped water, sewage system, cell phone services and availability of schools), the average level generalized trust in 2008 by county, the previous level of trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate, unemployment rate, and county characteristics (ethnic fractionalization, nightlight), fixed-effects on agencies and regions.

**Table 8.** Foreign aid and conflict - investigation on the determinants of foreign aid

| | (1) | (2) | (3) |
|---|---|---|---|
| All fighting | 2.162 | 0.942 | -.037 |
| | (4.620) | (6.056) | (6.639) |
| County/Districts-level controls | N | Y | Y |
| Historical ethnic controls (Nunn) | N | N | Y |
| Errors clustered | District | District | District |
| Observations | 98 | 98 | 98 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: model applied is a a probit with the presence of foreign aid (dummy fund) in the county as dependent variable. The second specification adds county demographic and economics controls. The third specification includes also control on ln of slave exported historically and ethnic fractionalization. Errors are robust and clustered at county level.

**Table 9.** Robustness check on foreign aid committed before 2006

| | | | |
|---|---|---|---|
| First stage regression | | | |
| ln(distance+1) from district committee | 1.23** | 1.21** | 1.23** |
| | (0.52) | (0.51) | (0.52) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Kleibergen-Paap F statistic | 5.64 | 5.65 | 5.62 |
| Second stage regression | | | |
| Dummy fund | 0.146 | 0.139 | 0.059 |
| | (0.259) | (0.314) | (0.276) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Errors clustered | County & Religion | County & Religion | County & Religion |
| Observations | 1046 | 1046 | 1046 |

*** $p<0.01$, ** $p<0.05$, * $p<0.10$

*Note*: model applied is a a 2 stage least square with trust (dummy 0-1) as dependent variable at individual level and the ratio between average county's distance from all the offices of Bank of Uganda on the county's area. All the specifications include demographic controls (age and age-squared, employment status, and educational level) social controls (population size radio/television/vehicle possession, urban/rural dummy, access to electricity, piped water, sewage system, cell phone services and school); generalized trust in 2008 by county, past trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate,unemployment rate), and county characteristics, fixed-effects on agency.

**Table 10.** Instrumental Probit estimation using ln of the distance from district committee as instrument for the presence of fund

| First stage regression | | | |
|---|---|---|---|
| ln(distance+1) from district commitee | -3.66** | -1.14** | -4.03*** |
| | (1.65) | (0.55) | (1.50) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Prob > chi2 | 0.048 | 0.019 | 0.014 |
| **Second stage regression** | | | |
| Dummy fund | 1.60*** | 1.52*** | 1.71*** |
| | (0.536) | (0.452) | (0.459) |
| Individual controls | Y | Y | Y |
| County/Districts-level controls | Y | Y | Y |
| Fixed Effects | Ethnic | Ethnic, Regions | Ethnic, Regions, Religion |
| Errors clustered | County | County | County |
| Observations | 875 | 875 | 847 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: model applied is a an istrumental probit with trust (dummy 0-1) as dependent variable at individual level and the ratio between average county's distance from all the offices of Bank of Uganda on the county's area. All the specifications include demographic controls (age and age-squared, employment status, and educational level) social controls (population size radio/television/vehicle possession, urban/rural dummy, access to electricity, piped water, sewage system, cell phone services and school); generalized trust in 2008 by county, past trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate,unemployment rate), and county characteristics, fixed-effects on agency.

**Table 11.** Probit estimation of the effect of fund on trust using the collapsed cross-county dataset

| | | | |
|---|---|---|---|
| Dummy fund | 0.593* | 0.711** | 0.865** |
| | (0.306) | (0.334) | (0.349) |
| Trust level during 2008 | Y | Y | Y |
| County/Districts-level controls | N | Y | Y |
| Historical ethnic controls (Nunn) | N | N | Y |
| Errors clustered | District | District | District |
| Observations | 98 | 98 | 98 |

*** p<0.01, ** p<0.05, * p<0.10

*Note*: model applied is a a probit with average trust in the county as dependent variable. All the specifications include controls on generalized trust in 2008 by county as well as on trust on relatives and on known people during 2008. The second specification adds county demographic and economics controls. The third specification includes also control on ln of slave exported historically and ethnic fractionalization. Errors are robust and clustered at county level.

**Table 12.** Probit and two stage least squares estimation of presence of fund on other dimension of trust (relative, neighbor, otherpeople

| Trust dimension | relative | relative | neighbor | neighbor | otherpeopleknown | otherpeopleknown |
|---|---|---|---|---|---|---|
| | Probit | 2SLS | Probit | 2SLS | Probit | 2SLS |
| dummy fund | 0.145 | -0.021 | -0.140 | 0.608* | -0.076 | -0.165 |
| | (0.204) | (0.193) | (0.236) | (0.192) | (0.160) | (0.132) |
| Agency FE | Y | N | Y | N | Y | N |
| $R^2$ | 0.14 | 0.18 | 0.13 | 0.10 | 0.13 | 0.18 |

County-clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

*Note*: Dependent variables are trust on relative, on neighbor, trust on other people. Model applied are a probit and 2sls with trust (dummy 0-1) as dependent variable at individual level. All the specifications include demographic controls (age and age-squared, employment status, and educational level) social controls (population size radio/television/vehicle possession, urban/rural dummy, access to electricity, piped water, sewage system, cell phone services and school); generalized trust in 2008 by county, past trust in own group, urbanization, age-dependency ratio, share of manufacture, share of subsistence farming, net migration, number of micro-enterprises, adjusted total fertility rate,unemployment rate), and county characteristics (ethnic fractionalization, nightlight), fixed-effects on agency.

# Appendix 2

**Table 13.** List of agencies and sectors in the analysis - first part

| Agency Name | Primary sector |
|---|---|
| African Development Fund | EDUCATION |
| African Development Fund | WORKS AND TRANSPORT |
| African Development Fund\|China\|Sweden | AGRICULTURE |
| ABEDA \|Belgium\|Germany\|IDB \|KFD\|OPEC\|SFD\|South Korea | EDUCATION |
| ABEDA\|OPEC | WORKS AND TRANSPORT |
| Austria | HEALTH |
| Austria | JLOS |
| Austria | SOCIAL DEVELOPMENT |
| Austria | TOURISM, TRADE AND INDUSTRY |
| China | AGRICULTURE |
| China | EDUCATION |
| China | ENERGY AND MINERAL DEVELOPMENT |
| China | HEALTH |
| China | SECURITY |
| China | TOURISM, TRADE AND INDUSTRY |
| China | WORKS AND TRANSPORT |
| Denmark/DANIDA | AGRICULTURE |
| Denmark/DANIDA | SOCIAL DEVELOPMENT |
| Denmark/DANIDA | WORKS AND TRANSPORT |
| European Union | AGRICULTURE |
| European Union | EDUCATION |
| European Union | HEALTH |
| European Union | JLOS |
| European Union | WORKS AND TRANSPORT |
| Germany | ENERGY AND MINERAL DEVELOPMENT |
| Iceland | EDUCATION |
| International Bank for Reconstruction and Development | ENERGY AND MINERAL DEVELOPMENT |
| IDA | ENERGY AND MINERAL DEVELOPMENT |
| IDA | HEALTH |
| IDA | TOURISM, TRADE AND INDUSTRY |
| IDA | WORKS AND TRANSPORT |
| IDA \| ADF | ENERGY AND MINERAL DEVELOPMENT |
| IDA \|Japan | WORKS AND TRANSPORT |
| IDA \|Norway | ENERGY AND MINERAL DEVELOPMENT |
| Ireland | EDUCATION |
| Ireland | ENERGY AND MINERAL DEVELOPMENT |
| Ireland | HEALTH |
| Ireland | SOCIAL DEVELOPMENT |
| Ireland\|Japan | EDUCATION |

**Table 14.** List of agencies and sectors in the analysis - second part

| Agency Name | Primary sector |
|---|---|
| Japan | AGRICULTURE |
| Japan | EDUCATION |
| Japan | ENERGY AND MINERAL DEVELOPMENT |
| Japan | HEALTH |
| Japan SOCIAL | DEVELOPMENT |
| Japan WORKS | AND TRANSPORT |
| Norway | AGRICULTURE\|EDUCATION |
| Norway | EDUCATION |
| Norway | ENERGY AND MINERAL DEVELOPMENT |
| Norway | HEALTH |
| Norway | SOCIAL DEVELOPMENT |
| Spain | HEALTH |
| Sweden | HEALTH |
| Sweden | SOCIAL DEVELOPMENT |
| Sweden | TOURISM, TRADE AND INDUSTRY |
| Swedish International Development Authority | HEALTH |
| United Kingdom | HEALTH |
| United Kingdom | SOCIAL DEVELOPMENT |
| UNDP | SOCIAL DEVELOPMENT |
| United States of America | AGRICULTURE |
| United States of America | HEALTH |
| United States of America | SOCIAL DEVELOPMENT |

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