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# What Motivates U.S. Food Aid Donations? Characteristics of Countries That Received Food Aid from the U.S. in 2012

Beth Monnier

**ABSTRACT.** The United States Agency for International Development (USAID) claims the purposes of U.S. food aid are “to reduce hunger and malnutrition and assure that people everywhere have enough food at all times for healthy, productive lives” (USAID 2014). In this paper, the researcher uses ordinary least squares regression analysis to test how accurately this mission statement reflects food aid allocations in the year 2012. The dependent variable is metric tons of food aid donated to each country by the United States. This study finds that recipient countries with high malnutrition death rates and large populations received a higher percent of the United States’ food aid allocations relative to other recipients. The recipient countries’ geographic location and corruption rate also matter. The results support USAID’s claim.

## **I. Introduction and Background**

In 2012 alone, 4,740,006.9 metric tons of food aid were donated to 84 countries. Of this, the United States Government and its citizens donated 2,085,722 tonnes of food aid, 44% of total donations, to 57 countries (World Food Programme “Quantity Reporting”).

Food aid research typically falls into one of the following categories: how food aid affects recipients, how food aid is distributed within recipient countries, or how food aid is allocated by donor countries. This paper falls into the last category by examining how the U.S. allocated food to external recipients in 2012. Specifically, this paper seeks to explain how characteristics of the recipient country influence the quantity of food aid the United States allocates to that country.

### **A. HISTORY OF FOOD AID IN THE UNITED STATES**

Early U.S. efforts to provide food assistance can be traced as far back as 1812 when James Madison authorized food donations to Venezuelans affected by an earthquake (American Foreign Relations). Independent efforts by churches and organizations to provide food relief throughout the 1800s were centralized during World War I with the establishment of the U.S. Food Administration. The U.S. Food Administration strictly

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controlled food supplies in order to help the United States' and Allied Powers' war efforts (National Archives). After WWI, the U.S. Food Administration was transformed into the American Relief Administration and began focusing on relief efforts, particularly in Europe (National Archives).

The United States' food aid program expanded in 1954 with the signing of Public Law 480, commonly known as the "Food for Peace Act" (US Food Aid). The law created several agencies that gathered and distributed food aid. In 1961, these agencies were consolidated and became USAID, or the United States Agency for International Development. The new USAID agency's stated mission was "to reduce hunger and malnutrition and assure that people everywhere have enough food at all times for healthy, productive lives" (USAID 2014). This paper tests the accuracy of this mission statement in 2012 by examining how the United States allocated food aid to foreign recipients.

## B. TYPES OF FOOD AID GIVEN BY THE UNITED STATES

The World Food Programme lists three types of food aid: emergency aid, project aid, and programme aid. The United States donates all three types. According to the World Food Programme, emergency aid is given to "victims of natural or man-made disasters... It is channelled multilaterally, through [non-governmental organizations] or, sometimes, bilaterally" (World Food Programme "The Variables"). Project food aid is "aim[ed] at supporting specific poverty-reduction and disaster-prevention activities" and also can be distributed by non-governmental organizations (World Food Programme "The Variables"). Additionally, project food aid can be sold by individual recipients and is commonly called monetized food aid. Programme aid is a government-to-government transfer and is not given to individuals directly. This type of aid "is sold on the open market and provided either as a grant or as a loan" (World Food Programme "The Variables").

## C. DELIVERY MODES

To deliver this aid, the United States uses all three of the accepted delivery modes. The first mode, local purchasing, consists of purchasing food in the country where the food will be distributed (World Food Programme "The Variables"). The second delivery mode, triangular

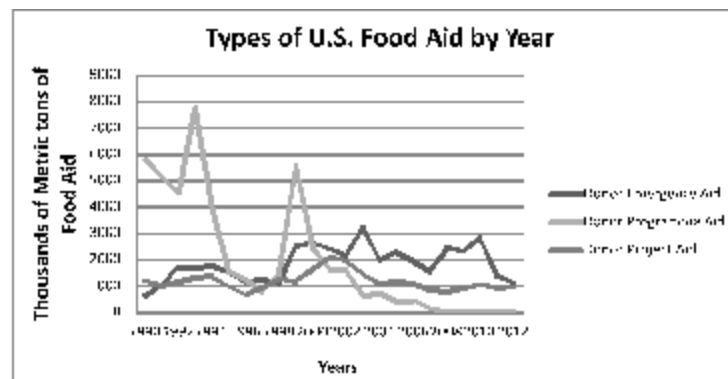
purchasing, occurs when the “donor provides commodities purchased in a third country as food aid to a final recipient country” (World Food Programme “The Variables”). For example, the United States could purchase grain in Vietnam to donate as aid in Cambodia. The third delivery mode is direct transferring. When the United States uses direct transferring, it donates food produced within United States to the recipient countries.

## II. Why This Topic Is Important

Because the U.S. is the single largest donor of food aid, the way the United States allocates food aid has far-reaching effects. If these donations are politically and economically motivated, then some people might be disproportionately affected by food aid allocations. The people most affected by food aid allocations are the malnourished and poor in foreign countries. Food aid affects these people through changes in food consumption, food and land prices, farming practices, and government policies that might be altered to attract or discourage food aid donations.

This study is also important because it is updating food aid research. In 2012 alone, 1,127,502 tonnes of emergency food aid, zero tonnes of programme aid, and 958,219.5 tonnes of project aid were distributed by the United States (WFP “Quantity Reporting”). This quantity differs substantially from food aid donations given twenty years ago by the United States. Figure 1, created with WFP data, shows how food aid allocations have changed from 1990 to 2012:

Figure 1. Food Aid Trends



Overall, the quantity of food aid is lower now than in some previous years and the quantity of emergency and project aid are greater than the quantity of programme aid. This could signal that the United States is changing the reasons it gives food aid. This study will explain how the characteristics of the recipient countries affect the United States' current food aid allocations.

### **III. Literature Review**

This paper is modeled after Dreher and Fuchs's paper, "Rogue Aid? The Determinants of China's Aid Allocations" (2011). Using five sets of cross-sectional data, Dreher and Fuchs concluded that there is "no evidence that China's aid allocation is dominated by natural resource endowments. Moreover, China's allocation of aid seems to be widely independent of democracy and governance in recipient countries" (2011, 1). In other words, there is no evidence that China gives more aid to countries with large endowments of natural resources, or that it favors a particular type of political system. Like Dreher and Fuchs, I analyze how a single country, the United States, determines its aid allocations. However, the scope of my research is limited to one year of data.

Fleck and Kilby (2010) note that a large number of econometric studies have been conducted to determine how political biases have affected the United States' aid allocations (186). Like previous researchers, Fleck and Kilby take the "natural log transformation of aid to reduce the influence of high-aid outliers" (2010, 189). Using cross-panel data from the mid 1990s through 2005, Fleck and Kilby found that "the importance of need as a criterion for aid eligibility fell so that the probability that a higher income (less poor) developing country would receive aid increased over time and approached that for a lower income developing country" (2010, 185). Fleck and Kilby attribute this policy change to the War on Terror and mention that a similar trend occurred during the Cold War (2010, 189).

Like Dreher and Fuchs (2011) and Fleck and Kilby (2010), Nelson (2012) examines the characteristics of recipient countries. Nelson (2012) found that humanitarian variables "were significant predictors of disaster aid provision" (109). Nelson examined aid allocations from 22 donor countries. He also found that donors were more likely to donate disaster aid "to trading partners, former colonies, and military allies" (2012, 109).

Round and Odedokun (2004), Tingley (2009), and Chong (2007) took a different approach by focusing on the characteristics of the donor countries rather than the characteristics of the recipient countries. Round and Odedokun were interested in the donation habits of Development Assistance Committee members like the United States (2004, 293). They focused on total quantity of aid donations rather than relative quantities of food donations. Countries that donated more per person tend to have larger populations, a “domestic pro-poor tendency,” and more “military adventurism” (Round and Odedokun, 2004, 293). Round and Odedokun found that, relative to other Development Assistance Committee members, the United States donated a smaller share of GDP and was more likely to donate to neighboring countries, (2004, 294-95).

#### IV. Method and Data

##### A. MODEL

This analysis uses ordinary least squares (OLS) regression with the log of metric tons of food aid donated per country as a function of several independent variables. Most data in this cross-section analysis are from 2012. The malnutrition death rate and the U.S military base variable are from 2011. Some of the independent variables collected and tested are not included in the final model due to a lack of data. The independent variables included in this study are similar to the independent variables included in Dreher and Fuchs (2011). The final model includes the following variables:

$$\begin{aligned} \ln \widehat{Foodaidreceived2012} = & \beta_0 + \beta_1 \widehat{MalnutritionDeathRate2011} + \beta_2 \ln \widehat{Population} \\ & + \beta_3 \ln \widehat{Top10DisastRelatedDeaths} + \beta_4 \widehat{CorruptionPerceptionScore} + \\ & \beta_5 \widehat{TradingAgreement} + \beta_6 \widehat{USMilitaryBaseendof2011} + \\ & \beta_7 \widehat{GeographicLocations} + \beta_8 \widehat{GDPpercapita2012} + \beta_9 \widehat{TotalOilSupply} \end{aligned}$$

This model is in the semilog functional form. In other words, the dependent variable and some, but not all, of the independent variables are transformed into natural logarithms.

## B. LIMITATIONS AND ADVANTAGES OF THIS MODEL

This study will only explain how characteristics of the recipient country influence the United States' food aid allocations. Because all variables are aggregated for 2012, the results of this analysis will not show changes in food aid allocation or in food aid policies which might have occurred in 2012. Nor will this study provide insight into the motivations of the United States' aid allocations for years prior to or following 2012. When examining the results, it should be noted that all forms of food aid were included in the dependent variable. As mentioned by Dreher and Fuchs (2011), emergency food aid given after a natural disaster or other shock may be less politically motivated than other types of food aid (7). Therefore, the political motivation behind some forms of aid might not be as visible in the results of this study as these results would be in a model that only examines one form of food aid.

This study will, however, provide insight into the motivations of food aid allocations for 2012. The results of this cross-section study can also be used as a reference point for researchers who want to determine how characteristics of recipient countries affect U.S. food aid allocations in other years or across several years.

## C. DATA

All data were collected at the country level. A random sample of one hundred and fourteen countries was selected from all of the countries recognized by the United States as independent, sovereign nations in 2012. Of these countries, four were excluded due to a lack of data. These exclusions could bias the outcome of the analysis. Not all of the countries included in this study received food aid from the United States in 2012. Descriptive statistics for all variables tested can be found in Table 1:

TABLE 1–Descriptive Statistics

VARIABLE NAME	# OF OBSERVATIONS	MEAN	STANDARD DEVIATION	MIN	MAX	UNITS/SCALE
<i>DEPENDENT VARIABLE</i>						
Foodaidreceived2012	110	17371	49543	0	433159	Tonnes
<i>INDEPENDENT VARIABLES</i>						
<i>Control Variables</i>						
MalnutritionDeathRate2011	110	10.26	9.98	0	53.3	Deaths per 100,000 people
GDPpercapita2012	110	7721	13845	0	67555	Current USD
Population	110	33	123	0.01	1259	Millions of people
<i>Emergency Variable</i>						
InTop10DisasterRelatedDeaths 2012	110	0.036	0.188	0	1	Dummy Variable
<i>Location variables</i>						
Europe & Central Asia	110	0.18	0.39	0	1	Dummy Variable
Middle East & North Africa	110	0.15	0.354	0	1	Dummy Variable
Latin America & Caribbean	110	0.16	0.37	0	1	Dummy Variable
North America	110	0.009	0.095	0	1	Dummy Variable
Sub-Saharan Africa	110	0.309	0.464	0	1	Dummy Variable
East Asia & Pacific	110	0.136	0.345	0	1	Dummy Variable
South Asia	110	0.055	0.228	0	1	Dummy Variable
<i>Political and Economic Variables</i>						
TradeAgreement	110	0.27	0.45	0	1	Dummy Variable
USMilitarybaseendof2011	110	0.16	0.37	0	1	Dummy Variable
DemocracyRating	91	5.17	1.94	1.08	9.73	0 is undemocratic, 10 is very democratic
WarinPast5Years	110	0.08	0.28	0	1	Dummy Variable
AtWarin2012	110	0.13	0.33	0	1	Dummy Variable
CorruptionPerceptionsScore	98	38.5	17.8	8	90	0 is very corrupt, 100 is very clean
TotalOilSupply	110	410	1244	0.54	10396	Thousands of barrels per day



The dependent variable, **L\_Foodaidreceived2012**, is measured in metric tons of food aid donated by the United States in 2012. The logarithm of this variable is used to reduce the effects of outliers. Data on the quantity of food aid donated to recipient countries were collected from the World Food Programme's Food Aid Information System (2013, "Quantity Reporting"). These data include U.S. food donations from January to December of 2012. The year 2012 was selected because 2012 is the most recent year with complete data. Donation totals for 2013 will be released by the World Food Programme in June, 2014 (World Food Programme "The Variables"). All types of food aid are included in the dependent variable. Additionally, all delivery modes—local, triangular, and direct—are included in the dependent variable.

Because the aggregate quantity of food aid donated to each country is used as the dependent variable, the log of population of each country is included as an independent variable to account for differing food aid allocations due to differing population sizes. The population sizes were measured mid 2012 and collected from the Population Reference Bureau (2013). In this study, the population variable is name **L\_Populationinmillions**. This variable is expected to have a positive coefficient. All else equal, a country with a large population should receive a greater quantity of food aid than a country with a small population.

The **MalnutritionDeathRate2011** variable is the number of people (per 100,000) who died in 2011 in each recipient country due to starvation. Data from 2011 were included rather than 2012 data because malnutrition death rates are released the following year. Therefore, policy makers in 2012 would not have been influenced by aggregate data from 2012. Policy makers, however, could have received monthly updates about malnutrition deaths in 2012. Therefore, this variable could create inaccuracies in the final results. Data were collected from a World Health Organization study (World Life Expectancy). The coefficient of this variable is expected to be positive.

**Geographic Location** variables are also included. Countries are divided into the following regions: Europe and Central Asia, Middle East and North Africa, Latin America and the Caribbean, North America, Sub-Saharan Africa, East Asia and Pacific, and South Asia (World Bank). The purpose of these variables is to determine if region affected the quantity of food aid allocated to the recipient. These variables are treated as dummy variables with "1" assigned when the recipient country belonged

to that region and “0” assigned when the recipient country did not belong to that region. The **Europe and Central Asia** variable is excluded from regression models to prevent perfect multicollinearity. With all else held constant, the coefficients of **Middle East and North Africa** and **Latin America** are expected to be positive because the United States government could want to increase its political influence in these regions. All other geographic location coefficients are expected to be negative. Data for this variable were collected from the World Bank.

The **GDPpercapita2012** variable accounts for differences in gross domestic product, or GDP, between countries. GDP was divided by the mid-year population of the respective country and calculated in current U.S. dollars. This variable, collected from the World Bank, measures “the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products” (World Bank). The coefficient of this variable is expected to be negative.

A **TradeAgreement** dummy variable is included to see if the United States disproportionately allocated food aid to its trading partners. A “1” was given to countries that have a trade agreement with the United States and a “0” given to countries that do not have a trade agreement with the United States. Data were collected from the International Trade Administration (2013). The coefficient of this variable is expected to be positive.

Another dummy variable included in this study is **USMilitarybaseendof2011**. For each recipient country, a “1” was assigned if the United States had a military base in that country at the end of 2011 and a “0” if the United States did not have a military base in that country. The Department of Defense, where the data for this variable were collected, defines a foreign military base as anything built and run by the Department of Defense that is “larger than 10 acres...[or has] a Plant Replacement Value (PRV) greater than \$10 million” (2012, 6). It is entirely possible that some military base locations were excluded for security and strategic reasons. The assumption is made that this report from the Department of Defense is accurate. The coefficient of **USMilitarybaseendof2011** is expected to be positive.

The **InTop10DisastRelatedDeaths2012** variable is a dummy variable where “1” is assigned to the ten countries with the highest number of deaths in 2012 due to natural and man-made disasters. A “0” is assigned to all other recipient countries. This information was collected from EM-

DAT which is a worldwide database on disasters (Guha-Sapir, Hoyois & Below 2013). While a variable containing the number of deaths in 2012 from every country would have been more accurate, a complete listing of country death rates is not available. The coefficient of this variable is expected to be positive.

The **CorruptionPerceptionsScore** variable is Transparency International's 2012 Corruption Perceptions Index number. This index is a measure of "the perceived level of public sector corruption on a scale of 0-100" (Transparency 2012). A low score indicates the public sector is perceived to be very corrupt and a high score indicates the public sector is perceived as "clean" (Transparency 2012). The variable is expected to have a negative coefficient. In other words, countries with low levels of corruption are expected to receive lower quantities of food aid relative to other nations, *ceteris paribus*. The reason the United States is expected to give more food aid to countries with more corruption is the United States could be trying to make sure enough food aid reaches the impoverished citizens. It is expected that corrupt governments will siphon food aid away from the intended recipients.

The **TotalOilSupply** variable is the average total number of barrels of oil supplied (in thousands) per day from each country. These data, collected from the U.S. Energy Information Administration, include both positive and negative numbers. A country with a negative number imports more oil than it exports (U.S. Energy Information Administration 2014). The coefficient of this variable is expected to be positive.

The final variable tested is **DemocracyRating**. Data for this variable were gathered from The Economist's Democracy Index (2013). This index ranks countries based on each country's electoral process, government, political participation, political culture, and civil liberties. Countries with high scores have better-functioning democratic systems. The coefficient of this variable is expected to be positive.

Other independent variables considered were a dummy variable for countries that ban genetically modified foods, the Gini coefficient which is a measure of income inequality, and a dummy variable for countries that host terrorist organizations. Due to a lack of reliable and complete data sets, these variables are not tested.

## V. Discussion of Results

The final OLS regression results are shown in the following table:

TABLE 2—Regression Results  
 Final Model: OLS, using observations 1-110 (n=98)  
 Missing or incomplete observations dropped: 12  
 Dependent variable: 1\_Foodaidreceived2012  
 Heteroskedasticity-robust standard errors, variant HC1

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>	
const	1.88495	1.5049	1.2525	0.21385	
MalnutritionDeathRate2011	0.146994	0.0365194	4.0251	0.00012	***
l_Populationinmillions	0.662412	0.294013	2.2530	0.02687	**
InTop10DisasterRelated Deaths201	-0.463209	1.79665	-0.2578	0.79718	
CorruptionPerceptionsScore	-0.0861136	0.0306267	-2.8117	0.00613	***
Trading Agreement	-0.176534	1.02244	-0.1727	0.86333	
USMilitarybaseendof2011	1.51719	1.01272	1.4981	0.13785	
Middle_East_North_Africa	1.97774	1.16074	1.7039	0.09211	*
Latin_America_Caribbean	1.66995	1.35772	1.2300	0.22214	
Sub_Saharan_Africa	4.83829	1.17285	4.1252	0.00009	***
East_Asia_Pacific	-0.898086	0.971404	-0.9245	0.35786	
South_Asia	2.52595	2.06592	1.2227	0.22487	
GDPpercapita2012	4.8428e-05	3.564453-05	1.3586	0.17790	
TotalOilSupply	-1.66604e-05	0.000223957	-0.0744	0.94088	
Mean dependent var	4.444715	S.D. dependent var	4.797376		
Sum squared resid	820.3402	S.E. of regression	3.125053		
R-squared	0.632536	Adjusted R-squared	0.575667		
F (13, 84)	31.79517	P-value (F)	5.96e-27		
Log-likelihood	-243.1688	Akaike criterion	514.3376		
Schwarz criterion	550.5272	Hanan-Quinn	528.9755		

\*\*\*significant at 1%, \*\*significant at 5%, \*significant at 10%

The dependent variable in this model is **l\_Foodaidreceived2012**, or the natural log of food aid donated by the United States to each recipient country in 2012. Twelve observations were dropped from this final model due to incomplete data. When examining the results, readers should note that all forms of food aid were included in the independent variable. As mentioned by Dreher and Fuchs, emergency food aid given after a natural disaster or other shock may be less politically motivated than other types of food aid (7). Therefore, the coefficients in this study represent average changes in food aid given in respect to the appropriate independent variable. The **InTop10DisasterRelatedDeaths2012**, **TradingAgreement**, **USMilitaryBaseendof2011**, **Latin\_America**, **East\_Asia\_Pacific**, **South\_Asia**, **GDPpercapita2012**, and **TotalOilSupply** variables are not significant. The **Middle\_East\_North\_Africa** variable is positively related and significant at the 10% level.

The **MalnutritionDeathRate2011** variable is positive and significant at the 1% level. This means that for every death (per 100,000 people) caused by malnutrition in one country, the United States was likely to allocate .14% more of its total food aid to that country in 2012.

The **L\_Populationinmillions** variable also is positively related to United States food aid allocations. This variable is significant at the 5% level. If the population of the recipient country increases by 1%, then the United States would have increased the amount of food aid allocated to that country by .66%. This means that countries with larger populations are slightly more likely to receive food aid from the United States than countries with smaller countries.

The **CorruptionPerceptionsScore** is negatively related and significant at the 1% level. A higher score on the Corruption Perceptions Index implies less corruption. Therefore, this result shows that for each one point score increase on the Corruption Perceptions Index, a recipient country was likely to receive .08% less food aid from the United States in 2012. In other words, a decrease in corruption in the recipient country is associated with a decrease in the percent of food aid allocated from the United States. This matches the hypothesized correlation.

The **Sub\_Saharan\_Africa** variable is positively related to the United States food aid allocations and significant at the 1% level. This means that, all else held constant in the model, the United States is 4.8% more likely to donate food aid to countries in Sub-Saharan Africa. Some of the countries that could have received a higher percent of food aid from the

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United States are Kenya, Ethiopia, Liberia, Rwanda, and Ghana. The **North\_America** variable was dropped from the regression because no countries in North America were in the sample.

The positive coefficient on **GDPpercapita2012** contradicts the hypothesized correlation of GDP per capita in 2012 and the logarithm of food aid received in 2012. The following auxiliary regression was run to determine if the **GDPpercapita2012** variable is being explained by the other independent variables:

TABLE 3—Auxiliary Regression with GDP per capita 2012 as  
Dependent Variable

Auxiliary Regression: OLS, using observations 1-110(n=98)  
Missing or incomplete observations dropped: 12  
Dependent variable: GDPpercapita2012  
Heteroskedasticity-robust standard errors, variant HC1

	<i>Coefficient</i>	<i>Std. Error</i>	<i>t-ratio</i>	<i>p-value</i>
const	-4926.77	4612.5	-1.0681	0.28845
TradingAgreement	3930.95	2855.17	1.3768	0.17215
Middle_East_North_Africa	-12016.6	3743.29	-3.2102	0.00187 ***
Latin_America_Caribbean	-12604.4	2880.25	-4.3762	0.00003 ***
Sub_Saharan_Africa	-11381.3	2913.27	-3.9067	0.00019 ***
East_Asia_Pacific	-5150.48	4356.13	-1.1824	0.24033
South_Asia	-15745.3	3441.24	-4.5755	0.00002 ***
USMilitarybaseendof2011	3536.18	2968.62	1.1912	0.23686
InTop10DisasterRelated Deaths201	1252.96	2636.87	0.4752	0.63587
CorruptionPerceptionsScore	442.67	86.8265	5.0983	<0.00001 ***
TotalOilSupply	-0.883471	0.631881	-1.3982	0.16566
l_Populationinmillions	1375.86	633.217	2.1728	0.03255 **
Mean dependent var	7811.034	S.D. dependent var	13829.92	
Sum squared resid	567e+09	S.E. of regression	8122.495	
R-squared	0.694180	Adjusted R-squared	0.655063	
F (11, 86)	10.52114	P-value (F)	6.00e-12	
Log-likelihood	-1014.890	Akaike criterion	2053.780	
Schwarz criterion	2084.800	Hanan-Quinn	2066.327	

\*\*\*significant at 1%, \*\*significant at 5%, \*significant at 10%

The relatively high R-squared value indicates multicollinearity between **GDPpercapita2012** and the independent variables. The model shows that these independent variables explained 65.5 percent of the changes in GDP per capita in 2012. The **Middle\_East\_North\_Africa**, **Latin\_America\_Caribbean**, **Sub\_Saharan\_Africa**, **South\_Asia**, and **CorruptionPerceptionsScore** variables are statistically significant at the one percent level. The **L\_Populationinmillions** variable is statistically significant at the five percent level. The variance inflation factor value<sup>1</sup> derived from this auxiliary regression model is equal to 3.27. Typically, an auxiliary regression with a variance inflation factor value above five is considered to have severe multicollinearity. Because the coefficient on **GDPpercapita2012** in the final regression model was not statistically significant and the multicollinearity is not severe, no adjustments were necessary in the final model to account for the unexpected positive relationship between **GDPpercapita** and **L\_Foodaidreceived2012**.

## VI. Conclusion

This study examined the relationship between the United States' food aid allocations in 2012 and the characteristics of the recipient countries. It found a significant and positive relationship between the dependent variable and countries in Sub-Saharan Africa as well as countries with relatively high corruption rates. Additionally, recipient countries with high malnutrition death rates and large populations received a higher percent of the United States' total food aid allocations relative to other recipients in 2012. Therefore, the United States Agency for International Development (USAID) mission "to reduce hunger and malnutrition and assure that people everywhere have enough food at all times for healthy, productive lives" could accurately reflect the United States' food aid policy (2014).

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**30**                    *Major Themes in Economics, Spring 2014*

**Endnotes**

1. Variance Inflation Factor =  $1/(1-R^2)$ . If the VIF is greater than 10, perfect multicollinearity exists in the model.