# Bryant University

## HONORS THESIS

# An Empirical Analysis of the Macroeconomic Determinants of Food Waste in High- and Middle-Income Countries

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## ABSTRACT

Food waste is a complex issue that impacts people all over the world. According to the Food and Agriculture Organization, a specialized agency of the United Nations, approximately 30% of the global food supply is wasted each year. The United States is believed to be the highest waster of food in the world, with 40% of the United States food supply wasted each year (USDA, 2021). There are a multitude of studies on household and consumer food waste, however this is only the final stage in the supply chain. To understand how to mitigate the food waste problem in countries of varying income levels, the entire food supply chain must be examined and analyzed. Waste happens at every stage in the food supply chain, and in this study, I conduct an empirical analysis of the macroeconomic determinants of food waste as defined by the FAO for the year 2013 in middle- and high-income countries as classified by the World Bank. This study contributes to the literature on food waste by providing a more holistic and complete picture of the global food waste problem by examining macroeconomic level data instead of just household data.

## INTRODUCTION

The food industry has widespread and significant impacts on everyone in the world. Unfortunately, the food industry does not function as efficiently as some may believe it does, and not as efficiently as it could. In 2011, the Food and Agriculture Organization (FAO, Food and Agriculture Organizaiton, 2013) estimated that about one third of the world's food is lost or wasted each year, which amounts to 1.3 billion tons of food (FAO, Food and Agriculture Organizaiton, 2013). The United States is one of the worst offenders of food waste, with up to 40% of their food supply being wasted each year (USDA, 2021). Food waste happens at every step of the supply chain for a multitude of reasons.

When up to 40% of food produced never reaches consumers or is thrown out by consumers once they have purchased it, that can be considered a market failure. Especially with food waste at the industry and retail level, this market failure suggests that the food production systems of the United States and other countries around the world are inefficient. It is also important to note that the agriculture industry in the United States, as in most developed countries, is heavily subsidized, and yet the food waste is still incredibly high in these countries. In 2019 the total amount of agricultural subsidies in the United States was $9,184,000,000 (Environmental Working Group, 2020). In the United Kingdom, the government hands out around $4 billion in agricultural subsidies every year (Hirsh, 2020). The agriculture industry is subsidized with the intent to protect the supply and output from unforeseen crises such as natural disasters or major recessions, and agriculture is subsidized so heavily in most developed countries because the price of their products is so low, so farmers need subsidies in order to produce the amount of food demanded, especially in the event of a disaster (Amadeo, 2019). However, knowing that 30% of the global food supply is wasted each year, it is worth considering whether farmers in developed countries need subsidies to produce more. Since a large percentage of the food they produce is thrown away, it does not make sense for governments to continue to provide funding for wasted produce. If the final product is wasted at such a high rate, then the resources that went into producing and transporting these products were wasted as well. The opportunity cost of the millions of

dollars in agricultural subsidies given out each year is high, as that funding could go to other areas in the federal budget, such as education or public health.

In the United States, it is estimated that 18-28% of viable cropland is used for growing wasted food (Quest Resource Management Group, 2021). Globally, about 25% of the produced food supply is lost within the food supply chain (Kummu, 2012). The reasons that a lot of the food is wasted may seem trivial to some: a study in Minnesota found that up to 20% of fruits and vegetables are not considered viable because they do not meet cosmetic standards. Strict cosmetic standards are thought to be one of the most important causes of food waste across multiple supply chain levels (Hooge, 2018). This specific issue in the larger food waste problem seems to have a simple fix: abolish cosmetic standards in food production. However, similar to the food waste issue as a whole, cosmetic standards in food production are very complicated and cannot be erased easily. It is another complex issue inside the already complex issue of food waste.

The effects of extreme food waste can be seen in almost every area of these countries. When such large quantities of food are wasted each year, a lot of the waste ends up in landfills. As the food breaks down in these landfills, it emits large quantities of greenhouse gasses, which are extremely harmful to the environment in both the short and long term. It is also important to note that 12.3% of households reported being food insecure in the United States (LeBlanc, 2019), meaning they do not consistently have the means to feed themselves or their families. Food insecurity has fluctuated around the same levels as the United States in the European Union, with food insecurity in the EU usually falling a couple percentage points lower than the United States (Loopstra, 2016). With such a large percentage of food being wasted each year that could go to feeding those who are food insecure, it is clear that there is a widespread and significant global issue with food waste.

There is a combined effort from the Environmental Protection Agency (EPA) and United States Department of Agriculture (USDA) to reduce food waste by half by 2030, according to the USDA. These goals were introduced in 2015 and show a public effort from the Unites States government to significantly reduce the amount of food the country wastes. The USDA,

EPA, and Food and Drug Administration (FDA) have also all signed a joint agreement, the Winning on Reducing Food Waste Initiative, which aims to coordinate across federal agencies to educate Americans on the importance of reducing food waste. The European Union (EU) has also introduced a number of programs in order to mitigate the food waste issue they face. Similar to the United States, the EU has set a goal of cutting food waste in half by 2030, which shows a multinational coordinated and quantitative effort to reduce food waste in the United States and Europe.

Food waste is a global issue that spans across income levels in countries. This study will analyze food waste data from high income, upper-middle income, and lower-middle income countries. The United Nations Environment Programme's "Food Waste Index Report 2021" found that there were significant amounts of food waste in every country measured in the report, regardless of income levels (Welsh, 2021). These results are different from the previous widespread belief that only wealthy, high income countries have such a problem with food waste. With only household-level waste, lower-middle income countries have the highest levels of food waste in kilograms per capita per year. The next highest was high income countries, and upper-middle income countries had the lowest level of waste in kilograms per capita per year out of the three income levels. The prevailing belief before this report was that household waste was mainly an issue for higher income countries, and that in lower income countries food waste was more of an issue in the production, storage, and transportation losses stages of the supply chain (Welsh, 2021). However, this study shows that different types of waste are common in countries of various income levels, which is why a macroeconomic analysis of food waste data in these countries middle- and high-income countries can give more insight into the issue.

The United Nations Sustainable Development goals include a goal of cutting food waste in half by 2030, and the data collected by the FAO on food waste helps to measure the progress of these goals. The United Nations Environment Programme (UNEP) index shows detailed data and analysis that shows the scope of the problem. The UNEP index also includes the methodology that all the countries can use to measure their food waste in order to help shape

their various national strategies to eliminate it (Welsh, 2021). This index provides clear and measurable goals on a global level to reduce food waste in countries across different income levels.

Given the massive amounts of food waste and global government efforts to reduce waste, with this study I seek to examine the macroeconomic determinants of food waste to assist in those efforts to reduce food waste. Food waste is considered to be a massive, global issue, yet there have been few economic studies to examine the determinants of the issue at a country or global level. Through an empirical analysis of food waste using country level data from the FAO in 2013, and economic indicators in high- and middle-income countries, I aim to provide better understanding on the macroeconomic determinants of food waste.

## LITERATURE REVIEW

Household Waste

A number of studies have examined the determinants of food waste at the consumer and household level, and many of these studies examine consumer behavior and shopping practices in the Unites States. In order to attempt to reduce household food waste, researchers and policymakers must concern themselves not only with policy to encourage consumers to waste less of their food, but also the psychological aspect of food waste. Psychology and sociology are referenced in many of the following papers on household food waste, because consumer behavior is often irrational and cannot be explained by policy or economics alone.

Schanes et al (2018) conducted a systematic review of household food waste practices and their policy implications. This paper acknowledges that food waste can happen at every stage in the supply chain but points out that private households have been identified as key actors in food waste generation (Schanes, 2018). The authors reviewed empirical studies on food waste for this paper as well as the growing literature on food waste. The authors also examined the factors that can foster or impede food waste generation. The literature collected was then sorted into three categories that the authors deemed significant: socio-demographic factors, psycho-social factors, and food-related household behaviors. Since the paper looks at

household food waste, it was important to examine psychology related approaches and social practice theory as they pertain to food waste. The final analysis found that food waste is indeed a complicated and multifaceted issue that cannot be explained or attributed to any single variables. It was found in this study that mapping the determinants of food waste was key in developing prevention strategies, and ultimately suggested a variety of business, policy, and retailer options to limit household food waste. The authors conclude that socio-demographic factors play less of a predictive role, but several studies have shown that guidelines, negative attitudes towards food waste, and perceived behavioral control "may predict the intention to reduce food waste and/or reported food waste" (Schanes, 2018). The importance of acknowledging that individuals are part of wider social, economic, and cultural structures is stressed, and it is recommended that in determining a strategy for reducing food waste that policymakers consider these wider ties that may prevent individuals from adopting preventative strategies in their households. The main recommendation is that although a large portion of food waste is generated by individuals, it is important to devise a "holistic food waste prevention approach that goes beyond putting the responsibility solely on individuals" (Schanes, 2018) For future research, the authors recommend that studies employ more objective techniques for data collection, as self-reporting of food waste has a lot of potential biases. Another recommendation is to research emerging technologies such as smart fridges to see if there is potential there to reduce food waste in households.

Chalak et al (2015) conducted a cross-country analysis on the global economic and regulatory determinants of household food waste generation. Part of the reason household waste was chosen for the focus of this study was that it is estimated that about 35% of food waste comes from the household level (Chalak, 2015). The goal of this paper is to investigate the impact of legislation and economic incentives on household food waste generation. The authors examined data from 44 countries of varying income levels from eight different regions around the world. The data were analyzed using an ordinary least squares regression in STATA. The results of their analysis determined that clear, well-defined regulations, policies, and strategies are more effective in limiting household food waste generation than fiscal measures. In investigating awareness campaigns based on the economic model from this study, the authors

found that awareness campaigns have a positive impact on household food waste generation; food waste generation decreases when food waste awareness campaigns are run. For future research, the authors note that since theirs was a macroeconomic study, they may have overlooked many microeconomic concerns, and therefore recommend that future studies complement global data with country or region-based data that are sourced from household surveys in order to evaluate all the factors associated with food waste.

<u>Global Waste</u>

Cosmin and Mihaela (2018) study food waste across Romania, and they are concerned with two components of food waste: food policy and nutrition policy. The authors identify these two components as having the most impact on food waste in Romania. Within food policy, there are two dimensions identified by the authors: one that relates to the quality and supply of products, and one related directly to the consumer and consumption capacity of consumers. The Romanian government has, like many other countries and organizations, set up a plan for food waste reduction through the Ministry of Agriculture and Rural Development and the Ministry of Environment and Climate Change. Romania is unique in their food waste since they have a lot of agricultural potential from their natural resources, but they are ranked fairly low for food security. The authors conclude that Romania's food security should be a component of national security, that Romania does not have an adequate strategy for food security, and therefore recommend that the maximization of the supply-flow stability of agricultural products is of the upmost importance.

Hanne et al (2016) examine some of the microeconomic determinants of food waste, with particular focus on date labeling. The study examined food waste across all the countries in the Nordic Council of Ministers, which include Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, and Greenland. The stated purpose of this study is to identify how date labeling legislation practiced in Denmark, Finland, Norway, and Sweden has impacted the food supply chain. The researchers used several different methods of data collection for this study, and the methods varied based on different perspectives and on which part of the value chain was in focus. Interviews were conducted with food manufacturers and store managers,

legal requirements for temperature in wholesale and retail were compiled, food waste mapping and a waste composition analysis in retail were conducted, two case studies were conducted on durability and extended durability, and a literature review was conducted. One of the most important findings of this study is that the durability of food products can be extended by changing the manufacturing process, the packaging solution, or by increasing the amount of time a product is available in stores. The general recommendation of this study is to create enhanced guidelines for manufacturers, retailers, and consumers regarding date labeling. The authors also recommend that date labeling be chosen with care, and many of the date labels should only be used on highly perishable food products, otherwise there is a significant risk that edible foods are wasted as a result of date labeling.

Sheahan and Barrett (2017) examine food waste and food loss in Sub-Saharan Africa. Due to the nature of the agriculture industry in Sub-Saharan Africa as being mostly subsistence farmers, food loss in this region is referred to as post-harvest losses (PHL). This study examines the existing measures to limit PHL, summarizes the estimated magnitude of losses, and evaluate and critique the impact evaluation literature regarding both on and off farm interventions that are expected to deliver PHL reductions. After an examination on the current strategies to mitigate PHL, the authors offer several alternate approaches. One argument made is that poverty, not PHL levels, is the main driver of food insecurity, so measures to reduce poverty would have a marked impact on PHL levels. Another suggestion by the authors is to invest in greater food safety surveillance instead of only on PHL reduction, since this would reduce the amount of food necessitated to be throw away for lack of safety. The authors conclude that there are four underlying objectives of PHL reduction: improve food security, improve food safety, reduce wasted resources, and increase profits along the food supply chain. For future research, the authors recommend that researchers attempt to fill the gap in current knowledge on PHL in Sub-Saharan Africa, and that more emphasis should be placed on an analysis of the cost-effectiveness of current PHL reduction strategies.

Vaqué (2015) published a study on former, current, and potential European Union (EU) initiatives to mitigate food waste. The author acknowledges that food waste as whole is too

complex to address completely in one paper, so he instead chose to focus on former, current, and potential European Union (EU) initiatives to mitigate food waste (Vaque, 2015). One of the initiatives mentioned that has been enacted by the EU is to promote direct relations between producers and consumers, as well as shortening the food supply chain. The author notes that in 2013, the European Commission (EC) published a retail action plan aimed at reducing food waste in retail without affecting food safety. The EC also agreed to develop a long-term policy on food waste, showing that the issue is being taken seriously in the European Union. The author concludes that defining the meaning of food waste as an urgent matter is extremely important, as it can then be applied to all relevant legislation and statistics. The author also recommends adopting regulations that focus on the treatment of waste at all stages of the food supply chain and setting compulsory food waste prevention goals.

Other Waste

Lipinski and Robertson (2017) provide a report with an overview of food waste and outline a series of policy improvements for developed countries. One of the most important developments identified by the authors in quantifying food waste is the Food Loss and Waste Accounting and Reporting Standard (FLW Standard). Published in 2016 by the World Resources Institute, this is a voluntary standard designed for widespread, global usage. The FLW Standard includes guidance, resources, and examples to assist in using the standard. The four primary components of the FLW Standard are timeframe, material type, destination, and boundary, all with regard to food products and food waste. The authors present reasoning on the importance of quantifying food waste and food loss. The most important reason to focus on quantifying food waste and food loss is that it provides a foundation for waste reduction initiatives that can deliver a wide variety of benefits.

Neff (2015) studies the importance of reducing food loss and food waste while taking into account public health considerations. One of the main goals in this study is to show the relationship between mitigating food loss and increasing public health. The author examines how some policies may benefit public health while increasing food waste and vice versa. Their ultimate aim is to highlight and recommend policies that benefit both public health and

the reduction of food waste. The primary areas where food waste and public health intersect are food security, food safety, and nutrition. The author concludes that while efforts are increasing to prevent and reduce food waste and food loss, it is essential to include public health in the policy decisions on food waste.

The United States Government Accountability Office (GAO) released a report detailing how building on existing federal efforts could help the nation achieve its food waste reduction goal. This report found three major areas where challenges exist in reducing food waste and loss: limited data and information about food waste, lack of access and education, and limited infrastructure and capacity (Office, U.S. Government Accountability, 2019). The report cites a United States Department of Agriculture (USDA) report that states that the causes of food waste across the supply chain, but the total food waste occurring from each of these causes is unknown. The GAO concludes the report with the general recommendation that the USDA, EPA, and FDA "incorporate leading collaboration practices as they implement their interagency strategic plan to reduce [food waste]" (Office, U.S. Government Accountability, 2019).

A 2014 paper published by the FAO details the economics of food loss and waste. In the report, it detailed both macroeconomic and microeconomic policy on food waste. This report cites that food loss is greater where links between producers and consumers are weak. This is supported by other resources and seems especially relevant to developed countries with large food supply chains. In the report, there is data from 2011 detailing food waste in kilograms per year at pre-consumption and consumption levels in different regions around the world. The highest wasters in the production to retailing stage (pre-consumption) are Latin America, Europe, and North America and Oceania. In terms of globalization, due to the reduction of protectionist policies such as high tariffs and export subsidies, and the improvement of global transport systems, world food trade has increased by more than four times between 1961 and 2003. Increased levels of globalization mean that many food supply chains are now global, and the report states that while "the relationship between global supply chains and food losses and waste is not well understood," initial findings indicate that improved connectivity and

better integration among segments of the supply chain can reduce food losses. Another macroeconomic determinant mentioned in this report is unemployment. The impacts of unemployment on food waste are similar to inflation, and the long-term impacts are still relatively unknown. The report identifies three possibilities from increased unemployment in relation to food waste: more losses due to a less efficient organization of the work and of the entire food chain, more waste due to the imbalance between supply and demand, or less waste due to the need to improve food management at the household level.

The majority of studies on food waste in the United States and other developed countries focus on waste at the household and consumer level. This research is important and shows a large amount of waste at the household level, but food is wasted all across the supply chain. I have chosen to research food waste at the macroeconomic level by analyzing total food waste in 53 countries, which includes every country for which data is available, and I have found a lack of similar studies in this area. This presents a clear gap in research on food waste, which I intend to fill with my thesis. I conduct an empirical analysis of food waste data from high- and middle-income countries and various economic indicators in order to fill the gap in the research on food waste. If the problem of food waste is to be addressed there needs to be a holistic review of total waste in these countries, and my study adds to the bigger picture review of food waste in these 53 countries that have data available in the year 2013.

## DATA AND ECONOMETRIC METHODS

Data Collection

For the empirical research and analysis, I gather food waste data from the FAO and from the United Nations to run multiple regressions and get a better understanding of the results. These data from the FAO are collected from hundreds of publications and reports from around the world and are compiled into a database. These data are also collected against the definition of food waste by the FAO: "the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers" (FAO, Food and Agriculture Organizaiton, 2013). Food waste is defined differently from food loss by the

FAO, and the organization defines food loss as "the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers" (FAO, Food and Agriculture Organizaiton, 2013).

The countries I analyze in this study will be the 53 countries for which food waste data is available that are classified as high income, upper-middle income, and lower-middle income. The sample includes every high- and middle-income country for which the data was available in the year 2013. The year 2013 was the most recent year that had an appropriate number of countries with available data to analyze.

The table below shows a complete list of the 53 countries included in this analysis, broken down by income classification.

| High Income Countries | Upper Middle-Income Countries | Lower Middle-Income Countries |
|---|---|---|
| Austria | Argentina | Benin |
| Chile | Armenia | Cambodia |
| Czech Republic | Azerbaijan | Cameroon |
| Estonia | Guinea | Cote d'Ivoire |
| France | Ecuador | Egypt |
| Germany | Gabon | El Salvador |
| Hungary | Georgia | Ghana |
| Israel | Guatemala | Kenya |
| Italy | Indonesia | Lesotho |
| Japan | Iran | Mauritania |
| Luxembourg | Kazakhstan | Nepal |
| Norway | Mexico | Nicaragua |
| Panama | Peru | Nigeria |
| Romania | Russian Federation | Pakistan |
| Trinidad and Tobago | Serbia | Philippines |
| United Kingdom | South Africa | Senegal |
| | Saint Lucia | Tanzania |
| | Turkey | Ukraine |
| | | Zimbabwe |

I analyze these data with STATA and run multiple regressions with various independent variables. Food waste is the dependent variable, and the independent variables that will be tested are government policies, education, employment in agriculture, population, population growth, gross domestic product per capita, inflation, unemployment, public sector corruption to determine their impact on food waste. The data for these economic indicators is obtained from the World Development Indicators DataBank (WDI). This database provides the majority of the data I need for analysis, however there were several missing data points that needed to be filled in with information from secondary sources. There are two different measures of food waste used as separate dependent variables, one is sourced from the FAO and the other is sourced from the United Nations. The data from the FAO is measured in percentages, and the data from the United Nations is measured in kilograms per capita per year.

Variable Explanations

There are 13 variables that were collected to be used in the regression analysis in this study. They are analyzed in four separate regressions, and descriptions of the variables can be found below.

The government policy dummy variable has the variable name GovPolicy. Countries with a government policy by 2013 have a value of 1 in this variable, and countries without a policy in place by 2013 have a value of 0. The criteria I use to determine whether a government policy is in place is if food waste is specifically mentioned as a policy by a governing body or government agency, and if there are tangible goals in this policy. There were several countries that had significant activity by private organizations that make food waste reduction a priority, but these were not counted as having a food waste policy since it was not implemented by any government or government agency in the given country. I collected data for this variable by researching all of the countries individually and finding a policy in either a news release or on the government websites. I only counted a country as having a government policy in place if there were multiple sources confirming the policy. A large effort on the part of a charitable organization in a country was not counted as a government policy, even if the

organization's work has an impact on food waste. For example, Nepal has the Food Act of 1966, which is the primary basis for food safety regulations in the country and many advocates in the country are pushing to include a food waste policy in this legislation, but there is no formal food waste policy in place, so Nepal is marked as not having a food waste policy.

The time since a government policy for food waste was implemented has the variable name GovPolicyT. This variable is based on the dummy variable for government policy as described above to determine if a policy is in place by 2013. This variable is measured by the number of years that have passed since a government policy was implemented. For example, if a country implemented their food waste policy in 2013 then they will have a value of 1 for this variable, since 0 is being used as a value for countries with no food wase policy.

The total food waste data for the 53 countries included in this study sourced from the FAO is represented by the variable FWall. This data is in the year 2013. This data is the dependent variable for the main model used in the empirical analysis. The values in this variable are measured in percentages. Food waste is defined by the FAO as "the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers" (FAO, Food and Agriculture Organizaiton, 2013).

The total food waste data for the 53 countries included in this study sourced from the United Nations is represented by the variable FWUN. The values are measured in kilograms per capita per year, as opposed to the FAO food waste variable that is measured in percentages. This variable is a second, alternative measure of food waste. Food waste is defined by the United Nations as "food and the associated inedible parts removed from the human supply chain in retail, food service, and household sectors" (United Nations Environment Programme, n.d.).

The variable that measures the educational attainment of the countries being examined is the edu variable. This variable measures the completion rate of at least primary education. This variable is included in the model to determine whether education levels in a country can have

an impact on the level of food waste. This data is sourced mainly from the WDI DataBank, with missing data points being filled in by other secondary sources.

The employment in agriculture in a country as a percentage of total employment is represented by the variable agemp. This variable is included to see whether the size of the agriculture industry in a given country has an impact on the level of food waste in these countries. This variable is especially relevant because there is a variety of income levels in the countries that I am analyzing in this study and many of the upper-middle and lower-middle income countries have more agrarian based economies.

The gross domestic product per capita, variable is measured in constant 2010 United States dollars, with the variable code as gdppc. This variable is included as an economic variable in the analysis to get a general measure of the economic conditions in each of the countries in the study. I chose GDP per capita instead of GDP because of the varying income levels of the countries in the study, the countries that are classified as high income would have a much higher GDP than the rest of the countries, so using GDP per capita standardizes the variable. This data is sourced from the WDI DataBank.

Inflation measured in consumer prices as an annual percentage is included as an economic variable since it is a basic economic indicator. The variable code in this analysis is inf. This variable is included in the analysis because inflation rates can impact food prices, which may impact food waste. This data is sourced from the WDI DataBank.

Total population (pop) is included as another general economic indicator to see how total population can impact food waste levels in a country. The variable code in this analysis is pop. Population growth as an annual percentage (popgr) is included to supplement the total population variable and as another general economic indicator. The variable code in this analysis is popgr. This data is sourced from the WDI DataBank.

The total unemployment rate as a percentage of the total labor force is included as one of the economic indicators following previous literature. It is included in this analysis based on

previous literature, and the variable code is unemp. This data is sourced from the WDI DataBank.

The domestic food price volatility index variable is included to show the specific effect of food price volatility on food waste. The variable code being used is dfpvi. This statistic shows the variation in domestic food prices over time and is measured as the weighted average of a basket of commodities based on consumer market prices. High values in this variable indicate a higher volatility and more variation in food prices. The index is sourced from Our World in Data.

Corruption in the public sector is measured by the corruption perceptions index, which gives all countries a score out of 100, and a higher score is equated with less corruption. The variable code used is corrupt. This variable is included because corruption in the public sector is often correlated with more waste overall, so it is conceivable that food waste could be higher in countries with higher levels of corruption. This data is sourced from the Transparency International Corruption Perception Index.

Econometric Model

$FWall = \beta_0 + \beta_1 GovPolicy + \beta_2 edu + \beta_3 agemp + \beta_4 gdppc + \beta_5 inf + \beta_6 pop + \beta_7 popgr + \beta_8 unemp + \beta_9 corrupt + \varepsilon$

The equation above is the main econometric model being used for the empirical analysis of this study. The variables are all described above, and Appendix II is a reference table with all the variable codes. I am using the FAO data as the dependent variable for food waste in the main model. There are three other models that will be used in the empirical analysis, shown below. The first analyzes the food waste data from the United Nations as the dependent variable, the second includes a variable for food price volatility, and the third replaces the government policy dummy variable with a variable that measures time since the government policy was implemented.

$$FWUN = \beta_0 + \beta_1 GovPolicy + \beta_2 edu + \beta_3 agemp + \beta_4 gdppc + \beta_5 inf + \beta_6 pop + \beta_7 popgr + \beta_8 unemp + \beta_9 corrupt + \varepsilon$$

$$FWall = \beta_0 + \beta_1 GovPolicy + \beta_2 edu + \beta_3 agemp + \beta_4 gdppc + \beta_5 inf + \beta_6 pop + \beta_7 popgr + \beta_8 unemp + \beta_9 corrupt + \beta_{10} dfpvi + \varepsilon$$

$$FWall = \beta_0 + \beta_1 GovPolicyT + \beta_2 edu + \beta_3 agemp + \beta_4 gdppc + \beta_5 inf + \beta_6 pop + \beta_7 popgr + \beta_8 unemp + \beta_9 corrupt + \varepsilon$$

Summary Statistics

The summary statistics for all the variables used in the analysis can be found below.

| Variable | Mean | Minimum | Maximum | Standard Deviation |
|---|---|---|---|---|
| **GovPolicy** | 0.17 | 0 | 1 | .38 |
| **GovPolicyT** | 0.40 | 0 | 5 | 1.12 |
| **FWall** | 10.68 | .12 | 46.11 | 11.23 |
| **FWUN** | 87.26 | 33 | 189 | 23.63 |
| **Ag** | 9.59 | 0.28 | 31.60 | 8.73 |
| **Edu** | 89.11 | 27.35 | 109.32 | 16.81 |
| **Agemp** | 26.04 | 0.62 | 68.69 | 20.19 |
| **Gdppc** | 13,885.88 | 670.84 | 103,721.7 | 21,020.03 |
| **Inf** | 4.65 | -0.51 | 36.60 | 5.48 |
| **Pop** | 41,900,000 | 177,513 | 252,000,000 | 54,200,000 |
| **Popgr** | 1.29 | -0.49 | 3.78 | 1.06 |
| **Unemp** | 7.59 | 0.44 | 24.58 | 6.13 |
| **Dfpvi** | 8.17 | 3.21 | 22.30 | 4.09 |
| **Corrupt** | 42.45 | 20 | 86 | 17.84 |

The total food waste variable from the FAO, FWall, is shown in the table above to have a minimum value of about 0.122%, and the country that this value represents is Italy, which is classified as a high-income country. With this measurement, Italy wastes the lowest total percentage of food. The maximum for this variable is 46.1%, which represents Trinidad and

Tobago, which is also classified as a high-income country. This variation in the high-income countries supports the recent findings in the UNEP report that show that food waste occurs in countries of all income levels. The mean for this variable is about 10.7%, which is a significant amount of food waste. The standard deviation for this variable is about 11.2, which is a high amount of variation, and that supports the belief that food waste has variation across the three income levels of the countries being analyzed in this study.

The total food waste variable from the United Nations, FWUN, is shown in the table above to have a minimum value of 33 kilograms per capita per year, and this value represents Nigeria, which is classified as a lower-middle income country. The maximum value for this variable is 189 kilograms per capita per year, and this value represents the Russian Federation, which is classified as an upper-middle income country. This shows a very large spread in this variable. The mean for this variable is about 87.3, and the standard deviation is about 26.3, which seems like a high level of variation. This fits with the high variation of the other food waste variable.

The domestic food price volatility index variable, dfpvi, has a minimum value of 3.2, and this value represents Panama, which is classified as a high-income country. The maximum value for this variable is 22.3, and it represents the country Gabon, which is classified as an upper-middle income country. The mean for this variable is 8.17, and the standard deviation is 4.09. For this variable, a higher value indicates more volatility in food prices in a given country, so Gabon has the highest volatility, and Panama has the lowest volatility. The distribution and standard deviation of this variable seems to be normal, which suggests that the income level of a country does not have a major impact on food price volatility.


**RESULTS**

FWall = $\beta 0 + \beta 1 GovPolicy + \beta 2 edu + \beta 3 agemp + \beta 4 gdppc + \beta \neg 5 inf + \beta 6 pop + \beta 7 popgr + \beta 8 unemp + \beta 9 corrupt + \varepsilon$

This is the main regression with the major independent variables being analyzed: government policy dummy variable, educational attainment, employment in agriculture, GDP per capita,

inflation, total population, population growth, unemployment rate, and corruption rate. Many of the variables in this regression have negative coefficients: employment in agriculture, GDP per capita, total population, unemployment, and corruption. Government policy, educational attainment, inflation, and population growth all have positive coefficients. The $R^2$ value for this regression is .1576, which suggests that 15.76% of the variance in total food waste can be predicted from the independent variables in the regression. The results can be found in Table III in Column 1.

GDP per capita has a negative coefficient, which shows that an increase in GDP per capita is correlated with a decrease in food waste. This could be why lower-middle income countries waste the most on average according to the UNEP report. However, the variable is not significant in this regression, which suggests that there is no relationship between GDP per capita and food waste.

The positive coefficient in the government policy dummy variable is interesting, since it suggests that there is a higher level of food waste when a country has a government policy for food waste in place. However, the result is not statistically significant, suggesting that there is no relationship between a government policy and food waste in this regression.

The result of the employment in agriculture variable in relation to food waste is negative and significant in this regression at the 10% level. This suggests that a higher level of employment in agriculture is correlated with a lower level of food waste.

These results also show that higher inflation levels are correlated with higher levels of food waste, which I expected prior to doing this analysis. Higher levels of inflation can mean that food prices increase more quickly, which can contribute to more food waste if consumers buy slightly less food as a result and therefore grocery stores and other food retailers throw away more perishable products that do not sell before they expire.

Corruption was not originally going to be included in the main analysis, but it was not statistically significant on its own, so it was included as one of the normal independent variables. The coefficient for corruption is negative in this regression, meaning that an

increase in corruption in the public sector is correlated with a decrease in food waste. This is the opposite result of what I expected for this variable, since government corruption generally increases waste across most areas of a country. One potential reason for the negative coefficient could be if household waste is a major aspect of a country's food waste, this would likely not be as responsive to government corruption. However, given the results shown in Column 1, the relationship between corruption and food waste is not statistically significant, which suggests there is no relationship between the two variables.

$$FWUN = \beta 0 + \beta 1 GovPolicy + \beta 2 edu + \beta 3 agemp + \beta 4 gdppc + \beta \neg 5 inf + \beta 6 pop + \beta 7 popgr + \beta 8 unemp + \beta 9 corrupt + \varepsilon$$

This is the regression with the food waste data from the United Nations as the dependent variable, instead of the main food waste data from the FAO. The government policy dummy variable, educational attainment, GDP per capita, inflation, and total population all have negative coefficients in this regression. Employment in agriculture, population growth, unemployment, and corruption all have positive correlations. Compared with the previous regression with FAO data, this regression has the same sign for the coefficients of population growth, GDP per capita, and total population. The rest of the variables have different signs. Some of this change is likely because the FAO data is measured in percentages, while the data from the UN in this regression is measured in kilograms per capita per year. The $R^2$ value for this regression is much higher than in the previous regression, which suggests that the data from the UN might be more accurately correlated with the economic variables than the data from the FAO is.

The government policy dummy variable has a negative coefficient in this regression, which is the opposite of the regression with food waste data from the FAO. This suggests that a country having a government policy in place is correlated with a lower quantity of food waste in that country. This is the expected result that I hypothesized before I ran these regressions, since the existence of a government policy in a country indicates that the country is taking the issue of food waste seriously and is taking steps to limit the severity of the issue. However, as with the FAO food waste dependent variable, the government policy variable is not

statistically significant, suggesting there is no relationship between a government policy and food waste.

Employment in agriculture has a positive coefficient and is statistically significant at the 10% level, as seen in Table III. This suggests a positive relationship between employment in agriculture and food waste, showing that a higher level of employment in agriculture is correlated with a higher level of food waste.

Population growth has a positive coefficient and is statistically significant at the 1% level, as seen in Table III. This suggests a positive relationship between population growth and food waste, and that a higher rate of population growth is correlated with a higher level of food waste.

Unemployment has a positive coefficient and is statistically significant at the 5% level as seen in Table III. This suggests a positive relationship between unemployment and food waste, and that a higher unemployment rate is correlated with a higher level of food waste.

$$FWall = \beta 0 + \beta 1 GovPolicy + \beta 2 edu + \beta 3 agemp + \beta 4 gdppc + \beta \neg 5 inf + \beta 6 pop + \beta 7 popgr + \beta 8 unemp + \beta 9 corrupt + \beta 10 dfpvi + \varepsilon$$

The regression above includes the variable for the domestic food price volatility index (variable code: dfpvi). The $R^2$ value for this regression is slightly higher than the regression with the UN data, and it is much higher than the original regression with the FAO data. Since this regression is run with the FAO data, it suggests that the inclusion of the food price volatility index makes this model more accurate. There are also fewer observations for this regression, since the food price volatility index did not have any values for seven of the 53 countries, so this could also explain the increased R2 value if some of the outlying observations were the ones that were eliminated here for lack of data available.

The food price volatility index variable has a positive coefficient and is statistically significant at the 1% level, as seen in Column 2. This suggests that a higher level of volatility is correlated with a higher level of food waste. This result makes sense in the context of

household food waste especially, since more changes in food prices can cause consumers to buy more than they need when prices are low, and this can cause them to waste some of this food.

The coefficient of the government policy variable is positive here, as with the original regression with the FAO data. This variable is significant in this regression with the addition of the food price volatility index. The government policy variable has a negative coefficient and is statistically significant at the 5% level. This suggests a negative relationship between government policy and food waste, and that a government policy in place is correlated with a higher level of food waste. This is opposite of the result I expected; if a country has a food waste policy in place, it signifies that they are addressing the issue and taking steps to mitigate it, however that is not what is suggested by these results. The result of the government policy variable suggests reverse causality and could mean that food waste may already be very high in countries with a government policy, and this high food waste may have prompted the implementation of the policy.

Employment in agriculture has a positive coefficient and is statistically significant at the 10% level, as seen in Column 2. This suggests a positive relationship between employment in agriculture and food waste, showing that a higher level of employment in agriculture is correlated with a higher level of food waste.

$$FWall = \beta 0 + \beta 1 GovPolicyT + \beta 2 edu + \beta 3 agemp + \beta 4 gdppc + \beta\neg 5 inf + \beta 6 pop + \beta 7 popgr + \beta 8 unemp + \beta 9 corrupt + \varepsilon$$

This regression is identical to the main regression, but with the government policy (GovPolicy) dummy variable replaced with a variable that measures the time that has passed since the implementation of the government policy (GovPolicyT). The $R^2$ value for this regression is the lowest of the four regressions shown here at 15.25%. The coefficient for the time since the government policy variable is positive, but it lower than any of the positive coefficients for the government policy dummy variable. It shows that the length of time since a government policy was implemented does not have as much of an impact on food waste as

whether a government policy is implemented at all, since the coefficient for this variable is not statistically significant, as seen in Column 3.

Employment in agriculture has a positive coefficient and is statistically significant at the 10% level, as seen in Column 3. This suggests a positive relationship between employment in agriculture and food waste, showing that a higher level of employment in agriculture is correlated with a higher level of food waste.

Population growth has a positive coefficient and is statistically significant at the 10% level, as seen in Column 3. This suggests a positive relationship between population growth and food waste, and that a higher rate of population growth is correlated with a higher level of food waste.

## CONCLUSION

The issue of global food waste is extremely important, and it has impacts in a multitude of areas, including climate change and economic losses. It is estimated that one third of the food produced each year around the world is wasted in all areas of the supply chain (FAO). It was believed for many years that high income countries have higher levels of household waste than lower-income countries, but the 2021 United Nations Environmental Programme report showed that household food waste is evenly distributed among high- and middle-income countries, with lower-middle income countries seeing the highest levels of household waste. Many previous studies on this topic have focused solely on household waste since household waste is generally a large portion of total waste in a country, but my analysis focuses on total food waste in 53 countries from high income, upper-middle income, and lower-middle income classifications to be able to analyze food waste at the macroeconomic level.

My empirical analysis included four different regressions. The main regression includes 9 independent economic variables to analyze with the dependent food waste variable. The food waste variable in the main model is with the data from the FAO, which is measured in percentages. The results of this regression include that the employment in agriculture variable was significant at the 10% level, and the population growth rate variable is significant at the

10% level. In the second regression food waste data from the UN is used as a dependent variable instead of the food waste data from the FAO. The results of this regression show that the employment in agriculture variable is significant at the 10% level, the population growth rate variable is significant at the 1% level, and the unemployment rate variable was significant at the 5% level. In the third regression, the food waste data from the FAO is used as the dependent variable, and another independent variable is added that measures the food price volatility in each of the included countries. The results from this regression show that the government policy dummy variable is significant at the 5% level, the employment in agriculture variable is significant at the 10% level, and the domestic food price volatility index variable is significant at the 1% level. The fourth regression removes the government policy dummy variable and instead includes a variable that measures the amount of time that has passed since the implementation of a government policy on food waste. The results of this regression show that the employment in agriculture variable is significant at the 10% level, and the population growth rate variable is significant at the 10% level.

There are several limitations to this study, one of the major limitations being that the data is only available for the year 2013 for the countries included. There is a very limited amount of food waste data available, so in order to gather a large enough sample size I had to expand the list of countries from only high income to include middle income countries as well. This gave a sufficient sample size of 53 countries, but it took away from the original purpose of the study. Once I expanded the income classifications of the countries, I also had to narrow the years being focused on to just 2013, when I had originally planned to do a panel analysis of the years 2010-2015. Only analyzing data from one year limits the impacts of this study, and the most widely available data is from 8 years ago which is not necessarily current, and the food waste issue has developed greatly in the past several years.

The results of this study give way to several policy implications. Employment in agriculture and population growth are significant in most of the models here. This suggests that if governments can target their policy to focus on the determinants of food waste, specifically employment in agriculture then it could have a significant impact on food waste. Efforts to

decrease food price volatility could also lead to a decrease in food waste based on the results of that analysis. This is consistent with previous literature suggesting that focusing on the determinants of food waste is more important than focusing on the effects of food waste. Population growth is difficult to control, so focusing on maintaining or decreasing the rate of employment in agriculture and reducing food price volatility can be ideal strategies for countries of varying income levels to reduce their food waste.

This study is different from others in the same area since previous studies focused solely on household food waste, while this study analyzes total waste in countries of various income levels. Originally, I planned on doing an analysis of OECD countries over a period of 5 years, but the data was simply not available. My goal with this study is to provide a basis for future research in analyzing total food waste with macroeconomic variables. I would hope that in the future, when more data becomes available in more years that it would be possible to do the analysis I originally planned to do here. Food waste is becoming more of an important issue worldwide, and is gaining more recognition, so there is a good possibility that there will be more data in the next 5-10 years that will make a study like that possible. The results of this study are significant for global food waste, and can inform future research in a multitude of areas.

APPENDICES

Table 1: Variable Codes and Descriptions

| Variable Name | Variable Description |
|---|---|
| GovPolicy | Dummy variable, if the country has a government policy in place |
| GovPolicyT | Time since government policy was implemented |
| FWall | Total food waste in a country, percentage. Source: FAO |
| FWUN | Total food waste in a country, kilograms/capita. Source: UN |
| Edu | Educational attainment, at least completed primary |
| Agemp | Employment in agriculture as a percent of total employment |
| gdppc | Gross domestic product per capita in constant 2010 US dollars |
| inf | Inflation, consumer prices, annual percentage |
| pop | Population, total |
| Popgr | Population growth, annual percentage |
| unemp | Total unemployment as a percentage of total labor force |
| dfpvi | Domestic food price volatility index |
| corrupt | Corruption perceptions index, score out of 100 |

Table II: Model Results, FAO

| Variable | Fixed | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Dependent variable: total food waste (percentage, source: FAO) | | | |
| Government Policy | 2.67 | 8.601** | |
| | (-4.542) | (4.374) | |
| Education | 0.027 | -0.029 | 0.026 |
| | (-0.115) | (0.109) | (0.117) |
| Employment in agriculture | -0.207* | -0.219* | -0.197* |
| | (-0.117) | (0.123) | (0.116) |
| GDP per capita | -0.0002 | -0.0001 | -0.0002 |
| | (-0.0001) | (0.0001) | (0.0001) |
| Inflation | 0.225 | -0.335 | 0.23 |
| | (0.316) | (0.337) | (0.317) |
| Total Population | -4.04E-08 | -1.54E-08 | -4.20E-08 |
| | (3.10E-08) | (3.54E-08) | (3.10E-08) |
| Population growth | 3.4* | 0.656 | 3.554* |
| | (1.99) | (1.996) | (1.997) |
| Unemployment | -0.173 | -0.429 | -0.168 |
| | (0.289) | (0.293) | (0.293) |
| Public Sector Corruption | 0.014 | -0.171 | -0.007 |
| | (0.174) | (0.161) | (0.174) |
| Domestic Food Price Volatility Index | | 1.906*** | |
| | | (0.481) | |
| Time since Government Policy | | | 0.448 |
| | | | (1.518) |
| Constant | 13.702 | 16.091 | 13.145 |
| | (14.181) | (13.106) | (14.225) |
| # of Observations | 53 | 46 | 53 |
| F-Statistic | 0.89 | 2.77 | 0.86 |
| Prob>F | 0.5388 | 0.0126 | 0.567 |
| R2 | 0.1576 | 0.4414 | 0.1525 |
| Adjusted R2 | -0.0187 | 0.2818 | -0.0248 |
| Root MSE | 11.336 | 9.9411 | 11.37 |

*** = 1%, ** = 5%, * = 10%, () = Standard Error

Table III: Model Results, UN

| | Fixed |
|---|---|
| **Variable** | 1 |
| Dependent variable: total food waste (kg/capita, source: UN) | |
| Government Policy | -4.877 |
| | (7.969) |
| Education | -0.049 |
| | (0.202) |
| Employment in agriculture | 0.392* |
| | (0.205) |
| GDP per capita | -0.00005 |
| | (0.0003) |
| Inflation | -0.368 |
| | (0.554) |
| Total Population | 1.26E-07 |
| | (5.45E-08) |
| Population growth | 9.566*** |
| | (3.502) |
| Unemployment | 1.018** |
| | (0.506) |
| Public Sector Corruption | 0.177 |
| | (0.305) |
| Constant | 51.916** |
| | (24.884) |
| # of Observations | 53 |
| F-Statistic | 3.38 |
| Prob>F | 0.0033 |
| R2 | 0.4143 |
| Adjusted R2 | 0.2917 |
| Root MSE | 19.891 |

*** = 1%, ** = 5%, * = 10%, () = Standard Error

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