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The Effects of GMO deregulation on Global Food Security and Biotechnological Acceptance

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Table of Contents:

Abstract

In international relations, political tension has been rising over state deregulation of genetically modified organisms (GMOs). The United States, Argentina, and Brazil have been the chief proponents of the global liberalization of GM crops for both trade and production, while members of the European Union (EU) have been the strongest opponents to GMO proliferation, leading to global trade blocs and fierce discourse with transnational entities such as the WTO. The purpose of this research is to test the primary argument of proponents for an empirically significant correlation: that GMO deregulation has significantly contributed to global food security. Eighteen states are separated into three groups based on their level of GMO corn deregulation. Regression models for Global Hunger Index (GHI) for each group are compared to each other for the span between 1990 and 2013. These models are also compared with other proposed causal factors to decreasing GHI, namely the level of political and civil freedom (Freedom House Score), government stability (Political Stability Score from the World Bank Development Research), and GDP per capita. Results from data since 1990 revealed that there is no significant causal relationship that can be observed between GMO deregulation and improving food security relative to other possible factors, inferring an interaction effect of multiple influences irrespective of GMO acceptance. As the literature indicates, the push to deregulate GMOs by certain states underscores their intention not to provide global food security, but to secure bio-hegemony in the intellectual property rights and operations of biotechnology within the agricultural sector.

Chapter 1: Introduction

The purpose of this research is to explain the relationship between food security concerns and the dispute among states on the deregulation of the cultivation and trade of genetically modified organisms. Is the international dispute over the deregulation of genetically engineered crops a matter of ensuring global food security or preventing biotechnological hegemony? Quantitative analysis should illustrate that commercial crop deregulation of GMOs (X_1) alone will not significantly contribute to global food security. Multiple variables, namely political stability (X_2), GDP per capita (X_3), and political freedoms (X_4) can significantly or equally contribute to the access of sufficient food. Furthermore, based on the existing literature, the underlying motive of GMO proliferation is not necessarily food security, as proponents would claim, but the struggle for bio-hegemony over the global food market. This literature can be qualitatively pitted against the existing scientific research behind the claims of GMO proponents concerning increased yield, higher stress resistance, and decreased environmental degradation, justifying or disqualifying resistance against GMO deregulation by both developed and lesser developed countries.

The editor of the Journal of Agricultural and Environmental Ethics, Dr. Richard P . Haynes, summarizes the proposed food security solution best: states claim "'that the world needs GM crops to counter future poverty, food deficits, hunger, and climatic changes'" (Haynes 2010)**.** Proponent states of GMO proliferation range across various geopolitical and economic backgrounds, attesting to the necessity of GMOs as a causal factor toward food security (Runge and Senauer 2000). Among states, there is also considerable resistance against the GMO market, unconvinced of proponents' claims while emphasizing their own wariness of the potential risks of GMOs to food security. The purpose of this research is to analyze state food security measurements relative to the GMO acceptance levels of selected states with a focus on corn as a case study. Any correlation measured that may infer causality is set against other possible explanatory variables that have been measured between the years of 1990 and 2013. The results of this study can help guide state policy makers in their decisions to support or deny the deregulation of any GM crop variety based on the idea that GM crops have been a global contributor to decreased global hunger.

Currently, the key players in promoting GMO proliferation are the US, Brazil and Argentina (Stone 2010). Today, about 41% of biotech crops in world markets are of US origin. The industry has reportedly brought up to $43.6 billion in additional revenue to the USA over 16 years, and $8.8 billion in 2011 (Clives 2012). The industry is projected to increase at 10-15% annually. Meanwhile, Brazil is currently the second largest plant biotech producer in the world and currently exports more agricultural products to the USA than it receives from the USA. Brazil is also the leading exporter of GM soy, corn, and cotton to China and the European Union (Silva and O'Kray 2013). It is also the largest exporter of GM soy. Moreover, Brazil is a growing source of food aid to lesser developed countries (LDCs), although it is currently not GM. In addition to being a key market producer, Brazilian production is also a factor in world price controls. Argentina is the third largest biotech producer, and has recently opened Chinese markets to its GM corn. This news comes in the mists of tension between China and the US over rejected US corn tainted with unapproved GM varieties (Bronstein 2013).

The United States, Brazil and Argentina have united in the creation of the international Maize Alliance (MAIZALL). Although the U.S. Grain Council's Board of Directors may admit that the three countries are in competition to sell similar products, they also face similar issues for market access. MAIZALL coordinates communications for lobbying governments to lower regulatory practices against MAIZALL farm products and biotechnology (Yankelevich 2013). Although several countries have begun cultivating, importing, and exporting GM crops since biotech crops were introduced in 1996, these countries face several challenges in the promotion of their products. The main cause of these market obstacles is the regulatory practices against GMO crops by economically and politically noteworthy countries.

The key countries and trading blocs that function as obstacles to GMO proliferation are China, Japan, and the European Union. Despite their government's personal opinion of GMOs, LDCs are generally reactionary to the regulatory behavior of these countries. The GMO issue creates a triangular dilemma between GMO proponents, opponents, and potential suppliers of GM crops.

The key argument among proponent countries of GM crops is that they will help provide food for a population that is rapidly growing. Biotechnological corporations could purportedly produce the most resilient and nutritious crops for public consumption and livestock feed from genetically modify seed varieties. The world appears to be experiencing considerable population pressure. Conservative estimates agree that approximately 925 million people are currently experiencing undernourishment, and the number is expected to reach 1 billion by 2025 (Bone and France 2003). Furthermore, when hunger is not the problem, nutritional deficiency poses a greater issue. More than 3.6 billion people suffer from deficiencies in vital nutrients such as iodine, Vitamin A, and iron due to limited variety in diets and the lack of commercial supplements. Increased corporate farming has all but decimated natural genetic variety among crops, increasing the vulnerability of populations to crop plagues that can wipe out food staples. Furthermore, there is the added dilemma of living standard increases affecting global meat consumption. It is expected that developing countries will increase their meat and milk consumption by 107 million metric tons and 177 million metric tons, respectively, by 2020. To meet the demand of this consumption, livestock feed (such as corn and soy) must increase by up to 300 million metric tons by 2020 (Delgado, Crosson, and Courbois 1997). As the dietary demands of consumers take priority among suppliers, the increased use of chemical pesticides and fertilizers threaten the long-term sustainability of ecosystems and crop production. These chemicals have been known to cause devastating effects on water and soil quality. They have also increased concerns regarding the increased presence of pesticide-resistant insects and herbicide-resistant weeds. Lastly, as desertification increases, arable land for crop production becomes increasingly valuable and scarce. The pursuit of arable land for farming can lead to further decimation of vital ecosystems and threaten the peace between states seeking the resources to feed their people.

According to proponent states, genetically modified organisms can remedy the mentioned issues facing population growth and ecological harm. Genetically modified versions of corn, for example, can produce their own pesticide by incorporating bacterial genes of the pesticide-producing Bacillus thuringiensis (Bt). Growing this form of corn can drastically reduce the use of chemical pesticides to control for insect infestation (Snow et al. 2005). While there are currently no crops that provide their own herbicide, there are herbicide-resistant crop varieties that minimize the risk of chemical herbicides destroying the potential harvest.   GM varieties also fuse plant and bacterial genes that allow crops to fight fungal and viral diseases, preventing the likelihood of famine-inducing plagues. As climate change expands the desert landscape, GM crops are produced which can tolerate drought and the increased exposure to stressors such as salts (Snow et al. 2005). The principal argument therefore, is that GM crops are superior to non-GM varieties. They are able to survive infestations and climate changes that could cause serious global repercussions, including the extinction of entire crops and debilitating mass starvation. Furthermore, experimental varieties can potentially absorb environmental toxins such as petroleum, allowing for more land to be available for farming.

Accordingly, states in opposition to GM crops hold a deep skepticism toward the proponents' arguments. They also pose concerns that can allegedly obstruct environmental integrity and, of equal if not superior more importance, political power. Certain studies have concluded that pesticide-producing GM crops have led to an increase in Bt-resistant insects. Herbicide-resistant GMOs have reportedly led to the increased and more liberal use of chemical herbicides on fields (Guruswamy 2002). Virus-resistance by GM crops has also reportedly led to increased resilience in virus species (Snow et al. 2005).

If one takes into account the WHO definition of food security, one would know that the correlation between GMO acceptance and food security is of relative importance. The primary factor behind a state's perspective on GMOs is bio-hegemony (Newell 2009). A powerful state will base its decision regarding GMO acceptance on how GM crops may affect its sovereignty over food production and trade. Any state that prefers the status quo of the agricultural sector will resist change in order to guard its influence, while states that wish to improve their power status will push to institute change (Schneider and Urpelainen 2013).

While neoliberals may zealously emphasize the benefits of free market cooperation in the agricultural sector, we will see that this perspective masks the realist state's objective to gain more definitive influence over another state's food supply. One can deduce from policy studies that GMO safety field trails and GMO production data are irrelevant in global politics. Nevertheless, there are serious implications regarding the uncontrolled proliferation of GMOs on food and state security through a realist perspective. Bio-tech producing states, protecting the intellectual property of GMO transnational entities, can push to open markets under neoliberal ideals, securing ownership of this market through the WTO protection of biotechnological intellectual property rights. Although a plant itself can never be considered intellectual property, the genes inserted into a GM crop can be patented and protected under the law. Growers of GM crops, respecting IPR, are forbidden to save GM seeds for subsequent seasons or to grow GM crops without submitting royalty payments to the owners of the patent. If this ownership remains unchallenged, it can seize a state's autonomous right to produce food unregulated by foreign powers. The state's ambition to allow uncontrolled proliferation of GMO crops will ultimately undermine and threaten food security for individual consumer states.

Defining The Terms Used In This Analysis:

GMO (Genetically Modified Organism): organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally. The technology is often called "modern biotechnology" or "gene technology," sometimes also "recombinant DNA technology" or "genetic engineering." It allows selected individual genes to be transferred from one organism into another, and also between non-related species (World Health Organization 2013).

Commercial crop: Also known as a cash crop: a crop (such as tobacco or cotton) that is grown to be sold rather than for use by the farmer ("Cash Crop" 2013).

Deregulation: The process of removing legal or quasi-legal restrictions on the amount of competition, the sorts of business done, or the prices charged within a particular industry (The Free Merriam-Webster Dictionary 2013)

Food Security: when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (Food and Agriculture Organization 2001)

Dependent Variable

For the purposes of this research, quantitative analysis of food security will be done through the measurements of the International Food Policy Research Institute's Global Hunger Index (GHI). GHI measurements of many states have been taken since 1990.

Independent Variable

The potential causative explanatory variable is the level of deregulation for GM maize by selected states.

For the purposes of this study, GM crop laws will be principally observed for GM maize. Based on the literature, this crop is the most extensively cultivated and utilized worldwide. Maize is also considered a staple crop for most countries around the world, especially the countries included in this analysis. Due to these factors, the survival, deregulation, acceptance, and proliferation of this crop are of chief concern for food security. Secondly, including other GM crops or all GM products in this study would minimize efficiency, creating difficulty in categorizing states that have varied laws on each GMO. Including other

GM crops would also decrease the study's ability to make a strong inference of particular GMOs and their effects on food security. Nevertheless, since maize is a widely used staple crop, results from this study can be used to make inferences on the potential effects of other GM crops of lesser significance.

The independent variable is subdivided into 4 groups (Group A, B, C and D) based on a state's level of GMO deregulation. The groups are categorized as follows:

A. In these countries, GM maize has been officially banned for cultivation and import of products containing GM maize. In this group, virtually all GM products have been outlawed as well.
B. GM maize has been forbidden for cultivation, but imports are allowed (officially or unofficially).
C. GM maize may be cultivated for commercialization as well as imported. In this group, several, if not all, GM products may be introduced into the country for cultivation or commercial consumption.
D. A randomly selected sample of 29 countries that will undergo the same quantitative analysis as Group A, B, and C.

<u>Confounding Variables</u>

The following variables potentially confound the results of this study, and various controls have been instituted in order to provide for the most thorough analysis:

1. GMO import acceptance is a greater causal factor in the decrease of a state's GHI than cultivation.

   Control: To analyze whether import acceptance is significantly different to an import ban, the regression analysis between Import Accepting Countries (Group B) and Import Ban countries (Group A) will be compared for a statistically significant difference in correlation.

2. Interaction Effect: GMO cultivation and import acceptance are both necessary for a significant decrease in GHI when compared to a complete GMO ban or the mere acceptance of imports.

   Control: Similar to the control for first confounding variable, Group C states will undergo a regression analysis that will compare with Group B and A countries for a greater correlation.

3. Reverse Causality – Increased food security leads to GMO deregulation, possibly because countries with low GHI are less wary of the potential effects of GM crops on environmental degradation or the loss of crop diversity.

   Control: GMO deregulation is highly contested in states that are already highly food secure, namely the states of the European Union. A literature review regarding these states will serve as a control as we assess why several EU states have shown stern resistance against GMO cash crops and imports based on the existing research on GM crop yields and environmental impact.

4. Increased civil liberties is the principal cause of food security.

   Control: This idea necessitates separate analysis. Using the Freedom House Score (FHS) as the explanatory variable for GHI, each group will undergo comparative regression analyses. The FHS will be converted numerically into 1 (Free), 2 (partially free), and 3 (Not Free) for each measured year of GHI of that state. The resulting scatter plots and regression analysis for each state and group will be compared with the ones obtained from the initial test series (explained under Procedure).

5. Increased political stability leads to food security.

   Control: This possible confounding variable necessitates separate tests comparing regression scores for statistical significance. The Political Stability Score (PSS) from the World Bank Development Research will serve as the potential explanatory valuable for decrease in GHI. The PSS for each country of each group will be set against its most closely corresponding GHI. The regression analyses gathered will be tested with the ones obtained from the initial test (explained under Procedure).

6. GDP per capita is an extraneous variable significantly contributing to food security.

   Control: As with 4 and 5, GDP for corresponding GHI years of each state will allow for analysis.

7. Traditional and non-GMO farming methods are sufficient to sustain for food security.

   Control: Group A serves as a test for this hypothesis. If regression models show that each state's GHI decreases over time without GMO deregulation when compared with Group B and C states, then status quo farming methods may suffice for ensuring food security despite population growth.

Cases

Initially, 18 countries will be measured for a relationship between GHI and GMO deregulation, and this is liable to expansion, especially for the list of Group B countries in an effort to improve accuracy.

Group A – Based on the most current literature, there are only 6 countries with official GMO bans for cultivation and import (Serbia is excluded from the study due to lack of GHI measurements). This group serves as the primary control group that can most closely represent the null hypothesis. The states in this group are: Algeria, Angola, Benin, Turkey, Zambia, and Zimbabwe.

Group B – Many countries fall under this category, either officially or otherwise, but for the purposes of this study, I include states that a) are considered lesser developed or developing b) are under pressure by neighbors to cultivate and accept more GMO crops c) have measurable changes in GHI since 1990 (measurements above 5), and d) import corn. These states are: Ecuador, El Salvador, Guatemala, Nicaragua, Peru, and Venezuela.

Group C– As with Group A countries, there are relatively few countries that officially allow GMO corn for commercial cultivation and importation. The only state excluded from this list is the United States, since GHI scores are not on record. These states are: Argentina, Brazil, Chile, Colombia, Honduras, and Uruguay.

Group D – As a second statistical control and to minimize any suspicion of bias, a random sample of 29 countries will be drawn to undergo the procedure of this research for overall comparative purposes. The countries randomly selected are: Chad, Swaziland, India, Albania, Mozambique, Cuba, Philippines, Syrian Arab Republic, Yemen, Laos, Ecuador, Nigeria, Ethiopia, Panama, Bolivia, Sri Lanka, North Korea, Cambodia, Bangladesh, Peru, Guyana, Nepal, Niger, Namibia, Morocco, Mongolia, South Africa, Sierre Leone, and Thailand.

Note: Western European countries were completely excluded from this study for a few reasons. Most western European countries never had a measurable GHI changes from 1990 to 2013. The GHI of western European countries were often not even measured.

<u>Procedure</u>

The Initial Test Series (ITS):

Analysis will begin with Group A, our control group. There will be scatter plot graphs created for each state and their relative GHI from the period 1990 to 2013. Using Microsoft Excel, a regression analysis will test for the correlation coefficient and r^2 within each model for each state. The mean r^2 will be calculated for group comparative purposes of relative variance and overall reliability of their models. This procedure will be repeated for the states of Group B, C, and D.

The calculated mean r^2 will serve to objectively deduce if either group produces a more affective model of decreasing GHI over time.

The Initial Test Series is followed by subsequent tests to rule out or support the effects of measurable confounding variables: the Political Stability Score (PSS) and Freedom House Score (FHS).

Political Stability Score (PSS):

For each group, the PSS is found which corresponds closest to the GHI for each country in 1990, 1995, 2000, 2005, and 2013. The results are described on scatter plot graphs with their regression models, correlation coefficients, and corresponding r^2 . The resulting individual state r^2 and correlation coefficients will be compared to its r^2 and correlation coefficients found in the ITS. The mean correlation of determination for each group is also compared with the results from other groups of the same analysis.

Freedom House Score (FHS):

For each group states, the FHS is found by taking the average for each state's civil liberties (CL) and political rights (PR) scores. The scores used are the ones that correspond closest to the GHI of each country in 1990, 1995, 2000, 2005, and 2013. Results for the FHS will be labeled with the following scale: Free = 1 to 2.5, Partially Free = 3 to 5, Not Free = 5.5 to 7 The results are described on scatter plot graphs with each state's regression line, correlation coefficients, and corresponding r^2 . The resulting r^2 and correlation coefficients for each state is compared with the results found in the ITS. The mean r^2 of each group is also compared with other groups of the same analysis.

GDP per Capita:

For each group, the GDP per capita is found which best corresponds with the GHI of each country in 1990, 1995, 2000, 2005, 2013. The results are described on scatter plot graphs with each state's regression line, correlation coefficients, and corresponding r^2 . The resulting r^2 and correlation coefficients for each state is compared with the results found in the ITS. The mean r^2 of each group is also compared with other groups of the same analysis.

<u>Qualitative Analysis:</u>

After assessing the results from quantitative research, it is necessary to qualitatively review each country for correlations between the data and the literature that may relate to the historical, political, economical, and ecological reasons for changes in GHI and overall food security.

Chapter 2: Literature Review

Scholars in global economics, international relations, anthropology, biology, the humanities and various interdisciplinary studies have delved into the potential benefits and harm associated with the deregulation of genetically modified organisms for the production of food and livestock feed. Research indicates that the trade of GMOs has led to a shift in trading patterns, international tensions, and alliances. The cause of this shift is due to varying opinions of GMOs and their impact on food security. Meanwhile, there is also the alternative perspective of GMOs being a tool to secure biotechnological hegemony (bio-hegemony) rather than food security. When one considers the competitiveness of the agricultural sector, states hoping to increase their political influence will push for changes in favor of their markets, and states satisfied with their status will fight to preserve the status quo.

According to Nielsen and Anderson (Nielsen and Anderson 2001), the market for genetically modified organisms has led to the analysis of shifting trade patterns, mainly between GMO producers, the European Union, and several lesser developed states that vary their regulatory policies based on the demands of large importers of agriculture. Although the EU has approved every request to authorize GMO imports and usage for member states, Kurzer and Cooper (Kurzer and Cooper 2007) contend that consumers and member state policymakers have been relatively unwavering in their resolve to limit or eliminate their exposure to GM products, even as the expense of this endeavor rises. According to Falkner (Falkner 2000), the cause of this struggle to pry open the agricultural gates of EU member states has been tied to alleged biosafety and food security issues posed by both proponent and opponent states. Furthermore, Kurzer and Cooper (Kurzer and Cooper 2007) point out that there is a growing distrust by wary states regarding the favorable claims of GMOs by proponent states, multinational corporations, and even academia. Noussair, Robin, and Ruffieux (2004) summarize the claims by proponent states, which include the increased yield, higher resilience under stressful conditions, and decreased environmental degradation associated with the use of genetically modified crops. If true, genetically modified crops would be strategically superior in ensuring global food security as populations rise and arable land decreases.

Falkner (Falkner 2000) asserts that resistance by EU member states to accept GMO approval, citing the precautionary principle of the Cartagena Protocol to secure the legality of this resistance, has been the primary stimulus to polarize states and prompt trade disputes between developed and lesser developed countries. Clapp (Clapp 2005) points out that states across southern Africa, wary of lax monitoring of agriculture in the US, have refused food aid that may contain GMOs unless it has been fully processed, fearing that GM food aid can contaminate their agriculture, which would consequently disrupt trade relations with European states. Alluding to food security fears, McAfee (McAfee 2003) highlights how cross-contamination of GM corn into non-GMO fields in Oaxaca, Mexico has backed suspicions that producer states of GM crops are not concerned with the preservation of local varieties in the interest of food security. Nevertheless, the US, Brazil and Argentina, among others, continue to assert that genetically modified crops pose no threat to non-GM varieties. As observed by Qvist et al.(Qvist, Lundsgaard, and Brandt 2006), there have been wide-ranging hopes that GM crop usage would decrease the use of harmful agricultural inputs. Chhakchhuak (Chhakchhuak 2005) has assessed and summarized cases that strongly suggest the use of biotech crops have substantially reduced chemical pesticides, notably reported in

Indian cotton. Nevertheless, through the use of GM crops, Pimentel (Pimentel 2001) has noted that states have witnessed the increased use of pesticides and herbicides due to growing pest and weed resistance. They have also witnessed that the standardization methods of corporate farming tactics, through the use of GM crops, have led to the elimination and endangerment of local varieties. The loss of local crop varieties, according to states opposing GMOs, implicates the loss of vital genes that could save crop yields in the event of devastating famines. Meanwhile, according to Halfon (Halfon 2010), states and transnational organizations, including the WTO and EU, in favor of deregulation, have cited there is no “significant scientific uncertainty” to justify a complete ban of any GMO crop. The WTO, in fact, has demanded that EU and non-EU states lift moratoriums and import bans, claiming that their attempts to prevent trade of GMOs undermines the liberal ideals of WTO membership while imposing protectionist policies to preserve the status of their agricultural sector.

While disputes over the merits of GM crops are paradoxical and politicized, an additional fear behind GMO proliferation is the collection of royalties for intellectual property rights. Coleman and Gabler (Coleman and Gabler 2002) mention that the WTO has agreed to support the rights of a state’s multinational corporations to collect fees and licensing agreements for the distribution, use, and sale of any of their GM seed and crop varieties. Scholars have questioned if GMO deregulation is really a matter of food security, or if states such as Argentina, Brazil, and the United States have goals of securing bio-hegemony in the agricultural sector. These principal GMO-producing countries, according to Newell (Newell 2009), have been known to collaborate in prying open markets while simultaneously competing for the most lucrative trade agreements. Meanwhile, as Munson

(Munson 1993) points out, states fear that subjecting their food production to intellectual property rights would eventually become an obstacle for their long-term food sovereignty and security. Contrary to proponents' claims on the link between GMO deregulation and food security, Tweeten (Tweeten 1999) upholds the long-standing theory that has been the interaction effect of various factors, such as economic equity and efficiency in land use accompanied by sufficient state investment.

Chapter 3: Results of Quantitative Analysis

Groups and their corresponding correlation coefficient and p-value were measured for each variable.

For Group A, Group B, and Group C, data were collected for GHI and organized as follows (Fig. 1):

GLOBAL HUNGER INDEX					
http://www.ifpri.org/book-8018/node/8058					
Import and Cultivation Ban Countries and their GHI (Group A):					
	1990	1995	2000	2005	2012
Algeria	7	7.7	5.3	5	5
Angola	39.5	38.5	31.6	22.7	19.1
Benin	22.5	20.5	17.3	15.2	13.3
Turkey	5	5	5	5	5
Zambia	24.9	24.5	26.3	25.3	24.1
Zimbabwe	20	22	21.7	20.5	16.5
No Cultivation but allows GM imports (Group B)					
	1990	1995	2000	2005	2012
Ecuador	14	11.6	12.3	10.1	8.5
El Salvador	10.9	8.7	7.4	6.4	6.8
Guatemala	15	16.1	17	17	15.5

Nicaragua	24.1	19.9	15.4	11.5	9.5
Peru	16.3	12.3	10.5	9.9	5.5
Venezuela	7.8	7.7	7.2	5.2	5
Import and Cultivation (Group C)					
	1990	1995	2000	2005	2012
Argentina	5	5	5	5	5
Brazil	8.7	7.6	6.4	5	5
Chile	5	5	5	5	5
Colombia	10.4	8	6.8	6.9	5.9
Honduras	14.2	13.6	10.8	8.5	7.9
Uruguay	5.5	5	5	5	5

Figure 1.1: GHI data for Group A, B, and C for years measured. The lowest score is a 5, signifying virtually no serious hunger issues in the country. Higher numbers indicated progressively more serious problems related to hunger and food security in the country.

Separate charts were created for each group pertaining to FHS (Fig 1.2), PSS (Fig. 1.3), and GDP per Capita (Fig 1.4):

Freedom House Score	-	-	-		
http://www.freedomhouse.org/report-types/freedom-world	-	-	-		
Import and Cultivation Ban Countries and their Freedom House Score					

	1990	1995	2000	2005	2012
Algeria	4	6	5.5	5.5	5.5
Angola	7	6	6	5.5	5.5
Benin	5	2	2	2	2
Turkey	3	5	4.5	3	3.5
Zambia	5.5	3.5	4.5	4	3.5
Zimbabwe	5	5	5.5	6.5	6
No Cultivation but allows GM imports					
	1990	1995	2000	2005	2012
Ecuador	2	2.5	3	3	3
El Salvador	3.5	3	2.5	2.5	2.5
Guatemala	3.5	4.5	3.5	4	3.5
Nicaragua	3	4	3	3	4.5
Peru	3.5	4.5	3.5	2.5	2.5
Venezuela	2	3	4	4	5
Import and Cultivation					
	1990	1995	2000	2005	2012
Argentina	2	2.5	1.5	2	2
Brazil	2.5	3	3	2	2
Chile	2	2	2	1	1
Colombia	3.5	4	4	3	3.5

Honduras	2.5	3	3	3	4
Uruguay	1.5	2	1	1	1

Figure 1.2: Data summary of Group A, B, and C regarding Freedom House Score for years measured. Free states are rated between 1 and 2.5. Partially free states are rated between 3 and 5. States that are considered "not free" range between 5.5 and 7.

Political Stability Score	-	-	-	
http://info.worldbank.org/governance/wgi/index.aspx#home				
Import and Cultivation Ban Countries and their Political Stability Score				
	1996	2000	2005	2012
Algeria	- 1.86	- 1.50	- 0.93	- 1.34
Angola	- 2.11	- 2.09	- 0.89	- 0.38
Benin	0.96	0.72	0.45	0.31
Turkey	- 1.27	- 0.85	- 0.60	- 1.19
Zambia	- 0.23	- 0.05	0.07	0.61
Zimbabwe	- 0.53	- 1.42	- 1.24	- 0.79
No Cultivation but allows GM imports				
	1996	2000	2005	2012
Ecuador	- 0.87	- 0.69	- 0.80	- 0.60
El Salvador	-	0.27	-	0.21

	0.30		0.03	
Guatemala	-1.08	-0.83	-0.86	-0.65
Nicaragua	-0.61	-0.13	-0.32	-0.37
Peru	-1.09	-1.10	-0.98	-0.86
Venezuela	-0.62	-0.81	-1.22	-0.99
Import and Cultivation				
	1996	2000	2005	2012
Argentina	0.02	0.05	-0.01	0.07
Brazil	-0.25	0.18	-0.23	0.07
Chile	0.62	0.43	0.85	0.35
Colombia	-1.60	-1.61	-2.04	-1.40
Honduras	-0.57	-0.18	-0.65	-0.40
Uruguay	0.53	0.85	0.79	0.71

Figure 1.3: Data summary of Group A, B, and C regarding Political Stability Score for years measured. Negative scores deem the country's political atmosphere as generally unstable, while progressively more positive scores rate the country more toward political stability.

GDP PER CAPITA					
http://data.worldbank.org/indicator/NY.GDP.PCAP.CD					

Import and Cultivation Ban Countries and their GDP per Capita:					
	1990	1995	2000	2005	2012
Algeria	2365	1425	1727	3039	5310
Angola	993	416	656	1707	5539
Benin	392	362	339	533	751
Turkey	2791	2896	4220	7130	10661
Zambia	419	393	322	626	1463
Zimbabwe	840	611	535	453	909
No Cultivation but allows GM imports					
	1990	1995	2000	2005	2012
Ecuador	1505	2159	1462	3013	5425
El Salvador	898	1653	2204	2815	3782
Guatemala	860	1468	1722	2146	3341
Nicaragua	244	889	1001	1159	1777
Peru	1149	2132	1949	2675	6424
Venezuela	2382	3390	4800	5445	12729
Import and Cultivation					
	1990	1995	2000	2005	2012
Argentina	4333	8973	9329	5768	14680

Brazil	3087	4750	3694	4739	11320
Chile	2388	4941	5133	7615	15245
Colombia	1209	2529	2504	3393	7763
Honduras	622	699	1140	1402	2339
Uruguay	2990	5985	6873	5222	14728

Figure 1.4: Data summary of Group A, B, and C regarding GDP per Capita for years measured (in USD).

Each group went through a regression analysis where the dependent variable (GHI) was pitted against the potential independent variables.

Figure 1.5: Regression Analysis for Group A of Time determining GHI. A total of 30 observations of GHI changing over time yielded low correlation values for the x-variable (time) and statistically insignificant p-value for regression analysis at the 95% and 99% confidence interval:

SUMMARY OUTPUT	Group A
Regression Statistics	
Multiple R	0.23
R Square	0.05
Adjusted R Square	0.02
Standard Error	10.08
Observatio	30.00

ns

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	156.02	156.02	1.54	0.23
Residual	28.00	2842.45	101.52		
Total	29.00	2998.47			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	613.10	480.54	1.28	0.21	-371.24	1597.44	-371.24	1597.44
X Variable 1	-0.30	0.24	-1.24	0.23	-0.79	0.19	-0.79	0.19

Figure 1.6: Regression Analysis for Group B of Time determining GHI. A total of 30 observations of GHI changing over time yielded medium-low correlation values for the x-variable (time) and a statistically significant p-value from the regression analysis at the 99% confidence interval:

SUMMARY OUTPUT	GROUP B

Regression

Statistics	
Multiple R	0.46
R Square	0.21
Adjusted R Square	0.19
Standard Error	4.24
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	136.73	136.73	7.59	0.01
Residual	28.00	504.48	18.02		
Total	29.00	641.21			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	569.19	202.44	2.81	0.01	154.50	983.88	154.50	983.88
X Variable 1	-0.28	0.10	-2.75	0.01	-0.49	-0.07	-0.49	-0.07

Figure 1.7: Regression Analysis for Group C of Time determining GHI. A total of 30 observations of GHI changing over time yielded fairly low correlation values for the x-variable (time) and statistically significant p-value for regression analysis at the 95% confidence interval:

SUMMARY OUTPUT

GROUP C

Regression Statistics	
Multiple R	0.35
R Square	0.13
Adjusted R Square	0.09
Standard Error	2.46
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	24.33	24.33	4.01	0.05
Residual	28.00	169.67	6.06		
Total	29.00	194.00			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	241.95	117.40	2.06	0.05	1.46	482.44	1.46	482.44
X Variable 1	-0.12	0.06	-2.00	0.05	-0.24	0.00	-0.24	0.00

Figure 1.8: Regression Analysis for Group A of FHS determining GHI. A total of 30 observations of GHI changing over time yielded low correlation values for the x-variable

(FHS) and a statistically insignificant p-value from the regression analysis at the 95% and 99% confidence intervals:

SUMMARY OUTPUT	Group A Freedom House Score

Regression Statistics	
Multiple R	0.30
R Square	0.09
Adjusted R Square	0.06
Standard Error	9.88
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	263.30	263.30	2.70	0.11
Residual	28.00	2735.17	97.68		
Total	29.00	2998.47			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0	Upper 95.0

							%	%
Intercept	7.77	6.12	1.27	0.21	-4.76	20.30	-4.76	20.30
X Variable 1	2.09	1.28	1.64	0.11	-0.52	4.71	-0.52	4.71

Figure 1.9: Regression Analysis for Group B of FHS determining GHI. A total of 30 observations of GHI changing over time yielded low correlation values for the x-variable (FHS) and a statistically insignificant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT	Group B Freedom House Score				
Regression Statistics					
Multiple R	0.15				
R Square	0.02				
Adjusted R Square	-0.01				
Standard Error	4.73				
Observations	30.00				
ANOVA					
	df	SS	MS	F	Significance F

Regression	1.00	13.63	13.63	0.61	0.44
Residual	28.00	627.58	22.41		
Total	29.00	641.21			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	8.59	3.83	2.24	0.03	0.74	16.44	0.74	16.44
X Variable 1	0.89	1.14	0.78	0.44	-1.44	3.22	-1.44	3.22

Figure 2.0: Regression Analysis for Group C of FHS determining GHI. A total of 30 observations of GHI changing over time yielded medium correlation values for the x-variable (FHS) and a statistically significant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT	Group C Freedom House Score
Regression Statistics	
Multiple R	0.53
R Square	0.28
Adjusted R Square	0.25

Standard Error	2.23
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	54.39	54.39	10.91	0.00
Residual	28.00	139.61	4.99		
Total	29.00	194.00			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	3.25	1.12	2.89	0.01	0.94	5.55	0.94	5.55
X Variable 1	1.47	0.45	3.30	0.00	0.56	2.39	0.56	2.39

Figure 2.1: Regression Analysis for Group A of PSS determining GHI. A total of 24 observations of GHI changing over time yielded low correlation values for the x-variable (PSS) and a statistically insignificant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT	Group A Political Stability Score

Regression Statistics

Multiple R	0.07
R Square	0.01
Adjusted R Square	-0.04
Standard Error	9.86
Observations	24.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	11.66	11.66	0.12	0.73
Residual	22.00	2137.48	97.16		
Total	23.00	2149.14			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	17.30	2.55	6.79	0.00	12.01	22.58	12.01	22.58
X Variable 1	0.80	2.32	0.35	0.73	-4.01	5.62	-4.01	5.62

Figure 2.2: Regression Analysis for Group B of PSS determining GHI. A total of 24 observations of GHI changing over time yielded low correlation values for the x-variable

(PSS) and a statistically significant p-value from the regression analysis at the 95% confidence intervals.

SUMMARY OUTPUT	Group B Political Stability Score							
Regression Statistics								
Multiple R	0.14							
R Square	0.02							
Adjusted R Square	-0.02							
Standard Error	4.28							
Observations	24.00							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1.00	8.49	8.49	0.46	0.50			
Residual	22.00	403.33	18.33					
Total	23.00	411.82						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	9.76	1.64	5.95	0.00	6.36	13.16	6.36	13.16
X Variable 1	-1.48	2.17	-0.68	0.50	-5.98	3.03	-5.98	3.03

Figure 2.3: Regression Analysis for Group C of PSS determining GHI. A total of 24 observations of GHI changing over time yielded medium correlation values for the x-variable (PSS) and a statistically significant p-value from the regression analysis at the 95% confidence interval.

SUMMARY OUTPUT	Group C Political Stability Score							
Regression Statistics								
Multiple R	0.44							
R Square	0.19							
Adjusted R Square	0.15							
Standard Error	2.01							
Observations	24.00							
ANOVA								
	df	SS	MS	F	Significance F			
Regression	1.00	21.02	21.02	5.20	0.03			
Residual	22.00	88.88	4.04					
Total	23.00	109.90						
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%

Intercept	6.18	0.42	14.83	0.00	5.32	7.05	5.32	7.05
X Variable 1	-1.17	0.51	-2.28	0.03	-2.23	-0.11	-2.23	-0.11

Figure 2.4: Regression Analysis for Group A of GDP per Capita determining GHI. A total of 30 observations of GHI changing over time yielded medium correlation values for the x-variable (GDP per Capita) and a statistically significant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.58
R Square	0.34
Adjusted R Square	0.32
Standard Error	8.40
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	1021.63	1021.63	14.47	0.00
Residual	28.00	1976.84	70.60		
Total	29.00	2998.47			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	22.27	2.00	11.11	0.00	18.17	26.37	18.17	26.37
X Variable 1	0.00	0.00	-3.80	0.00	0.00	0.00	0.00	0.00

Figure 2.5: Regression Analysis for Group B of GDP per Capita determining GHI. A total of 30 observations of GHI changing over time yielded medium correlation values for the x-variable (GDP per Capita) and a statistically significant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.62				
R Square	0.38				
Adjusted R Square	0.36				
Standard Error	3.76				
Observations	30.00				
ANOVA					
	df	SS	MS	F	Significan

					Significance F
Regression	1.00	245.66	245.66	17.39	0.00
Residual	28.00	395.55	14.13		
Total	29.00	641.21			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	14.83	1.05	14.10	0.00	12.67	16.98	12.67	16.98
X Variable 1	0.00	0.00	-4.17	0.00	0.00	0.00	0.00	0.00

Figure 2.6: Regression Analysis for Group C of GDP per Capita determining GHI. A total of 30 observations of GHI changing over time yielded moderate correlation values for the x-variable (GDP per Capita) and a statistically significant p-value from the regression analysis at the 95% and 99% confidence intervals.

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.61
R Square	0.37

Adjusted R Square	0.35
Standard Error	2.09
Observations	30.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	72.27	72.27	16.62	0.00
Residual	28.00	121.73	4.35		
Total	29.00	194.00			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0 %	Upper 95.0 %
Intercept	8.81	0.64	13.75	0.00	7.49	10.12	7.49	10.12
X Variable 1	0.00	0.00	-4.08	0.00	0.00	0.00	0.00	0.00

The random sample of 27 countries were organized in a similar fashion for data collection.

Initially, data were collected pertaining to GHI (Figure 2.7):

Random Sample	Time and GHI				
	1990	**1995**	**2000**	**2005**	**2012**
Chad	38.8	34.9	29.8	29.7	26.9

Swaziland	10.4	12.9	12.7	12.5	14.4
India	32.6	27.1	24.8	24.0	21.3
Albania	9.2	6.0	7.8	6.1	5.2
Mozambique	36.0	32.0	28.5	25.1	21.5
Cuba	5.5	7.4	5.0	5.0	5.0
Philippines	19.9	17.4	17.7	14.0	13.2
Syrian Arab Republic	7.7	6.1	5.0	5.1	5.0
Yemen	29.8	27.7	26.9	27.9	26.5
Laos	33.4	30.3	28.0	23.7	18.7
Nigeria	25.3	22.6	17.9	16.3	15.0
Ethiopia	42.3	42.7	37.1	31.0	25.7
Panama	11.6	10.8	11.4	9.0	5.4
Bolivia	18.8	16.9	14.2	13.8	11.2
Sri Lanka	22.3	20.7	17.8	16.9	15.6
North Korea	18.8	22.6	22.5	20.0	18.0
Cambodia	32.2	30.7	27.8	20.9	16.8
Bangladesh	36.7	35.1	24.0	20.2	19.4
Guyana	14.3	10.2	8.2	8.0	6.6
Nepal	28.0	27.3	25.3	22.3	17.3
Niger	36.4	34.6	30.3	25.6	20.3
Namibia	22.1	21.9	17.5	17.1	18.4
Morocco	7.8	6.9	6.2	6.5	5.0
Mongolia	19.7	23.6	18.5	14.1	10.8
South Africa	7.2	6.5	7.4	7.7	5.4

Sierre Leone	31.3	29.5	30.0	28.4	22.8
Thailand	21.3	17.1	10.2	6.6	5.8

Figure 2.7: Data collection of GHI over a period time measured.

If possible, the corresponding year for GHI for each country was set against a FHS, PSS, and GDP per capita for each country. When there was no data, the country was eliminated from the regression analysis. For PSS, 1996 data was used as a substitute for 1995 since it was the earliest data available (Figure 2.8).

Random Sample	FHS				
	1990	**1995**	**2000**	**2005**	**2012**
Chad	6.5	5.5	5.5	5.5	6.5
Swaziland	5.5	5.5	5.5	6.0	6.0
India	2.5	4.0	2.5	2.5	2.5
Albania	6.5	3.5	4.5	3.0	3.0
Mozambique	6.0	3.5	3.5	3.5	3.5
Cuba	7.0	7.0	7.0	7.0	6.5
Philippines	3.0	3.0	2.5	3.0	3.0
Syrian Arab Republic	7.0	7.0	7.0	7.0	7.0
Yemen	5.5	5.5	5.5	5.0	6.0
Laos	6.5	6.5	6.5	6.5	6.5
Nigeria	5.0	7.0	4.0	4.0	4.5
Ethiopia	7.0	4.5	5.0	5.0	6.0
Panama	3.0	2.5	1.5	1.5	1.5
Bolivia	2.5	3.0	2.0	3.0	3.0

Sri Lanka	4.5	4.5	3.5	3.0	4.5
North Korea	7.0	7.0	7.0	7.0	7.0
Cambodia	7.0	6.0	6.0	5.5	5.5
Bangladesh	5.0	3.5	3.5	4.0	3.5
Guyana	4.5	2.0	2.0	3.0	2.5
Nepal	4.0	3.5	3.5	5.5	4.0
Niger	5.5	4.0	4.0	3.0	3.5
Namibia	2.5	2.5	2.5	2.0	2.0
Morocco	4.0	5.0	4.5	4.5	4.5
Mongolia	4.0	5.0	4.5	4.5	4.5
South Africa	4.5	1.5	1.5	1.5	2.0
Sierre Leone	5.5	6.5	4.5	3.5	2.5
Thailand	2.5	3.5	2.5	3.0	4.0

Figure 2.8: Data collection summary of PSS coinciding to the closest available GHI measurement for a given year.

GDP per Capita

	1990	**1995**	**2000**	**2005**	**2012**
Chad	292	207	167	664	1035
Swaziland	1292	1763	1433	2339	3290
India	376	384	457	740	1503
Albania	639	761	1193	2799	4406
Mozambique	185	141	236	313	570
Cuba	2702	2783	2744	3776	
Philippines	715	1065	1043	1201	2587

Syrian Arab Republic	989	795	1180	1589	
Yemen	479	284	550	832	1341
Laos	204	362	321	472	1412
Nigeria	322	263	164	804	2722
Ethiopia	249	132	123	160	467
Panama	2137	2868	3804	4594	9982
Bolivia	716	879	989	1021	2576
Sri Lanka	415	718	855	1242	2922
North Korea					
Cambodia		320	299	471	945
Bangladesh	281	317	356	421	750
Guyana	547	854	957	1084	3585
Nepal	200	214	237	321	699
Niger	320	205	164	258	395
Namibia	1981	2383	2059	3582	5931
Morocco	1037	1218	1276	1948	2902
Mongolia	1172	632	474	999	3691
South Africa	3182	3863	3020	5186	7314
Sierre Leone	161	222	154	318	633
Thailand	1508	2849	1969	2690	5480

Figure 2.9: Data collection summary of GDP per Capita for randomly selected countries (numbers in USD).

Afterwards, a regression analysis was undertaken in order to determine statistical significance for each model:

Regression Analysis for Group D of Time determining GHI (Figure 3.0):

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.31
R Square	0.09
Adjusted R Square	0.09
Standard Error	9.34
Observations	135.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	1194.31	1194.31	13.69	0.00
Residual	133.00	11602.01	87.23		
Total	134.00	12796.32			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	796.01	209.99	3.79	0.00	380.66	1211.36	380.66	1211.3
X Variable 1	-0.39	0.10	-3.70	0.00	-0.60	-0.18	-0.60	-0.1

Figure 3.0: Regression analysis summary of a random sample Group D of GHI and Time (the ITS). 135 observations yielded moderate correlation values with a regression analysis statistic of the x-value (time) that measured statistically significant at the 95% and 99% confidence intervals.

Regression Analysis for Group D of FHS determining GHI (Figure 3.1):

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.20
R Square	0.04
Adjusted R Square	0.03
Standard Error	9.62
Observations	135.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	495.67	495.67	5.36	0.02
Residual	133.00	12300.65	92.49		
Total	134.00	12796.32			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	13.93	2.35	5.92	0.00	9.27	18.58	9.27	18.58
X Variable 1	1.15	0.50	2.32	0.02	0.17	2.14	0.17	2.14

Figure 3.1: Regression analysis between GHI and Freedom House Score for Group D. 135 observations yielded low correlation values with a regression analysis statistic of the x-value (FHS) that measured statistically significant at the 95% confidence interval.

Regression Analysis for Group D of PSS determining GHI (Figure 3.2):

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.26
R Square	0.07
Adjusted R Square	0.06
Standard Error	8.93
Observations	108.00

ANOVA

	df	SS	MS	F	Significance F
Regression	1.00	607.06	607.06	7.62	0.01
Residual	106.00	8446.73	79.69		
Total	107.00	9053.79			

	Coefficients	Standard Error	T Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	16.10	1.11	14.49	0.00	13.90	18.30	13.90	18.30

X Variable 1	-3.18	1.15	-2.76	0.01	-5.47	-0.90	-5.47	-0.90

Figure 3.3: Regression Analysis of Group D between PSS and GHI. 108 observations yielded low correlation values with a regression analysis statistic of the x-value (PSS) that measured statistically significant at the 95% and 99% confidence intervals

Regression Analysis for Group D of GDP per Capita determining GHI (Figure 3.4):

Linear Regression

Regression Statistics

R	0.62
R Square	0.38
Adjusted R Square	0.38
Standard Error	7.68
Total Number Of Cases	126.00

38.8 = 24.3712 - 0.0038 * 292

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	1.00	4491.29	4491.29	76.09	0.00
Residual	124.00	7318.96	59.02		
Total	125.00	11810.25			

	Coefficients	*Standard Error*	*LCL*	*UCL*	*t Stat*	*p-level*	*H0 (2%) rejected?*

Intercept	24.37	0.93	22.19	26.55	26.32	0.00	*Yes*
292	0.00	0.00	0.00	0.00	-8.72	0.00	*Yes*
T (2%)	2.36						

LCL - Lower value of a reliable interval (LCL)

UCL - Upper value of a reliable interval (UCL)

Figure 3.4: Regression analysis for Group D between GHI and GDP per Capita. 126 observations yielded high correlation values with a regression analysis statistic of the x-value (GDP per capita) that measured statistically significant at the 95% and 99% confidence intervals.

Below is a summary depicting the data regarding correlation coefficients and the corresponding p-value of the regression models (Figure 3.5):

Data Set	GHI vs Time (ITS)	p-value	GHI vs FHS	p-value	GHI vs PSS	p-value	GHI vs GDP	p-value
Group A	-0.23	0.23	0.3	0.11	0.01	0.73	-0.58	0**
Group B	-0.46	0.01**	0.15	0.44	-0.14	0.5**	-0.62	0**
Group C	-0.13	0.05**	0.28	0**	-0.44	0.03**	-0.61	0**
Group D	-0.31	0**	0.2	0.02**	-0.26	.01**	-0.62	0**

Bold=Strongest Correlation per group	**=Statistical Significance

Figure 3.5: Summary of correlation coefficients and p-values associated with each group and the regression analysis between GHI and various possibly determinative independent variables

GMO deregulation (the ITS):

Figure 3.3 above summarizes data collected and analyzed for the four groups. Isolating GMO deregulation (GHI vs Time), GMO liberalization appears to have a weak to low moderate negative correlation for all four groups. Time alone appears to show no significant correlation for Group A states, while Group B, C, and D appear to show statistically significant change despite the weak correlation. Group B appears to have the strongest negative correlation between time and GHI.

Group A – GHI over Time:

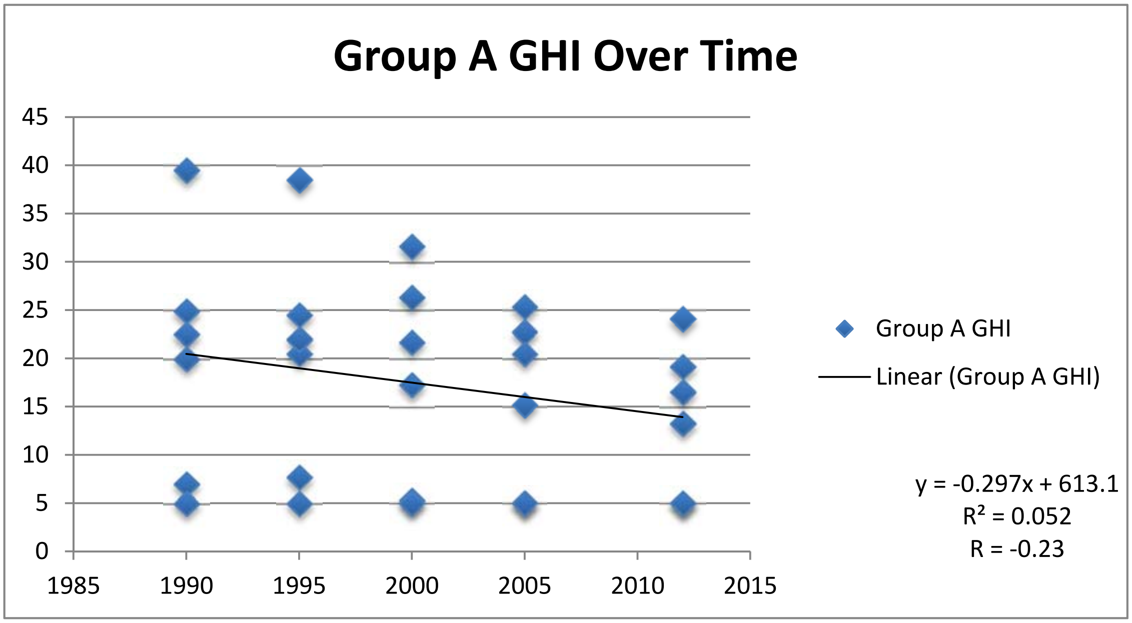

Figure 3.4: Scatter plot and trend line for Group A of GHI from 1990 to 2012 measurements.

Countries that have banned GMOs for cultivation and import show mild to steady progress toward a lower GHI from 1990 to 2012. Turkey has been at or below 5 GHI for the duration of study, indicating virtual complete elimination of hunger within the country. Algeria achieved this by 2000. At a p-value of .23, time alone does not appear to be a causative factor for the steady improvement of these countries.

Group B – GHI over Time.

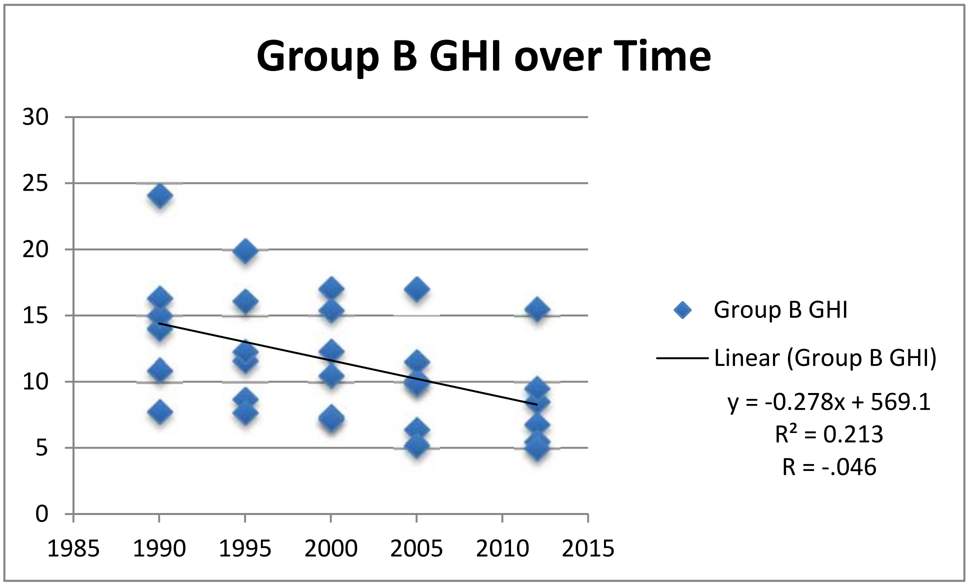

Figure 3.5: Scatter plot and trend line for Group B of GHI from 1990 to 2012 measurements.

Countries that have banned GMO cultivation, but their laws allow products that crops containing GMOs show a relatively clear pattern of lowering GHI over time. This negative correlation is moderately strong, with statistically significant p-value of .01. It appears from this result that it is no accident that countries accepting GMO imports are experiencing lowering GHI over time. Most countries in this group experience the greatest downward trend after 1996, when the first GMO crops were introduced for commercial production.

Group C: GHI over Time

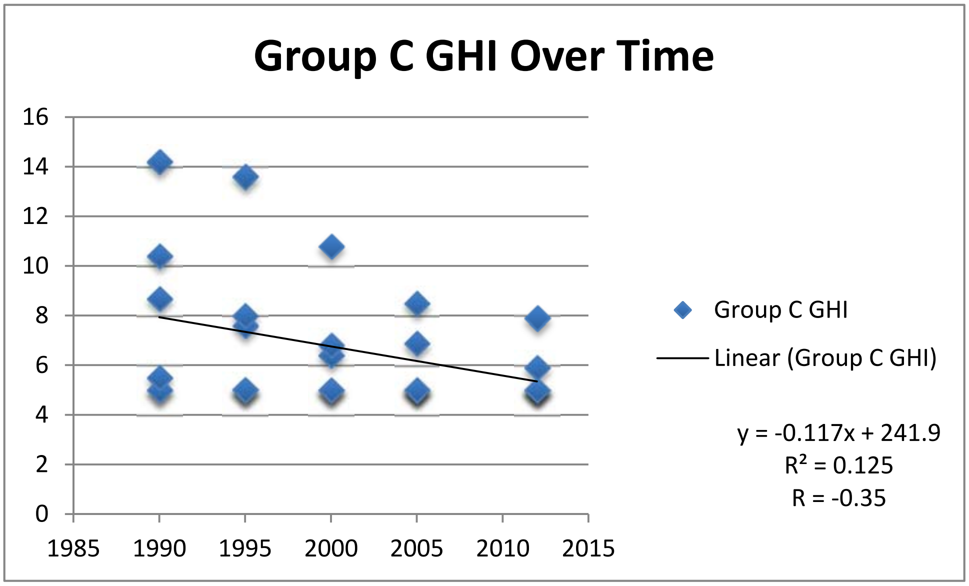

Figure 3.6: Scatter plot and trend line for Group C of GHI from 1990 to 2012 measurements.

Countries that have accepted GMOs for cultivation and importation have experienced a steady decrease in GHI. Argentina and Chile have remain steady at or below 5, indicating virtual elimination of hunger in the country. After 1996, countries such as Honduras and Colombia experienced the most dramatic falls in their GHI. At a p-value of 0.05, we can be 95% confident that the pattern observed is due to open GMO acceptance.

Group D: GHI over Time

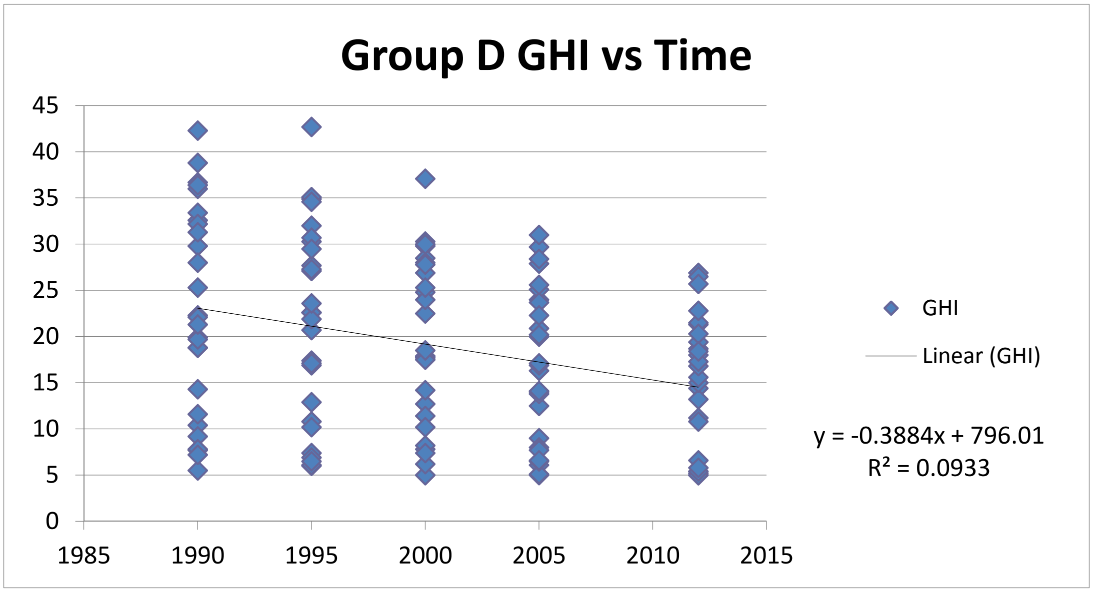

Figure 3.7: Scatter plot and trend line for Group D of GHI from 1990 to 2012 measurements.

The 27 randomly selected countries show a low-moderate correlation of decreased GHI due to time. African countries, such as Mozambique and Ethiopia, showed the most apparent changes after 1996. Mozambique currently accepts GM imports. Ethiopia has adopted a stringent regulatory practice since 2009, and it is unclear how this has affected imports and of GM products. A p-value of 0.00 indicates that we can infer that time alone may have statistically significant role in the gradual decline in the GHI of randomly selected countries.

Freedom House Score:

Similar to the ITS, Group A, B, and C have weak correlation coefficients. Although there appears to be a weak correlation between GHI and civil liberties, it is the strongest correlating factor for countries in Group A for this study. Furthermore, it is the statistically most significant factor for Group A and C countries.

Group A – Freedom House Score and GHI

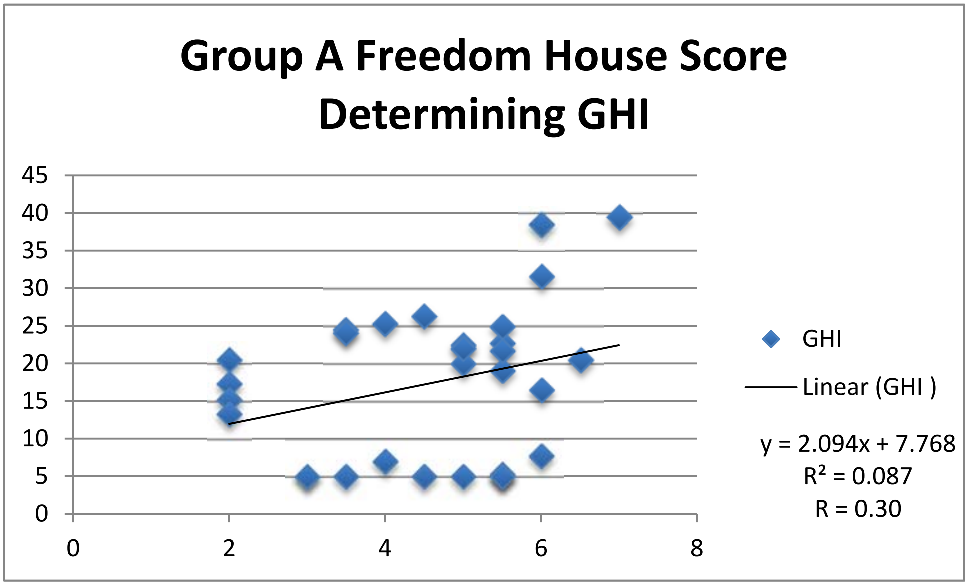

Figure 3.8: Scatter plot and trend line for Group A of GHI and FHS over the period of 1990 to 2012 measurements.

For Group A, there was a slightly stronger correlation between GHI and Freedom House Score (FHS) than between GHI and Time. The p-value, although statistically insignificant, shows the most significance among all categories for Group A. The graph shows a slight positive correlation between worsening levels of political/civil liberties and a worsening of hunger levels in the country.

Group B – Freedom House Score and GHI

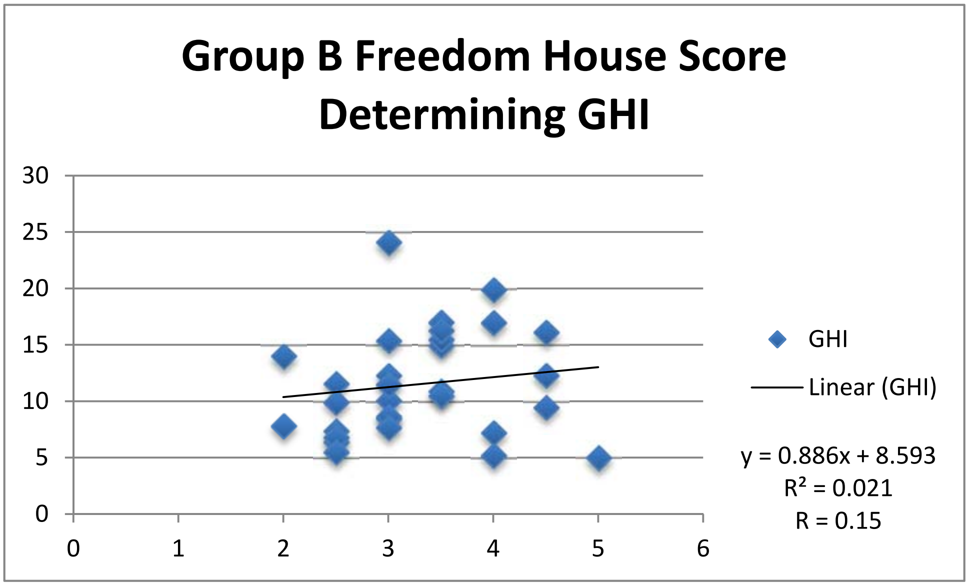

Figure 3.9: Scatter plot and trend line for Group B of GHI and FHS over the period of 1990 to 2012 measurements

Countries explicitly accepting GMO imports while banning GMO cultivation appear to have a very weak correlation coefficient of 0.15, indicating a weak to non-existent relationship between a decrease in civil liberties and increased hunger. A p-value of 0.44 indicates further the statistical insignificance of this correlation.

Group C – Freedom House Score and GHI

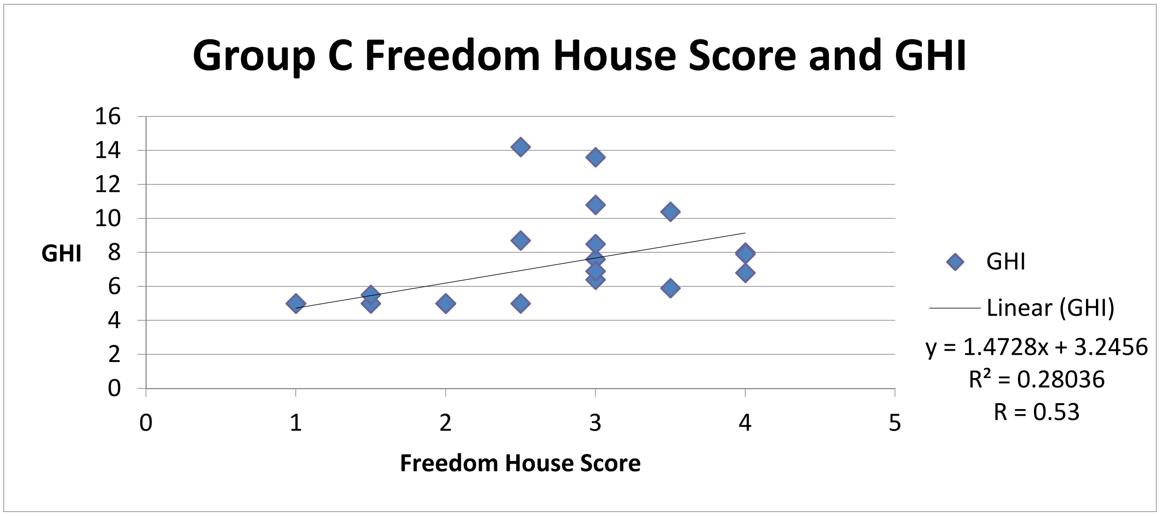

Figure 4.0: Scatter plot and trend line for Group C of GHI and FHS over the period of 1990 to 2012 measurements

Countries that have accepted GMOs for cultivation and importation moderately correlate an increase in a state's hunger with a decrease in civil liberties. A t-test revealed statistical significance at the 99% confidence interval.

Group D – Freedom House Score and GHI

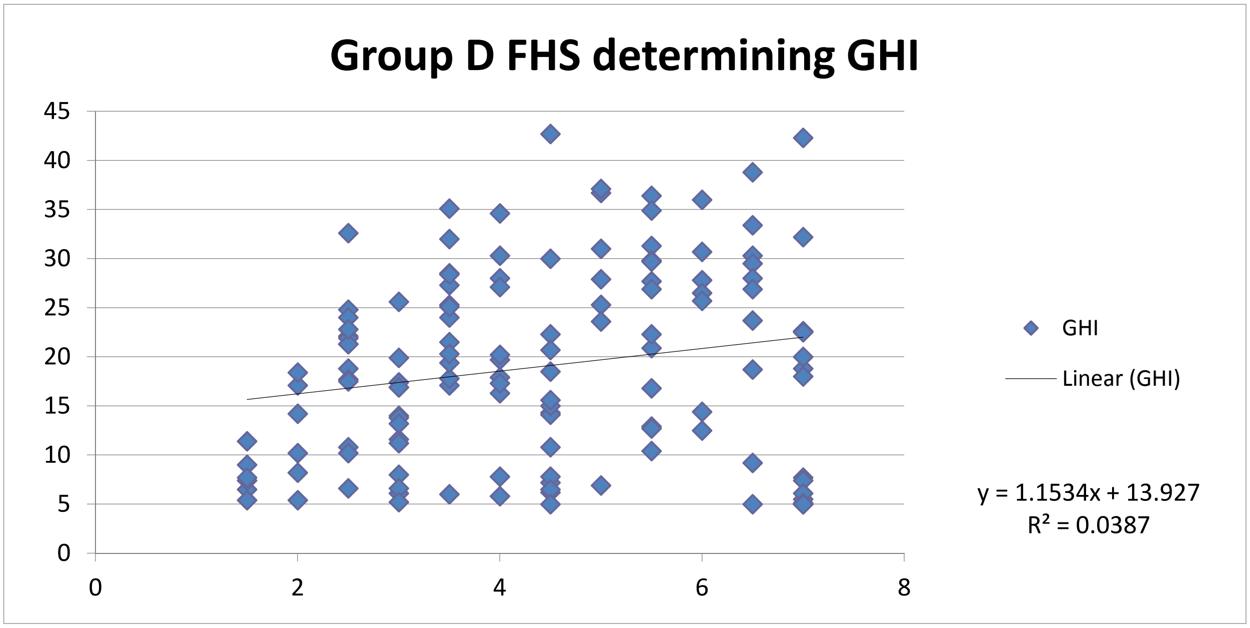

Figure 4.1: Scatter plot and trend line for Group D of GHI and FHS over the period of 1990 to 2012 measurements

For the random sample, there is a low-moderate correlation between the increase in a state's GHI and a decrease in political right and civil liberties. The p-value of the regression showed statistical significance at the 95% and 99% confidence interval.

Political Stability Score:

The data show weak and low-moderate scores for all three groups. PSS is also the strongest correlating factor to GHI for Group C, with a corresponding statistical significance at the 95% confidence interval.

Group A – Political Stability and GHI

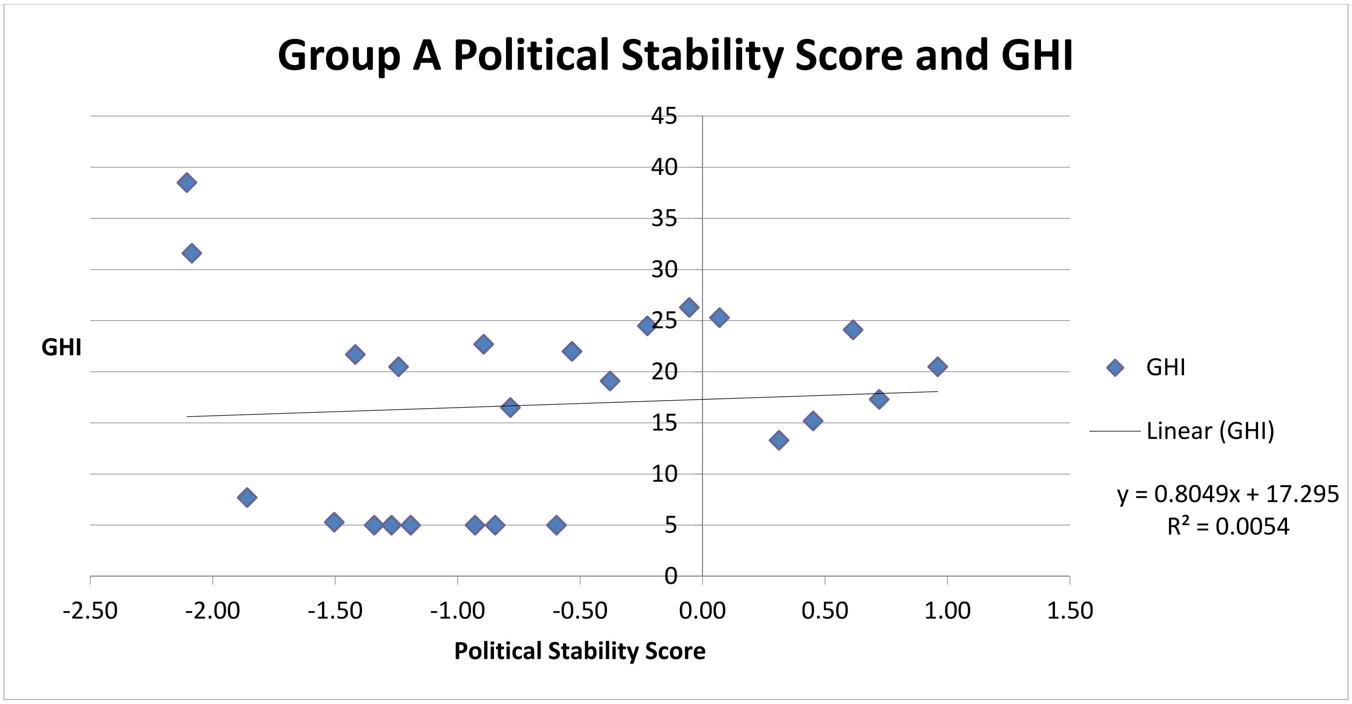

Figure 4.2: Scatter plot and trend line for Group A of GHI and PSS over the period of 1995 to 2012 measurements.

For Group A, the Political Stability Score (PSS) shows the weakest correlation for countries that have banned GMO imports and cultivation. PSS also showed the most statistically insignificant p-value of 0.73. As indicated by the graph, countries such as Turkey experienced low hunger despite relative political instability while countries such as Benin experienced a high GHI despite relatively high political stability.

Group B – Political Stability and GHI

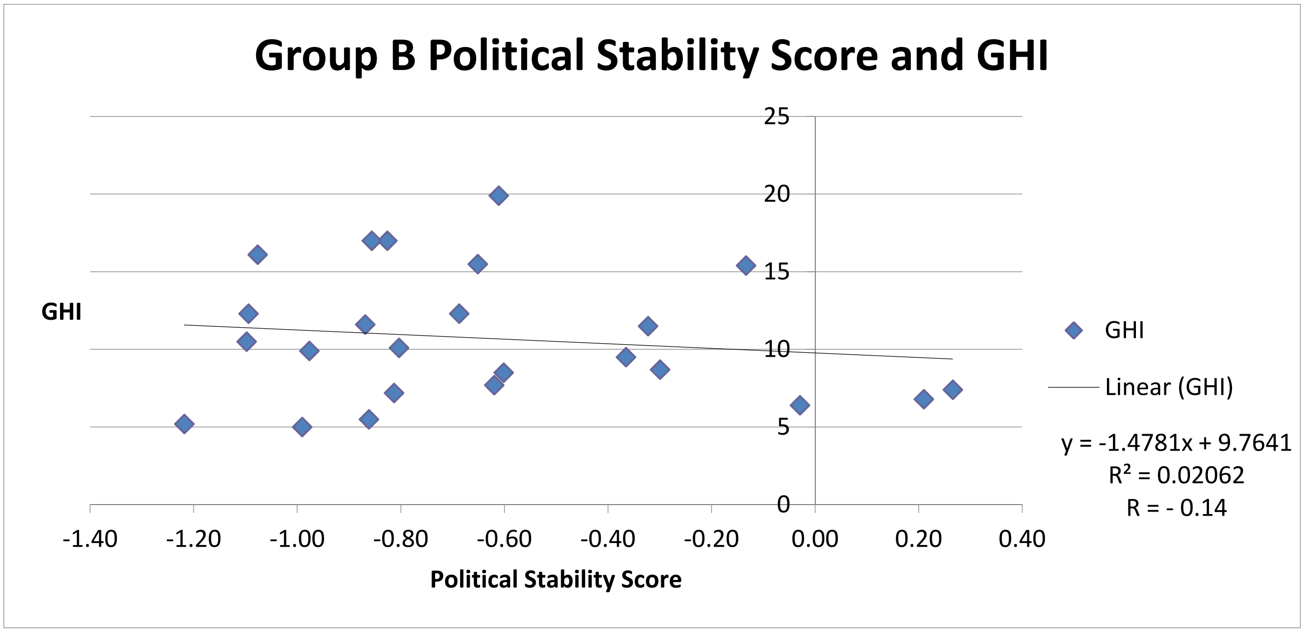

Figure 4.3: Scatter plot and trend line for Group B of GHI and PSS over the period of 1995 to 2012 measurements

Countries that have accepted importation while banning the cultivation of GMOs have shown a weak negative of decreased hunger relative to increased political stability. A p-value of 0.50 indicates statistical insignificance with this regression.

Group C – Political Stability and GHI

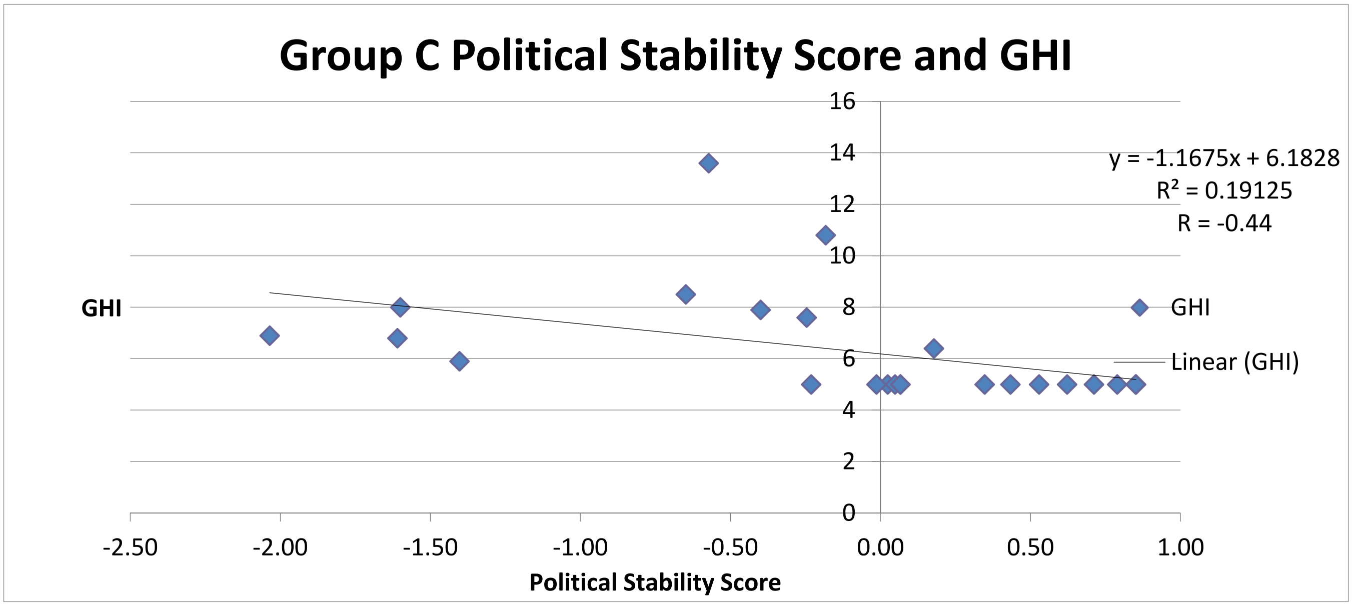

Figure 4.4: Scatter plot and trend line for Group C of GHI and PSS over the period of 1995 to 2012 measurements

Countries that have accepted GMOs show a moderate negative correlation between greater political stability and a lowered GHI. A regression analysis shows statistical significance of this regression model at the 95% confidence interval.

Group D – Political Stability and GHI

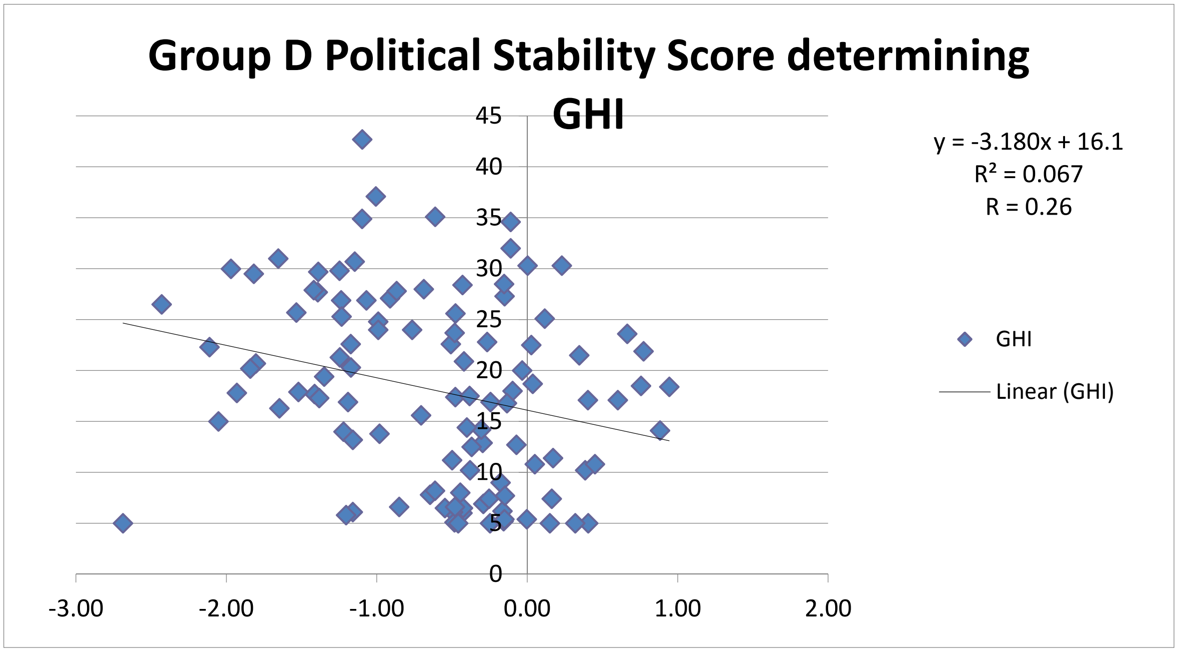

Figure 4.5: Scatter plot and trend line for Group D of GHI and PSS over the period of 1995 to 2012 measurements

The randomly selected group of 29 countries showed low-moderate negative correlation between the Political Stability Score (PSS) and GHI. The regression model, however, is found statistically significant at the 99% confidence interval.

GDP per capita:

Group A:

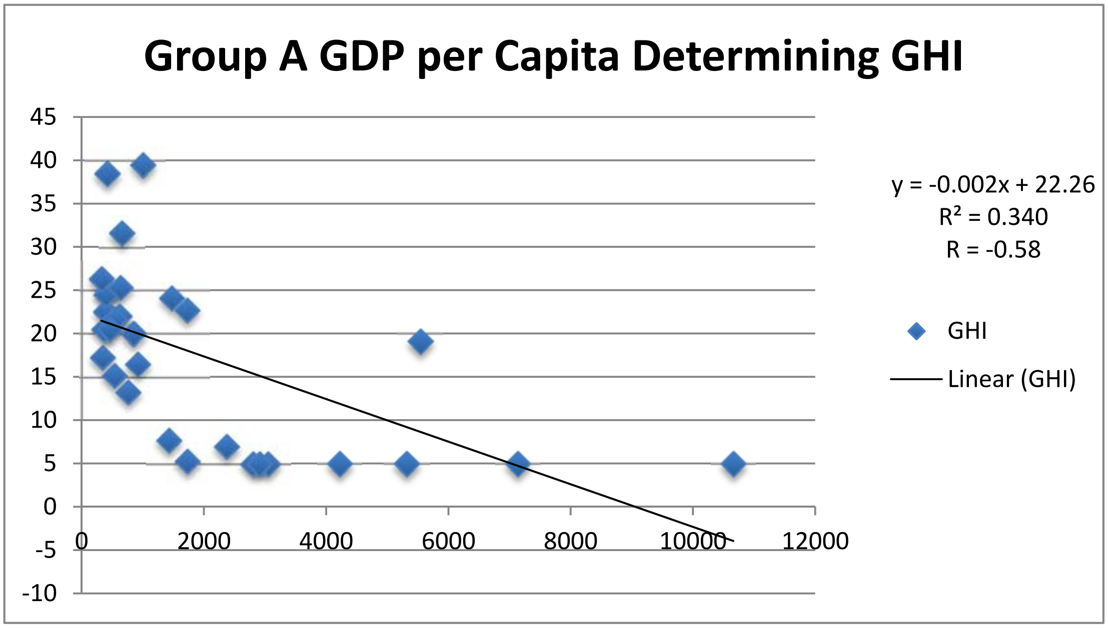

Figure 4.6: Scatter plot and trend line for Group A of GHI and GDP per Capita over the period of 1990 to 2012 measurements

Group A showed high-moderate negative correlation between GDP per capita and GHI. A regression analysis of the data showed that this correlation is significant at the 99% confidence interval.

<u>Group B:</u>

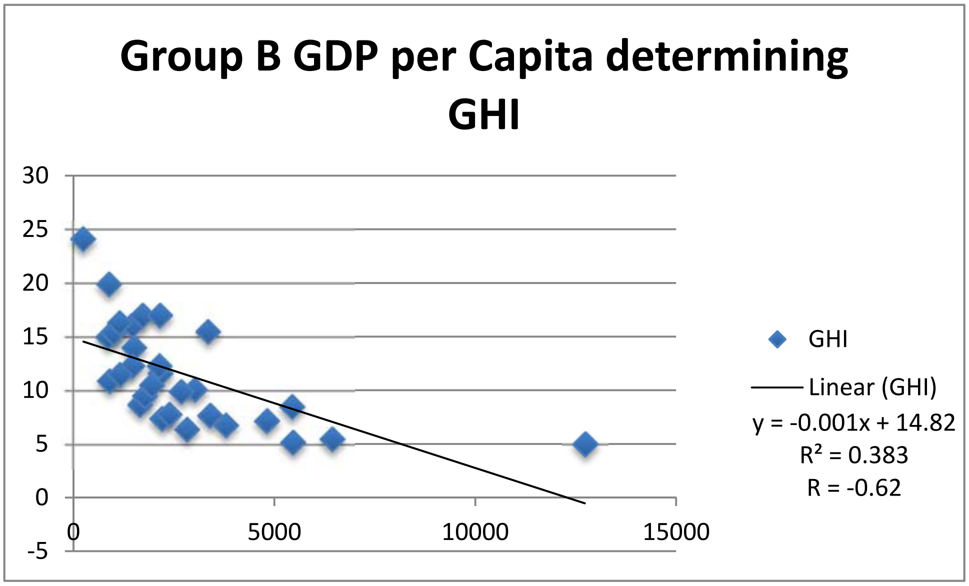

Figure 4.7: Scatter plot and trend line for Group B of GHI and GDP per Capita over the period of 1990 to 2012 measurements

Group B showed a high moderate negative correlation of -0.62. A regression analysis of these data showed that this regression is statistically significant at the 99% confidence interval.

Group C:

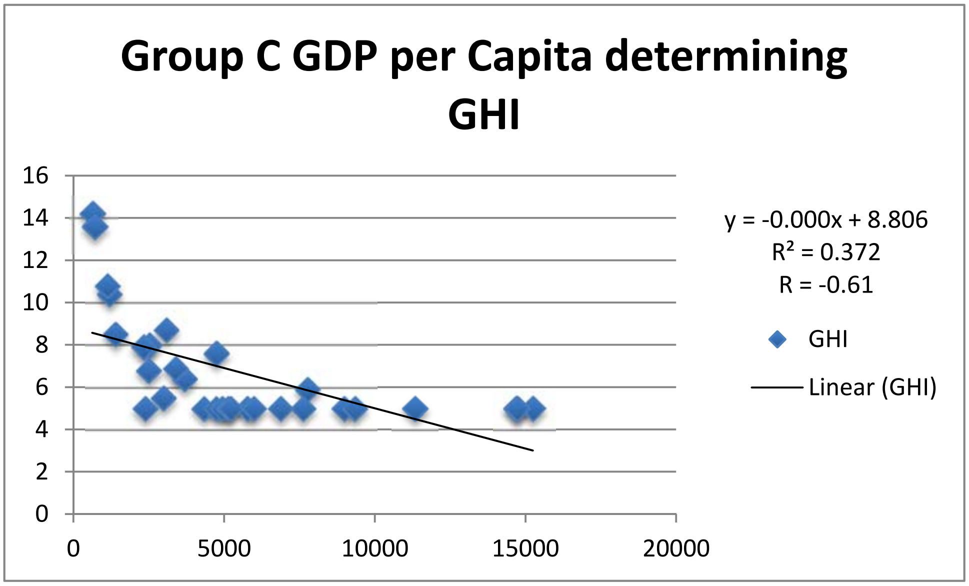

Figure 4.8: Scatter plot and trend line for Group C of GHI and GDP per Capita over the period of 1990 to 2012 measurements

Group C showed a high-moderate negative correlation between GDP and GHI of -0.61. A regression analysis of this model showed a statistical significant result at the 99% confidence interval.

Group D:

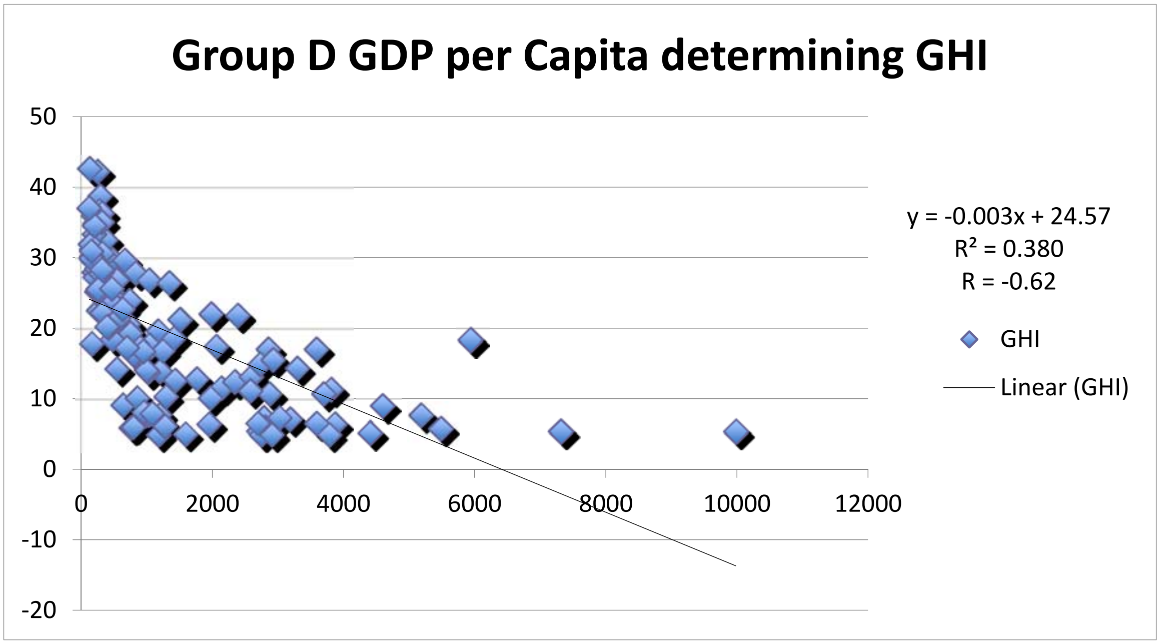

Figure 4.9: Scatter plot and trend line for Group D of GHI and GDP per Capita over the period of 1990 to 2012 measurements

Group D showed a high moderate negative correlation coefficient of -0.62. A regression analysis of this model showed statistically significant results at the 99% confidence interval.

Chapter 4: Results of Qualitative Analysis

Group A:

From the period of 1990 to 2012, the countries that currently ban genetically modified food for cultivation and importation have undergone various events that may correlate well with fluctuations in GHI. Historical, political, economic, and ecological were the main factors considered for analysis and appear to cover all possibilities.

Algeria: The oil shock of the late 1980s is seen as the main culprit contributing to a slowing of growth until 2001 (Tiliouine, Cummins, and Davern 2006). Furthermore, between 1991 and 2002, violence between Islamist armed groups and the national army had led to the lost of lives as well as social and political stability. The environment had calmed down slightly due to many armed groups being granted amnesty since 2000, but by then, 30% of the labor force was unemployed and approximately one-third of the population lived in poverty. Meanwhile, average consumer prices had risen by about 85%. Added to this, although there had been many known epidemics through Algeria each year, there has been substantial improvement since 2001 due to increasing oil prices.

Research through Algeria's perspective may support the idea that conflict – internal and territorial – is the main cause for hunger and fluctuations in food security. Violence within a country can hamper a country's ability to prioritize food production and build a productive economy (Cohen and Pinstrup-Andersen 1999). The quantitative data collected show some congruencies with the literature analysis. Economically, one can observe a severe drop in GDP per capita during the most severe periods of conflict from 1990 to 1995. Afterward, there is minor improvement until 2005, when GDP per Capita finally exceeds the figures in

1990. 2005 PSS is also seen as noticeably improved by 2005, although increases in violent protests in several cities toward 2011 may have contributed to a worsened PSS score. There is also a noticeable parallel between the FHS data and historical analysis, where political freedoms and civil rights significantly declined from 1990 to 1995 as the violence within the country escalated. Afterward, there was some mild relief, but violent protests keep Algeria in a defacto state of emergency. The GHI of Algeria fluctuates in concordance with the details of Algeria's historical conflicts and the economic repercussions of an oil crisis and war. Food security showed the most improvement since after 2000, when most of the armed conflict had declined.

Angola:

Several scholars would argue that countries such as Angola experience some of the most severe cases of food crises because of their prolonged violent conflicts (Scanlan and Jenkins 2001). Angola had experienced a civil war until 2002, whereby most of its economic reconstruction has been propelled by the oil trade (Soares de Oliveira 2011).The most noticeable decline in GHI is after 2000, from 31.6 in 2000 to 22.7 in 2005. Angola has also become noticeably most stable during this period, from a PSS score of -2.09 in 2000 to -0.89 in 2005 and -0.38 in 2012. The country has also experienced a rather significant jump in GDP per capita since 2000, from $656 in 2000 to $1707 in 2005 and $5539 in 2012.

Benin:

Elucidated by the GHI model, Benin has enjoyed a gradual decline in its GHI since 1990, from 22.5 in 1990 to 13.3 in 2012. This trend has occurred despite declining PSS and fluctuated GDP per capita, but improved FHS since 1990 when the official constitution of

Benin had been completed (Dossou-Yovo 1999). Benin, however, is heavily dependent on agricultural yields for its economy. Varying crop prices, despite steadily increasing yields, can help to explain Benin's irregular GDP per capita growth rate - especially for cotton exports (Baffes 2005).

Turkey:

Turkey has remained without a significant food security problem since the beginning of the GHI study. FHS and PSS have both fluctuated throughout this time period. Meanwhile, GDP per capita increased in Turkey faster and by more than any other country in Group A. With access to EU markets, Turkey's economy is heavily based on the production of motor vehicles and consumer electronics (Banalieva and Sarathy 2011).

Zambia:

Fluctuating minimally, Zambia's GHI has remained quite high from 1990 to 2012. GHI was at its worst in 2000, steadily climbing from 24.9 to 26.3, before dropping to 24.1 by 2012. According to some scholars, the primary obstacle between Zambia and its food security is geography. As a land-locked country, Zambia has access to less trade partners and options. Trading profits are also limited due tariffs and other fluctuating trade policies by neighboring transit countries. The extra costs associated with a landlocked country ultimately passes to the consumer, where food prices can become too high to afford (Naylor and Falcon 2010). Meanwhile, other scholars suggest that, since 1995, the local food economy has been hampered by the introduction of big chain supermarkets. Although Shoprite sources up to 80 percent of its fresh fruit and vegetables from Zambia, they are normally sources from large-scale commercial farms. Furthermore, processed foods are regularly sourced from South

Africa and other countries. As a result, many local markets and producers have been displaced (Crush and Frayne 2011). Zambia's drop in GDP per capita until after 2000 correlates well with Zambia's dependence on the copper trade. After 2002, increased investment, privatization, and increased consumption from countries such as China were factors that reportedly boosted the Zambian economy significantly(Carmody and Hampwaye 2010). Throughout the period of the study, Zambia has also reported significant increases in PSS, while FHS has remained variable. It was after 2000, however, that Zambia began on a trajectory that led to its current lowest GHI of 24.1

Zimbabwe:

Since 1990, Zimbabwe's FHS progressively worsened, from 5 to 6 over the period of the study. Political stability has also worsened, reaching its peak instability at the 2000 measurement of -1.42 before reaching a milder instability level -0.79. GDP per capita also reached its worst level by 2005, at $453, before shooting up to a high of $909 by 2012. The economic and political decline of the country prior to 2005 can be partially attributed to the economic drain in Zimbabwe's involvement in the war in the Democratic Republic of the Congo. It was also during this period that there was massive overhaul and redistribution of territory owned by the White population. Production had sharply declined, inflation had risen by as high as 11.2 million percent, and unemployment was as high as 80 percent. The boost in GDP per Capita, improvement in political stability, and decrease in GHI can be due to a variety of factors. The 2006 discovery of the Marange diamond fields contributed significantly to the economy. Furthermore, Zimplats, the country's largest platinum company, had invested significantly in expansion since 2009. Furthermore, efforts by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) had invested heavily in maintaining sustainable farming practices in Zimbabwe, reportedly preventing soil disturbances and increasing yields by as much as 100 percent between 2005 and 2011 (Mazvimavi et al. 2012).

Group B: Countries that do not cultivate GMO maize, but allow products containing GMO maize to be imported.

Ecuador:

Ecuador shows minor fluctuations from improvement across all variables from 1990 to 2012. The slight increase in GHI could be attributed to various causes and correlations. The increase in GHI correlates with a sudden drop in GDP per capita, a slight increase in FHS (the country became slightly less free), but also a slight improvement in political stability. The significant drop in GDP per capita may have been due to the banking crisis in the late 1990s, when Ecuador ultimately had to give up its sovereign currency, the sucre, in exchange for the US dollar (Jameson 2003).

El Salvador:

The data show that El Salvador showed a general trend of steadily improving GHI until the period between 2005 and 2012. During that time, there were no apparent changes in FHS, an improvement in political stability, and an improvement in GDP per capita. With no obvious correlation, other possible links must be explored. Scholars have actually pointed to the rapid and under-regulated adoption of liberalism as the culprit, making the country economically more unequal and expensive while less free (Wade 2008).

Guatemala:

The data show that Guatemala’s GHI steadily worsened from the beginning of the study until the 2012 results. Accounting for this is not apparent through the measured potential indicatives. GDP per capita consistently increased from $860 in 1990 to $3341 in 2012. Furthermore, according to studies such as Naylor and Falcon, price increases during notable staple crop hikes, such as in 2008, did not significantly impact domestic prices in Guatemala (2010). Nevertheless, the study concludes that Guatemalans have been particularly disadvantaged by crop prices and per capita expenses. Large portions of the Guatemalan population, especially the poor, are dependent on the sale of their crops in local markets, but crop prices and competition still push them to be net consumers. This results in a widening gap between the rich and poor, especially between small farmers and large landowners. Although GDP per capita may have increased throughout the years of this study, income inequality as measured by the GINI index has remained high and above average compared to neighboring countries (Holden and Jacobson 2008).

Nicaragua:

Nicaragua showed fairly significantly improvement in GHI by comparison to the beginning of the study, and without fluctuations from this trend. From 1990 to 2012, Nicaragua’s GHI went from 24.1 to 9.5, with no upward fluctuations. FHS remained between 3 and 4.5, fluctuating throughout the study’s durations, while PSS showed improvement in 2012 compared to 1996, but with fluctuations between worsening and improvement between those years. Meanwhile, GDP per capita had increased consistently throughout the study, most significantly between 1990 through 1995 and 2005 through 2012. Journal records are rather vague, besides pointing to increased foreign investment, creating a large tourist industry, and the heavy use of foreign food aid due to Nicaragua's inability of supply most of its own food needs (Clapp 2005).

Peru:

Peru's GHI dropped from 16.3 in 1990 to 5.5 in the 2012 analysis, indicating that Peru is close to having virtually insignificant hunger issues. This improvement proceeded with no fluctuations in the trend. During this study, Peru had fluctuated in its FHS trend, become less free from 1990 to 1995, but improving from 1995 to 2000 before settling at 2.5. Meanwhile, PSS showed instability, but a generally improving trend since 1996. Furthermore, it was between 1995 and 2000 that GDP per capita lowered from $2,132 to $1,949 after an upward trend from $1,149 in 1990. Peru is relatively resistant to GMO acceptance, but has taken steps to allow Peruvians to use GMOs for export (Nolte and Beillard 2014). Furthermore, the Asian crisis of 1997 is claimed as the primary culprit for Peru's sudden downward trend in economy prosperity, but it apparently did not affect GHI (Khan 2004).

Venezuela:

Venezuela has experienced a trend toward virtually no hunger at a GHI of 5 by 2012. During this time, there was uninterrupted increase in GDP per capita for each measured year, from $2,382 in 1990 to $12,729 in 2012. FHS was measured as gradually trending toward less free, from 2 in 1990 to 5 in 2012. Meanwhile, PSS had fluctuated, but generally measured as moderately or very unstable. The growth in Venezuela has been largely contributed to the discovery of the world's largest oil reserves. Since 1999, Chavez was known to use oil revenues to foster food security initiatives throughout the country (Clark 2010).

Argentina:

Since the beginning of this study, Argentina has showed no change in overall GHI - it has remained an insignificant issue. And beside a small fluctuation in 1995, Argentina has remained and trended more toward being a freer country according to its FHS. According to PSS, the country measures on the more stable (positive) end overall, with only a slight trend toward instability 2005. GDP per capita also dipped sometime between 2000 and 2005, from $9,329 to $5,768, before shooting up to $14,680 by 2012. Although it did not seem to affect food security, this drop in per capita GDP can be accounted to the December 2001 default of Argentina's $93 billion debt to the United States, which resulted in a deep recession and drastic decline in GDP (Arellano 2008).

Brazil:

Brazil showed a steady decline in GHI from 1990 to 2012, from 8.7 to 5, signifying the virtual elimination of hunger as a serious issue in Brazil. Brazil has remain relatively considered free by its FHS, but fluctuated slightly from 2.5 in 1990 to 3 in 1995 and 2000 before returning to 2 until the end of the study. Meanwhile, Brazil showed variable changes in PSS, with peak instability at 1996 with -0.25 and peak stability at 2000 with 0.18. GDP per capita also declined between 1995 and 2000, reaching a low of $3,694 in 2000 before climbing to a high of $11,320 by 2012. Agriculturally, Brazil primarily trades with the United States in order to supplement for any local shortfalls due to weather or other environmental issues. Nevertheless, it has grown to become a major producer and exporter of products such as soybeans, cotton, sugar, cocoa, coffee, frozen concentrated orange juice, beef, poultry, pork, tobacco, hides and skins, fruits, and nuts, and fish. As a source of food aid from several lesser developed countries, Brazil is expected to remain highly food secure in the near future. Its food aid exports are non-GMO, but Brazil is currently a leading exporter of biotech soybeans, corn, and cotton (Silva and O'Kray 2013). The economic downturns, along with political stability and civil liberty variations, occurred irrespective of the improvement in agriculture, and are regularly accounted for by the severe effects of several external circumstances such as the East Asian financial crisis and the Russian default in 1998 (Akcay and Zenginovuz 2001).

Chile:

Since the beginning of the study, Chile has remained consistently with a GHI reading equivalent to insignificant hunger issues – a score of 5. During this period, Chile has also remained a country considered free, moving from an FHS of 2 to 1 after 2000. Furthermore, PSS has remained positive, fluctuating moderately between a high of 0.85 in 2005 and a low of 0.35 in 2012. Meanwhile, Chile has also remained steadily increasing in GDP per capita since the beginning of the study, from $1,209 to $15,245 in 2012. Chile has been propagating GM crops for more than a decade, and can currently produce transgenic crops for export, including sugar beets, corn, alfalfa, and soybean (Ramirez 2013). With all possible indicators remaining consistent, it is not easy to predict the cause of Chile's food security success.

Colombia:

Various indicators imply considerable instability throughout the country. GHI, however, has shown relatively consistent improvement since the beginning of the study. Other than a minor spike from 6.8 to 6.9 between 2000 and 2005, there was an overall drop from 10.4 to 5.9. According to the Freedom House Score, the country has been partially free for the duration of the study, fluctuating from a low of 3 in 2005 to a high of 4 in 1995 and 2000.

Political instability happened to peak in 2005, as the country was considered most free. 2005 was also the year measured when Colombia's GDP per capita appeared to have recovered from a minor slump in GDP per capita growth in the previous year. Instability in the country has been long attributed to the FARC. Until approximately around 2000, the US has inadvertently strengthened the FARC by destroying its political and military rivals in the region (Peceny and Durnan 2006). The strengthening of the FARC contributed to negative economic and political consequences (Rocha Garcia 2003). Although Colombia has an abundance of arable land, most of less appropriate land is dedicated to food production. This has resulted in Colombia being highly reliant on food imports (Richani 2012). It is also a limited food aid recipient from the United States. Meanwhile, Colombia has been producing GM corn since 2007, along with GM cotton and carnations (Gilbert and Uribe 2014).

Honduras:

Honduras has experienced consistent and gradual improvement in GHI, from a high of 14.2 in 1990 to 7.9 in 2012. GDP per capita also shows consistent improvement, from $622 in 1990 to $2,339 in 2012. Meanwhile, other possible indicators are inconsistent during the period of measurements. PSS experienced its best level at -0.18 in 2000, worsening to -0.65 in 2005 before showing some slight improvement in 2012 at -0.40. FHS gradually worsened, from 2.5 in 1990 to 4 in 2012. Honduras happens to be the only Central Americans country that allows the commercial production and field trials of biotech crops, including bananas, corn, soybeans, and rice. Commercial population of corn is highly regulated, but allowed in specific areas (Gomez 2012). To combat remaining hunger issues, food aid programs have been established in Honduras for several years (Shaw, Crawshaw, and Fortier 1994).

Uruguay:

Uruguay has experienced virtually no significant hunger issues since the 1995 GHI analysis. Meanwhile, its FHS indicates that despite a slight increase from 1.5 to 2 (Free), Uruguay has remained “Free” according this measurement. Political Stability Score has also remained positive, from a low of .53 in 1996, it fluctuated from a high of 0.85 in 2000 before lowering to 0.71 by 2012. Meanwhile, GDP per capita dipped between 2000 at $6,873 to $5,222 in 2005. This can be largely attributed to a spillover effect after the economic downtown of Uruguay’s neighboring countries, especially Argentina (Meyer 2010 “Uruguay: Political and Economic Conditions and U.S. Relations”). None of these indicator seemed to have made a significant impact on the overall. Highly dependent on agriculture, around 10 percent of Uruguay’s GDP is dependent on agricultural trade, with 67 percent of the country’s total exports in agricultural products. Uruguay has been commercially producing biotech corn in 2003, with approval of biotech varieties mostly dependent on the export market (Yankelevich 2013).

Chapter 5: Discussion and Conclusion

Group A:

Countries that have banned GMO cultivation and imports are showing a low-moderate trend of decreased hunger within their states over time. Among all possible correlating factors, GDP per capita was the most statistically significant. The factor with the strongest correlating trend was the GDP per capita, followed by Freedom House Score. The factor or factors that truly help these countries to be become more food secure appears to be the interaction of the studied factors and others left for future research. One can conclude that food security does not depend on GMO acceptance, but will vary based on the specific historical needs of the states, as seen through the qualitative analysis. Being a "free" state may yield some indirect consequences that benefit food security, while GDP per capita is a clear indicator of overall wealth and the ability to purchase food.

Algeria has relied heavily on humanitarian aid, especially for its Sahrawi refugees, and that may contribute to its extremely low GHI despite being an arid and harsh climate for agriculture. Since independence, Algeria has suffered a complex array of issues that have prevented it from stabilizing its food supply. The primary reason, however, has been noted since the 1970s as government neglect and faulty government policies regarding agriculture. Some scholars would suggest, however, that the 1986 oil shock is responsible for destabilizing the country's clear growth trajectory (Tiliouine and Cummins 2006). As a country dependent on food imports, debt increased as the state's income decreased and overall growth has been minimal since that time. Other nuisances have affected agricultural output as well, such a large locust infestation in 2004 that upset agricultural output (Malkawi

2006). It is unclear if GMO crop approval may have led to the avoidance of such an infestation, but scholars such as Malkawi have indicated the possibility.

Angola, as seen on the graph (GHI Over Time), experiences the most dramatic fall in GHI after 2000. It is well known that the civil insurgency within Angola by militant group UNITA continued until 2002, when its leader passed away. This time period also coincides with a rather dramatic improvement in Angola's Political Stability Score (PSS) and a subtle improvement in its Freedom House Score (FHS) after 2000. A generally unstable political climate has been accused as the main culprit for lacking progress in food security, even when effort is made to fulfill liberal ideals such as the privatization of the agricultural sector (Munslow 1999).

Benin is a country that has shown gradual improvement in not only GHI, but also on all independent variables that may be correlated with greater food security. Studies have shown, however, that the greatest causal factor to hunger in the state may be climate fluctuation (Paeth et al 2008). Crops that are typically grown in the country appear to be especially sensitive to factors such as rainfall. The cause of increased food security in the area, according to one study, is the increased production of 2

Zambia's fluctuation, however, may be due to several historical factors that cannot be so readily deciphered. An economy based on copper mining, Zambia suffered greatly into the late 1990s as production fell due to lack of investment and falling copper prices. The economy did not report growth until 2007, shortly after a reported drop in GHI. Economic strength and changes in economic policy, such as austerity measures and conditionality agreements, are factors worthy of consideration in future studies of food security. A measurable factor such as GDP is suggested for future quantitative analysis, especially for countries that have banned the cultivation and importation of GMOs.

Group B:

Statistical significance is observed for regression models when observing GHI over time, GDP per capita, and GHI over varying periods of political stability (Political Stability Score). Although there is a relatively weak negative correlation between political stability and decreased hunger, this is, as seen with Group B, a possibly significant factor for specific countries within the group. Guatemala's mild jump in GHI after 1995 corresponds neither with increased political instability nor decreased civil/political freedoms. Furthermore, due to increased political stability after the 1996 peace accords ending the civil war, the country saw an increase in economic growth due to increased foreign investment, increased tourism, and receiving remittances from Guatemalans that had fled to the United States during the war. Possibly future studies can seek to clarify the complex consequences (positive and negative) of economic growth, such as income disparities. A possible statistic that may help in this study would be the GINI index.

Group C:

GDP per capita, political stability and civil/political freedoms seem to be greater correlative factors toward decreased hunger than the factor of GMO deregulation. The graph, GHI Over Time, for Group C shows a weaker negative correlation, indicating that isolating the factors of GMO acceptance for cultivation and import does less to ensure a state's food security than civil freedoms or political stability. The graph indicating PSS shows moderate correlation and statistical significance, while it is also visibly apparent that GMO cultivating and importing countries enjoy greater food security when their states were more stable and free. Colombia, for example, fluctuated in food security as the country experienced varying political stability from 2000 to 2012. Observations like this are less apparent for countries such as Honduras, which has experienced fluctuating degrees of political stability and civil freedoms for the duration of the study, but has experienced significant improvements in food security from the beginning to the end of this study. The acceptances of GMO crops may have played a role for this individual country, but it is advised that future studies investigate other factors further such as a economic growth, income per capita, and even the acceptance of food aid.

Group D:

It is apparent from the Initial Test Series (ITS) that the random sample has experienced decreased overall hunger in their respective countries over time. Furthermore, the correlation between GHI and GDP per capita is fairly strong. The factors of PSS and FHS are interestingly similar – a low-moderate correlation. Both regression models were statistically significant. There is a possibility that that PSS and FHS were significant contributors to food security for specific countries, while the specific reason for others may vary similarly to the countries in the other groups. Furthermore, PSS and FHS may two of several variables that contribute to security. Ultimately, relative to the objective of this study, food security is not clearly tied to GMO acceptance, but a complex interplay of economic, political, international and civil actions specific to each state.

There is no indication within this study that GMO acceptance is a significant causal factor toward food security. The implications of this study can counter claims from policymakers and corporations that GMOs are solving world hunger. Thus far, after almost two decades of GM-crop commercialization, it is unfair to state that GMOs have or will significantly contribute to food security. Although Group B appears to show moderate significant correlation between decreased GHI and GMO deregulation, the results are confounded by an inconsistent pattern between Group A, Group C, and Group D. Political Stability seemed to have been a stronger factor toward food security for Group C states that have deregulated corn for cultivation and imports. Although no statistically significant correlations were found for Group A states, increased civil liberties showed the strongest correlation toward food security, suggesting the need for an increased sample size or the testing of other variables. The overall results suggest there is an interaction effect of a variety of variables and, regardless of status in GMO regulation, there is a general decrease in hunger for all states in this study.

Previous research has compiled maize field trials. Such research has concluded that GM hybrid corn does contribute to increased yield, but they admittedly do not provide reliable estimates of their contribution to yield over time. Experimental trials also cannot account for environmental changes, the possibility of infestation mutations, and the long-term effects of GM crops on a large farm (Nolan and Santos 2012).

Legally, the WTO outlaws the banning of food imports unless there is scientifically established evidence of a product or crop to be hazardous to the health of citizens. Sufficient scientific uncertainty appears to be the only factor that may prevent the WTO from disallowing a ban of GM crops, as soon by WTO decisions to outlaw bans of US beef to the

EU. The reason for this decision was reportedly due to the inconclusiveness of safety research on artificial beef hormones (Brom 2004). The EU and US have apparent differences in their definition of safety, as with their definition of security. Unfortunately, due to the nature of states and businesses to financially support research that may produce specific results, academia can hardly be seen as an independent referee in the arena of biosafety (Stone 2010).

To combat this legal framework established by the WTO and backed by GMO producers, the Cartagena Protocol upholds the precautionary principle as a tool to override the necessity for unequivocal scientific evidence. The Protocol declares that any level of scientific uncertainty can warrant regulatory practices until unequivocal scientific results have answered any questions concerns safety (Levidow 2001). Furthermore, the empirical quantitative analysis of this paper can also conclude that claims by the US against the EU for exacerbating global hunger through their precautionary measures is unfounded (Clapp 2005). LDCs are naturally caught on the fringes when a conflict occurs between economic giants, as they will rationally preserve their own power, even if it may cost them short-term gains such as food aid (Schneider and Urpelainen 2013).

Based on this research, it is safe to conclude that GM crops pose no more of a significant contribution to food security as do other, less controversial factors. LDCs as well as EU countries may be advised to focus on fortifying their political stability and ensuring a safe economically and politically free foundation for the agricultural sector and other businesses to flourish. GM-producing states will continue to push their agenda to expand their market, irrespective of biosafety claims, in order to satisfy the realist agenda to shift the status-quo of biotechnological hegemony in their favor. Considering case studies such as that of Oaxaca, there is a burden for GMO-laden countries, intentionally or unintentionally, to be responsible for the loyalties consistent with IPR protection of GMO usage (McAfee 2003). Food security is, thus, understandably, an uncertainty while bio-hegemony is a clear goal of producer states. If IPR over GM crops are perceived to obstruct food sovereignty, states will have a consistent reason to utilize the precautionary principle of the Cartagena Protocol until sufficient tracking and accountability mechanisms are introduced.

Evidence suggests, however, that producer states would be wise to forgo claims that GMO will ensure food security and cure world hunger (Clives 2012). They may have a strong case to keep borders open to GM products, under WTO regulations, but EU member states can be relatively sure that lower government bodies and consumers will forestall or eliminate the possibility of GM-crop acceptance in the near future (Kurzer and Cooper 2007).

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