A Comparison of Biofuel Market Potential in Selected Countries

By
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Global population growth and dependence on traditional energy sources has created an interest in biofuels and other alternatives to traditional energy. The economic disparity between countries raises questions about their ability and willingness to create biofuel markets. The purpose of this study was to examine the relationship of specific factors of selected wealthy and less wealthy countries with respect to their potential for biofuel market development. The selected countries were the United States, Brazil, Germany, Japan, Cost Rica, Tanzania, and Thailand. Through this introductory study of the relationship between the selected wealthy and less wealthy countries and the specific factors examined, opportunities and barriers to biofuel market development have been ranked and examined. The selected factors inventoried and compared for each country were: the cost of gasoline, petroleum-based transportation, domestic petroleum, access to infrastructure, infrastructure investment, private industry, government support, personal income, population growth. This study found of the selected characteristics, Brazil ranked with the highest potential for a biofuels market out of the seven countries with one possible barrier, petroleum based transportation. The United States and Costa Rica both ranked second each with two potential barriers. The United States two barriers were the cost of gasoline and petroleum based transportation. Costa Rica's two barriers were private industry and access to infrastructure. Ranking third was Thailand with three potential barriers. Ranked fourth was Germany and Tanzania, with four possible barriers and ranked last was Japan with five possible barriers. The results brought into question the common assumption that biofuels are related to the wealth of a country and countries that are not as wealthy do not have as many potential opportunities for biofuel market development. All factors inventoried and compared were found to play an important role in the development of biofuel markets.

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

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1. Introduction

Global population growth, dependence on traditional energy sources and concerns over carbon dioxide has created an interest in biofuels and other alternatives to traditional energy. The economic disparity between countries raises questions about their ability and willingness to create biofuel markets. The purpose of this study was to examine the role of specific factors of selected countries with respect to their potential for biofuel market development. Through this introductory analysis of the role between selected countries and the specific factors examined, opportunities and barriers to biofuel market development have been estimated.

Biofuels are only one of the many alternative energies the world has and is developing to reduce traditional energy use. This comparison was a beginning look into what biofuel's role is in the optimal energy mix for the selected countries. The comparison provided an idea of how biofuel markets are being created in the selected countries around the globe. With countries from Asia, Africa, North and South America represented, this study attempted to get a global perspective of the possible opportunities and barriers biofuel markets are having around the world and what development is being done around this particular energy source.

2. Literature Review

This section outlines recent studies done on international biofuel markets and the challenges, factors and impacts they have on both wealthy countries and less wealthy countries based on a country's gross domestic product. The research focused primarily on international biofuel markets, the potential opportunities for biofuel market growth and the barriers different countries are facing in the biofuel marketplace.

Biofuels as Commodities

The most significant renewable energy for the medium to long-term replacement of fossil fuels is biomass (Junginger et al., 2013). For the purpose of this study biomass is defined as sugarcane, sorghum, corn and oilseed crops that can be used as a feedstock for biofuel production. Biomass will also reduce greenhouse gas emissions. However, without the collaboration of countries to create an international standard for renewable energy replacements, the variation in incentives, sustainability frameworks and targets and certification systems are too varied to be effective. This fragmentation of all the components just mentioned can create problems in the international trade of the bioenergy commodities. With the exponential growth in bioenergy commodities, such as ethanol, biodiesel and wood pellets, these commodities have reached "true" commodity volumes, for example, tens of millions of tons being traded each year. In 2013 alone the U.S. exported 630 million gallons of ethanol (Renewable Fuels Association, 2014). The result of the growth in bioenergy commodities is an annual value of billions of US dollars and Euros, making the international trend of biomass and biofuel market development a global stabilizing factor for the bioenergy sector. With the increase in bioenergy commodity volume and market development, a common language is necessary to continue creating a sustainable framework for biomass because policies are being created in a variety of legal and policy settings across the world.

New Markets

When markets are being created both voluntary certification and binding regulations should reflect how markets work with a variety of biomass applications. The markets should not discriminate against the users of biofuels and the end uses of biofuel, as this will make the market inefficient. Realizing the administrative requirements for smallholders, the investment decision-making process and the position of developing countries will improve the market (Junginger et al., 2013). The push for government support regarding biofuels has been due to energy security, climate change and to support the agriculture industry by increasing demand. The amount of biomass support policies in place has grown, at least 69 countries have had one or several policies put into place as of 2009 (Junginger et al., 2013).

In 2009 global government support for bioenergy policy according to the International Energy Agency (IEA), World Energy Outlook, was 20 billion dollars into biofuels (Junginger et al., 2013). Questions about the price of food, environmental impacts and greenhouse gas emissions have led countries to reevaluate their blending objectives. For example, in the U.S. biofuel spending was pushed by the need for energy security and fossil fuel import reduction. Germany adjusted its blending target in 2009 from 6.25 to 5.25 percent because the European Union (EU) resolved food prices, environmental impacts and green house gas emission issues, by including in their EU Renewable Energy Directive an environmental and social sustainability criteria for biofuels (Junginger et al., 2013).

An obstacle Germany has faced is creating impact assessment frameworks and a sustainability criterion without having to go through major changes in their methodology, process development and synchronization. If society wants the biofuel market to work, the increase in standards that have been adopted by various nations needs to be become one language, data needs to be easily accessible and reliable, and indicators need to be linked at both the micro and macro level (Junginger et al., 2013).

New Biofuel Market Opportunities by Country

United States

The United States gross domestic product (GDP) in 2013 was 16.8 trillion USD ranking first internationally (World Bank, 2014). The U.S. has 36.52 billion barrels of proven oil reserves as of 2014 (U.S. Energy Information Administration, 2015). In 2012, biofuels accounted for 7.1 percent of total transport fuel consumption or 13.8 billion gallons and in 2010 ethanol production and consumption mainly from corn was over 13 billion gallons making it the most widely used biofuel (Boundy et al., 2011). Additionally, more than 7.3 billion gasoline-equivalent gallons were added to U.S. gasoline in 2009 (Boundy et al., 2011). Other biofuels being explored in the United States are biodiesel, bio-oil and other hydrocarbon biofuels. Biodiesel in the U.S. blends diesel with ethyl or methyl ester or can be used as a net fuel meaning it is 100 percent biodiesel. It is made from any vegetable oil, animal fats, waste vegetable oils, or microalgae oils. Soybeans and Canola oils are the most common vegetable oils. As of 2009 for bio-oil there are only two commercial fast pyrolysis technologies. Bio-oil is used in boilers for electricity generation. There is a lot of research being conducted on creating bio-oils suitable for transportation applications. Other hydrocarbon biofuels are syngas or biosyngas. Syngas is used directly for generating heat and power but several types of biofuels may be derived from syngas. The gas can be run through a biological reactor to produce ethanol. The wide range of single molecule biofuels or fuel additives can be made from lignocellulosic biomass. This production makes it chemically the same as petroleum-based fuels so modifications to existing engines and fuel distribution infrastructure is not required.

Brazil

Brazil makes their ethanol predominately from sugarcane but also uses corn. Brazil is one of the largest biofuel markets in the world (Kojima and Johnson, 2006). At one point there was a decline in the consumption of ethanol in Brazil, but now flex-fuel vehicles are revitalizing the sale of ethanol. Ethanol accounts for more than 40 percent of Brazil's gasoline-ethanol market. Ethanol is more commercially viable in Brazil compared to biodiesel due to the high costs associated with producing biodiesel. However, from an international perspective currently sugar cane is the most cost effective and productive source for producing ethanol (Kojima and Johnson, 2006). For Brazil to produce a liter of ethanol from sugarcane, it costs an estimated $0.23-$0.29 making it the cheapest biofuel today (Kojima and Johnson, 2006). Sugarcane compared to biodiesel, which costs $0.50 per liter to produce makes sugarcane an ideal feedstock. Sugarcane as a feedstock is commercially viable for Brazil because it accounts for 50-65 percent of the production cost for ethanol, but it's viability also is dependent upon the cost of cane production. The cost of cane production is low and highly productive in the center-south region because the cane does not need irrigation; it gets all of the water needed from rainfall. There are not competing needs for the land used for cane production in Brazil because there is still a lot of unused land in this region making cane production expansion easy. Technology has played a large role in the success of Brazil's biofuel market because currently producers use over 500 commercial cane varieties that are resistant to the 40 plus crop diseases found here (Kojima and Johnson, 2006). Hybrid cars have allowed consumers to no longer fear a shortage of ethanol making this market more viable. Production flexibility is a key factor in Brazil's success. Cane distilleries belong to sugar mills or distillery complexes, so they are able to switch from producing sugar to ethanol when the price is in favor of one or the other, providing these producers the flexibility to maximize profits. Cane producers can also respond to fluctuations in the marketplace much quicker allowing them to turn molasses into ethanol.

Germany

Germany is ranked fourth internationally with a GDP of 3,634,823 million USD (World Bank, 2014). Germany has 0.23 billion barrels of proved reserves as of 2014 (U.S. Energy Information Administration, 2015). Currently there are lower direct fiscal costs regarding the German government's biofuel support policies because Germany integrates mandatory blending requirements with tax exemptions or reduced exercise tax rates for pure biofuels and a quota trade system. Germany has three main marketable biofuels, ethanol and pure vegetable oil and biodiesel. Biodiesel is consumed mainly in its pure form or as a blend, ethanol is consumed as a petroleum blend and vegetable oil cannot be blended so it is consumed in its pure form. Biodiesel is the most commonly consumed biofuel. Of total biofuel consumption, biodiesel consumption accounted for 77 percent in 2009 (Rauch, Thöne, 2012). In 2009 biodiesel production was 2.54 million tons and ethanol production was 0.59 million tons (Rauch, Thöne, 2012). However, Germany has moved away from tax incentives and mandates for blending requirements causing their market to have overcapacity production and companies going bankrupt. Fourteen companies since 2008 have filed for bankruptcy and in 2010 biodiesel consumption decreased from 2007 3.3

million tons to 2.6 million tons (Rauch, Thöne, 2012). The blending of ethanol and gasoline has increased from 88,000 tons in 2007 to 1,023,000 tons in 2010. Biofuels in Germany's transport sector only accounted for 5.5 percent in 2009 (Rauch, Thöne, 2012). Germany's primary fuel consumption for 2009 was petroleum at 38.5 percent, diesel at 56 percent, biodiesel at 4.2 percent, ethanol at 1.1 percent and vegetable oil at 0.2 percent (Rauch, Thöne, 2012).

Market Incentives and Policy

Certification has already proven it's local influence on the environmental and societal effects of bioenergy production through the amount of standards that have been implemented over the last four years (Junginger et. al., 2013). The impact that certification has had at the local level is important because domestic markets have a more significant role in biofuel policy than global energy and food markets, due to approximately 90 percent of biofuels being consumed domestically (Ziberman and Timilsin, 2014). Domestic market's large role in policy has forced biofuel exporters to face the issue of not receiving any of the subsidies that are provided for domestic consumption. The United States has domestic mandates and subsidies for corn ethanol in part due to the power of the commodity lobby groups and the U.S.'s concern over food security and trade balances, adding an additional push for these mandates. Each country is in a different place regarding biofuel mandate implementation and market creation. Japan as an example is a major importer of fuel and would like to focus on implementing biofuel mandates but cannot make this happen because they do not have a sufficient amount of land available and no reliable sources of exported biofuels (Ziberman, Timilsin, 2014). Other private companies in Asia are adjusting for this is by outsourcing their biofuel production to other Asian countries with more biofuel production capabilities. Regardless of outsourcing, different countries will have different policies put into place because of their individual economic and biophysical conditions and the variety of weight given to interest groups.

Germany's biofuel market has been negatively impacted by the reduction of tax incentives and government blending mandates and the increase in tax on the sale of biodiesel. This increase in the tax on the sale of biodiesel is still reduced, but has increased from previous years reducing the use of pure biodiesel. This is evident because in 2006 pure biodiesel (B100) was 67 percent of the biodiesel consumed in the domestic market but in 2010 pure biodiesel (B100) was only 11 percent of the biodiesel consumed in the domestic market. The incentives provided by the German government early on initiated the over-expansion of biodiesel producers, allowing consumers to have the choice of picking the cheapest fuel. Now, the cheapest fuel retailers are the large-scale production plants that have 50,000 tons per year of capacity giving them 95 percent of the biofuel production in Germany as of 2010 (Rauch, Thöne, 2012).

Barriers

Due to budget adjustments the biofuel subsidy mentioned earlier is no longer available in the U.S. and it is possible that many other countries will begin relaxing their mandates to account for rising agricultural commodity prices, pressure from domestic feed consumers and current food situations. But outsourcing is still an interesting method because although some developing countries may have more biofuel production capabilities, it is unlikely their political forces will support switching from grain to biofuel production. It is more likely a developing nation's government would support the development of energy crops if it would act as a new form of income for the rural sector and does not compete with resources already significantly utilized. A major deterrent for developing countries regarding biofuel production, even when they are in ideal locations is their inability to introduce effective policies and the presence of corruption. The importance of political and governmental economic considerations can be seen because government policies surrounding biofuels encouraged this new biofuel market.

Germany is an example where we can see how government policy can be a barrier when all externalities are not accounted for. The reduction of government mandates and taxes as nations begin to let markets become self-sustainable creates economic challenges for biofuel markets. Economics is the biggest barrier for biofuel industry development because of its direct connection to the price of oil (Kojima and Johnson, 2006). There is hope as we saw how Brazil overcame this issue, creating a thriving biofuel market.

The Future of Bioenergy Markets

The emergence of biofuel markets is not easy. There is a lot of push back from OPEC countries, the feed sector and food consumers. As of 2008, biofuels have 0.6 percent of the renewable energy share of global final energy consumption (Ziberman and Timilsin, 2014). Renewable energy is currently growing and this is especially true in developed countries. Developing countries are also seeing some growth in the renewable energy sector and there is a lot of support from the agriculture lobby, those concerned about fuel security and the balance of trade.

Bioenergy has seen rapid developments over the past years, which is demonstrated after reviewing the advances in biomass use, markets and policy. Growth is especially obvious for biomass in liquid and gaseous energy carriers, where biofuels have increased by 37 percent from 2006 to 2009 (Junginger et. al., 2013). This will only continue to grow due to the national targets counting on biomass to deliver a substantial increase in the share of renewable energy.

To create this increase over time in biomass production capacity and working markets, required infrastructure and conversion capacity has been created by consistent and stable policies. The United States was able to rapidly expand its production because of aligned national policies in the 1980's. The instability of petroleum prices and petroleum producing countries also assisted the United States in its rapid expansion of biofuel production. But as oil prices plummeted there was decreased policy support and thus biopower production. As environmental and state targets for renewable energy are developed, policy support and biopower production are again increasing.

Although a common language of commonly accepted definitions and measures needs to be established to achieve optimal results in global bioenergy market development, countries differ in their priorities, approaches, technology choices and support schemes for further development of bioenergy. These factors all contribute to an increasingly complex bioenergy market. These same complexities can be said for bioenergy deployment, agriculture and land use, energy policy and security, rural development and environmental policies. As the bioenergy market continues to grow, policies are becoming more holistic due to the sustainability starting point trend we are seeing across the globe. This trend exists in wealthy countries such as the European Union and the United States, as well as less wealthy countries like Tanzania. This is a great improvement in the bioenergy sector but fragmentation is still faced and this sector needs to continue striving to create international and multilateral collaboration and dialogue to generate the commonly accepted definitions and measures necessary for worldwide bioenergy market success.

As bioenergy markets develop, there are key areas upon which to build. So, based upon the proceeding review of literature, a strong demand for biomass and biofuels is a possible first step. With the sustainable starting point trend, biofuel market development could be on a sustainable growth path as society continues to choose to exploit biomass production potentials and develop biomass resources. Understanding what this means in different settings will ensure continued growth. In various markets the price of biomass resources and fuels can be volatile. This is because biomass markets are still young, especially regarding demand and they depend on government policy objectives and incentives, which are not always stable. It is important to continue building both supply and demand for biomass and energy carriers derived from biomass in a balanced way and to stay away from distortions or instability that can be detrimental to investment in biomass production, infrastructure and conversion capacity. Establishing international bioenergy markets will be a long-term project where key players such as policy makers, NGO's, international bodies and market players focus on these four areas; biomass supplied, sustainability and certification, trade, market and demand dynamics and transport, logistics and trade.

3. Methodology

This section discusses the framework used to assess whether characteristics of selected countries may create potential opportunities or barriers for biofuel market development.

Understanding why each country was selected, how the information for each country was found, the economic theory used and how characteristics of each country is compared and inventoried all played an important role in the results of this study.

Country Categorization

Wealthy and Less Wealthy Countries

The United States and Brazil were selected because these are two wealthy countries with GDP's of $16.77 trillion USD and $2.46 trillion USD. The country's gross domestic product (GDP) determined whether or not a country was in the wealthy or less wealthy category. GDP is calculated as the value of the total final output of all goods and services produced in a single year within a country's boundaries (Soubbotina and Sheram, 2000). If a country's GDP was greater than one trillion, it was classified as wealthy. If a country's GDP was less than one trillion it was classified as less wealthy. Then the world rank was used to assess how each country's GDP ranked against one another's GDP. World rank is based solely on a country's GDP and world rank provides a perspective of how the seven country's GDP ranked globally (World Bank, 2014). Additionally, the classification of wealthy and less wealthy countries used in this study was compared to the World Bank's categorization of developed and developing regions that had countries in each region listed. The World Bank's categorization included each country's Gross National Income (GNI) per capita per year, whereas the categorization used in this study only accounted for GDP and world rank (World Bank, 2014). According to the World Bank, if a country's GNI was $ 11,905 USD or less it is a developing country (International Statistical Institute, 2015). Although Brazil's GNI per capita is $11, 690 for the purpose of this study Brazil was included in the wealthy country category due to its high GDP and highly active biofuel market. Germany and Japan were also categorized as wealthy countries because of their high GDP. Germany had a GDP of $3.730 trillion in 2013 and Japan had a GDP of $4.920 trillion in 2013. Countries categorized as less wealthy are Costa Rica with a GDP of $49.62 billion, Tanzania with a GDP of $33.23 billion and Thailand with a GDP of $387.3 billion. As of 2013 the countries categorized as less wealthy had GNI per capita as follows: Thailand of $5,360, Tanzania $630 and Costa Rica $9,550. Countries categorized as wealthy had GNI per capita of: United States $53,470, Japan $46,330, Germany $47,270 and Brazil $11,690.

Proved Oil Reserves

To determine if a country had or did not have significant proved oil reserves the U.S. Energy Information Administration (EIA) 2013 classification of World Proved Reserves was used. Countries having 10 billion barrels or more of proven oil reserves were classified as having significant proved oil reserves. Countries with less than 10 billion to 0 were classified as not having significant proven reserves. Germany and Japan were selected because these are two wealthy countries that do not have significant oil reserves and are major importers of oil (U.S. Energy Information Administration, 2015). In 2014, Germany had .23 billion barrels of proved reserves of oil and Japan had .04 billion barrels of proved reserves of oil. Then Costa Rica, Tanzania and Thailand were chosen as the three less wealthy countries that would be analyzed due to not having a significant amount of proved oil reserves. In 2014 the amount of proved reserves of oil for Tanzania was zero, Thailand .45 billion barrels and Costa Rica zero (U.S. Energy Information Administration, 2015). The United States and Brazil are the two wealthy countries that have proved oil reserves of 36.52 and 15.05 billion barrels (U.S. Energy Information Administration, 2015), so they were placed into the wealthy country with significant proved oil reserves category.

Biomass Potential

For the purpose of this study biomass is defined as sugarcane, sorghum, corn and oilseed crops that can be used as a feedstock for biofuel production. A country was determined rich in biomass by assessing the transitional crops currently produced there. Transitional crops currently produced are defined as the crops each country currently produces that could be used as biofuel or transitioned from their current use to biofuel use. Then the acres of harvested transitional crops, was used to determine how much of the transitional crops are currently produced. The last factor used to determine if a country was rich in biomass was the percent of land that is arable. Arable land is defined as land under temporary crops (double cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded (World Bank, 2015). Additionally, hectares were converted to acres (2.5 acres per hectare). A country was classified as rich in biomass if the country had three or more transitional crops and 8 percent or more of arable land.

Data collected from the United States Department of Agriculture (USDA) National Statistics Service was used to obtain harvested acres. The acres of harvested corn in 2012 was found by, summing up the acres harvested of corn for grain 87,365,000 and the acres harvested of corn for silage 7,419,000 totaling 94.8 million acres (38.4 million hectares) harvested. This same process was repeated for sorghum where 4,995,000 acres of sorghum grain harvested was added to the 353,000 acres of silage sorghum, which equaled 53.5 million acres (21.7 million hectares) of sorghum harvested. The U.S. harvested 902,400 acres

(365,188 hectares) of sugarcane, 1.7 million acres (0.68 million hectares) of canola, 76 million acres (30.7 million hectares) of soybeans, 2,300 acres (930.7 hectares) of rapeseed, and 49,700 acres (20112 hectares) of mustard. Thus, the U.S. has eight transitional crops that could potentially be used as biomass as defined for the purpose of this study. Seventeen percent of the United State's land is arable (World Bank, 2015). These factors make the United States a country rich in biomass because it has more than three transitional crops and more than 8 percent of U.S. land is arable.

Brazil in 2012 harvested 67.5 million acres (27 million hectares) of soybeans, 37.5 million acres (15 million hectares) of corn, and 21.25 million acres (8.5 million hectares) of sugarcane (Velasco, 2013). Brazil had 2 million acres (0.80 million hectares) of sorghum area and 71.93 acres (28.77 million hectares) of oilseed area (USDA Foreign Agricultural Service, 2012). So, Brazil has five transitional crops that could be used as potential biomass. 8.7 percent of Brazil's land is arable (World Bank, 2015). Brazil is a country rich in biomass because it has more than three transitional crops and more than 8 percent of Brazil's land is arable.

Germany in 2012 had 11505 total acres (2564.2 hectares) of corn. The total hectares of silage corn were combined with the total hectares of grain corn. The rape, turnip rape, spring rape, winter rape, and winter and spring bird rape acres were combined totaling 6531 rapeseed acres (2612.4 hectares) harvested (Destatis Statistisches Bundesamt, 2015). Germany only has two transitional crops that could be used as biomass. Thirty four percent of Germany's land is arable (World Bank, 2015). Germany is not a country rich in biomass because it does not have more than three transitional crops even though it does have more than 8 percent of land arable.

In 2012 Japan had 61776 acres of sweet corn planted and 227336 acres of feed and forage corn, totaling of corn and 289113 total acres (117000 total hectares) of corn planted. Japan had a total of 360000 acres (144000 hectares) dried and vegetable soybeans. In Japan 57500 total acres (23000 hectares) of sugarcane was planted. In 2012 there was 42500 total acres (17000 hectares) of sorghum planted (Statistics Japan, 2012). Japan has four transitional crops that could be used as biomass. This study chose to compare the hectares planted rather than harvested because there was not access to hectares harvested data. Japan's land that is arable is 11.6 percent (World Bank, 2015). Japan is a country rich in biomass because it has more than three transitional crops and has more than 8 percent of their land arable.

Costa Rica in 2012 harvested 29,125 acres (11650 hectares) of cassava (Food and Agriculture Organization of the United Nations, 2014). Cassava is a tuberous root primarily grown in Africa, Asia and Latin America that can be used as a feedstock for biofuel production (Food and Agriculture Organization of the United Nations, 2008). There were 18662.5 acres (7465 hectares) of corn harvested, 158750 acres (63500 hectares) of palm fruit oil, and 144000 acres (57600 hectares) of sugarcane (Food and Agriculture Organization of the United Nations, 2014). Costa Rica has four transitional crops that could be used as biomass. 4.8 percent of Costa Rica's land is arable (World Bank, 2015). Costa

Rica is classified as a biomass rich country because it has more than three transitional crops and more than 8 percent of their land is arable.

In 2012 Tanzania had 10.3 million acres (4.12 million hectares) of corn area, 2.1 million acres (0.84 million hectares) of sorghum area, 3.25 million acres of (1.3 million hectares) oilseed area (USDA Foreign Agricultural Service, 2012). Tanzania has three transitional crops that could be used as biomass. Tanzania's arable land is 16.4 percent (World Bank, 2015). Tanzania is a country rich in biomass because it has three transitional crops and more than 8 percent of the land there is arable.

Thailand in 2012 had 2.5 million acres (1.01 million hectares) of corn area, 0.3 million acres (0.12 million hectares) of soybean area, 0.18 million acres (0.07 million hectares) of the oilseed Corpa, 0.78 million acres (0.31 million hectares) of palm kernel, and 3.9 million acres (1.55 million hectares) of palm oil (USDA Foreign Agricultural Service, 2012). The report from which this data was extracted from did not provide a definition for crop area. I did not have access to hectares harvested therefore I used crop area for all potential feedstock options. Thailand has five transitional crops that could be used as biomass. Thailand's arable land is 32.4 percent (World Bank, 2015). Thailand is a country rich in biomass because it has more than three transitional crops and more than 8 percent of Thailand's land is arable.

Summary of Selection Matrix

Overall, the United States and Brazil were chosen because these are two wealthy countries with significant proven oil reserves and are potentially rich in biomass. Germany and Japan were chosen because these are two wealthy countries without significant proved oil reserves and Germany is not potentially rich in biomass. Costa Rica, Tanzania and Thailand were chosen because these are three less wealthy countries without significant proved oil reserves but are potentially rich in biomass. It was important to have as many continents represented as possible, which is why the United States, Brazil, Germany, Japan, Costa Rica, Tanzania and Thailand were chosen. These seven countries represent Africa, North America, South America, Europe and Asia and provide a diverse look into the potential opportunities and barriers for biofuel market development in different countries.

Table 1. The Factors Used to Classify Selected Countries.

	Wealthy countries with significant proved oil reserves		**Wealthy countries without significant proved oil reserves**		**Less wealthy countries without significant proved oil reserves but are potentially rich in biomass**		
Rule/Characteristic	United States	Brazil	Germany	Japan	Costa Rica	Tanzania	Thailand
2013 Gross domestic product (GDP), trillion USD[a]	$16.77	$2.46	$3.73	$4.92	$.0462	$.0332	$.0387
Gross national income (GNI) 2013 USD[a]	$53,470	$11,690	$47,270	$46,330	$9,550	$630	$5,340
2013 World rank[a]	1	7	4	3	80	93	29
Billion barrels of proved reserves in 2014[b]	36.52	15.05	.23	.04	0	0	.45
Transitional crops produced in 2012	Corn, soybeans, sorghum, sugarcane, canola, mustard, rapeseed, sunflower[f,c]	Corn, soybeans, sugarcane[d], sorghum, oilseed[k]	Corn, rapeseed[g]	Corn, soybeans, sugarcane, sorghum[h]	Cassava, Corn, palm fruit oil, sugarcane[l]	Corn, sorghum, oilseed[k]	Corn, soybeans, oilseed Corpa, palm kernel, palm oil[k]
2012 Harvested transitional crops (in 1000 acres)	Corn 948000, soybeans 76000, sorghum 53500, sugarcane 902.4, canola 1700, mustard 49.7, rapeseed 2.3, sunflower 1800[f]	Corn 37500, soybean 67500, sugarcane 21250[d], sorghum 2000, oilseed 71930[k]	Corn 11.5, rapeseed 6.5[g]	Corn 292.5, soybean 360, sugarcane 57.5, sorghum 42.5[h]	Cassava 29, Corn 18.6, palm oil 158.7, sugarcane 144[l]	Corn 10300, sorghum 2100, oilseed 3250[k]	Corn 2500, soybean 300, corpa 180, palm kernel 780, palm oil 3900[k]
Percent of land arable in 2012[e.]	17.0	8.7	34.0	11.6	4.8	16.4	32.4

a. World Bank, 2014.
b. Energy Information Agency, 2015
c. EPA, 2013
d. Velasco, 2013
e. World Bank, 2015
f. United States Department of Agriculture, 2014
g. Destatis Statistisches Bundesamt, 2015
h. Statistics Japan, 2012 (acres planted)
k. USDA Foreign Agricultural Service, 2012 (crop area)
l. Food and Agriculture Organization of the United Nations, 2014

Characteristics Inventoried and Compared

Factor data for countries selected in the previous section were collected and used to determine possible opportunities and barriers to biofuel market development across selected countries. A rating of positive, negative and neutral in the table was used to determine if a characteristic created a potential opportunity, a potential barrier or if the characteristic had neither a positive or negative affect on biofuel market development. The symbol for a potential opportunity is +, for a neutral characteristic o is used and a – symbol signals the characteristic is a potential barrier.

The first characteristic assessed is the cost of gasoline because this allows an assessment of whether this is an opportunity or a barrier for biofuels. Lower gasoline prices would be a potential deterrent to biofuels. This would provide insight into how consumer behavior and demand could change. Assessing whether each country's petroleum based transportation is a positive or negative characteristic determines if biofuels could be an alternative fuel or if it is relevant to the specified nation. If the majority of a nation's transportation were not petroleum-based such as vehicles or trucks, then biofuels would possibly not be as viable as if, the society depends mainly on automobiles, trucks, buses or other petroleum based transportation methods. Domestic petroleum use assesses if a country is a petroleum importer or exporter. It allows a look at how biofuels would change the country's economy either having a positive, negative or neutral effect. Access to infrastructure allows an assessment of the type of infrastructure within a country and if it could increase or decrease transaction costs. It provides information about the transportation costs and how that could affect the demand for biofuel as an end product.

Also it is important because if a country does not have roads or a highway system in place, then biofuels may not be option for consumers to transition too. Infrastructure can also directly affect how inputs necessary for biofuels would be transported and delivered. Infrastructure investment in each country assesses whether or not infrastructure is a possible opportunity or a possible barrier for new infrastructure to be put into place that would be for biofuels. Infrastructure investment also can assist in determining the quality of the country's current infrastructure. If a country is planning to build new infrastructure and the country has a viable biofuel market then the country could potentially invest in biofuel based rather than petroleum-based infrastructure that would reduce a country's dependence and for some their petroleum importing costs. Private industry is included to assess what private industry's role is in the country's economy and if they are supportive of biofuels. If private industry is not supportive of biofuel markets and play a large role in the country's economy they could be a possible barrier or if they are supportive could be a possible opportunity. Government support can provide information about it's role in the success of biofuel market development for each country and the variety of policies put into place that would affect biofuel market opportunities and barriers. It was included to see how the government contributes to biofuels. Personal income provides some evidence as to the population's expendable income. If a majority of the nation's population has little to no disposable income, it is most likely the income will not be spent on biofuels, leaving little opportunity for biofuel market development to be successful. Population growth is important because it can possibly increase fuel consumption, which could then increase the need for biofuels and other alternative energies making those options more relevant.

I conducted secondary research for this analysis and collected information from a variety of scholarly resources. Journal articles, books, organizations, government documents or websites, studies researching similar questions and other online sources were the sources utilized. This information came from a variety of sources providing a diverse and well-rounded look into the possible opportunities and barriers of biofuel markets for these seven countries.

This study differs from those mentioned in the Literature Review above because not only will the policies and international trade components around biofuel markets be assessed, but also the many other characteristics of each country that could create potential opportunities and barriers for the implementation of biofuel markets in the selected countries.

4. Results

The results of this qualitative analysis are presented in Table 2. Each factor of influence and an individual country's ranking within that factor is reflected in rankings found in Table 2. The results assessed the selected factors in terms of whether they were possible opportunities or possible barriers for each country.

Table 2. Possible Opportunities and Barriers to Biofuel Markets.

Factors	United States	Brazil	Germany	Japan	Costa Rica	Tanzania	Thailand
1. Cost gasoline	-	+	+	+	+	-	-
2. Petroleum based transportation	-	-	-	-	+	+	+
3. Domestic petroleum	+	+	+	+	+	+	+
4. Access to infrastructure	+	+	+	+	-	-	+
5. Infrastructure investment	+	+	-	-	o	+	+
6. Private industry	+	+	-	-	-	-	-
7. Government support	+	+	+	-	+	+	+
8. Personal income	+	+	+	+	+	-	-
9. Population growth	+	+	-	-	+	+	+

Assessment of Selected Factors

Cost of gasoline

All gasoline prices are in USD and are given per gallon and per liter. The cost of one gallon of gasoline for the United States in May 2015 was $2.84 ($0.75 per liter) (Global Petrol Prices, 2015). The cost of gasoline for Germany in May 2015 was $6.16 per gallon ($1.63 per liter) (Global Petrol Prices, 2015). The cost of gasoline for Brazil in May 2015 was $4.15 per gallon ($1.10 per liter) (Global Petrol Prices, 2015). Gasoline per gallon in May 2015 for Japan was $4.27 ($1.13 per liter) (Global Petrol Prices, 2015). In Costa Rica in May 2015 gasoline costs were $4.31 per gallon ($1.14 per liter) (Global Petrol Prices, 2015). Gasoline costs in Tanzania in May 2015 were $3.63 per gallon ($0.96 per liter) (Global Petrol Prices, 2015). In May 2015 Thailand gasoline prices were $3.89 ($1.03 per liter) (Global Petrol Prices, 2015). Gasoline price was determined a possible opportunity if the price was higher than $4 dollars and a possible barrier if it was $4 dollars or lower because the world average price of a gallon of gasoline is $4.19 and $1.11 per liter (Global Petrol Prices, 2015). If the price of gasoline is high then consumers will most likely reduce the amount of gasoline they consume and provide biofuel markets an opportunity to develop, compared to if the price of gasoline is low then consumers either consume the same or more gasoline and the opportunity for biofuel market development is reduced.

Petroleum Based Transportation

The United States transportation petroleum use in 2009 is 13.56 million barrels per day (U.S. Department of Transportation, 2012). Germany in 2009 consumed 2.4901 million barrels per day of petroleum-based fuel in their transportation sector (International Energy Agency, 2012). This was found by summing together the amount of demand for motor gasoline, which was 473.2 thousand barrels per day, gas/diesel oil, which was 1065.9 thousand barrels per day, residual fuel oil, which was 159 thousand barrels per day and other oil, which was 792 thousand barrels per day (International Energy Agency, 2012). In 2009 Costa Rica consumed 0.0476 million barrels per day of petroleum based fuel (U.S. Energy Information Administration, 2013). Brazil in 2009 used 2.4593 million barrels per day of petroleum based fuel (U.S. Energy Information Administration, 2013). Japan used 4.3628 million barrels per day of petroleum-based fuel in 2009 (U.S. Energy Information Administration, 2013). Tanzania used 0.0344 million barrels per day of petroleum based fuel in 2009 (U.S. Energy Information Administration, 2013). Thailand used 1.0586 million barrels of petroleum-based fuel in 2009 (U.S. Energy Information Administration, 2013). If a country consumed two million barrels of petroleum based fuel per day or more, then petroleum based transportation was a possible barrier for the country, if the country consumed less than one million barrels of petroleum based fuel per day then petroleum based transportation was a possible opportunity. Having a large amount of petroleum-based transportation can make transitioning to biofuels difficult because often there is already a lot of investment in petroleum based infrastructure and vehicles. So, consuming less petroleum based fuel was a possible opportunity because it was assumed the less dependent a country is on petroleum fuel for transportation, the increased opportunity for investment in biofuels or other alternative energies

Domestic Petroleum

The United States is an importer of petroleum with net imports of 5.04 million barrels per day in 2014 (U.S. Energy Information Administration, 2013). Brazil is an importer of petroleum products, which are mainly for the transportation industry in 2013 (U.S. Energy Information Administration, 2013). This is because the refining sector has not had sufficient reinvestment, demand has increased and fuel price subsidies are being continued. Germany is a petroleum importer and relies on imports for the majority of their energy demand. Petroleum and other liquids are 37 percent of the Germany's total primary energy consumption in 2012 (U.S. Energy Information Administration, 2013). Japan is an importer of petroleum products and in 2012 was the third largest importer having imported 4.6 million barrels per day (Dunn Candace; Eshbaugh Mark, 2013). Tanzania is a petroleum importer with refined petroleum making up 25 percent of their imports (atlas.media.mit.edu, 2015). Thailand is an importer of petroleum products even though it does produce oil and natural gas. Thailand is an importer due to the rise in fuel demand and the limitations of their domestic oil reserves (U.S. Energy Information Administration, 2013). Costa Rica is a petroleum importer and it is their top imported product making up

12 percent of their imports (atlas.media.mit.edu, 2015). If a country had positive net imports (imports subtracted from exports) of petroleum then the country was considered a petroleum importer. If a country was an importer of petroleum this was a possible opportunity because biofuels could be viewed as an opportunity for increased energy independence and a way to increase the nation's domestic economy by producing biofuels domestically rather than importing petroleum.

Access to Infrastructure

In the United States there are currently 4.08 million miles (6.58 million kilometers) of road, with 229159.21 miles (368796 kilometers) in National Highway System (American Road and Transportation Builders Association, 2015). There are 2.97 million miles (4.79 million kilometers) of roads that are located in rural areas and 1.10 miles (1.78 kilometers) of road are in urban areas (American Road and Transportation Builders Association, 2015). There are currently 360 commercial ports in the United States and 150 deep draft seaports (American Association of Port Authorities, 2015). The United States has 3298 miles (5,308 kilometers) of railway that can be used for transportation (Federal Railroad Administration, 2015). The United States has 13,513 airports as of 2013 (Central Intelligence Agency, 2015). Brazil has 4,093 airports and 17732.69 miles (28538 kilometers) of railway. There is 0.98 million miles (1.58 million kilometers) of roadways in Brazil and 7 major seaports (Central Intelligence Agency, 2015). Germany has 539 airports, 26085.78 miles (41981 kilometers) of railway, 400784.41 miles (645000 kilometers) of roadways, and two major seaports (Central Intelligence Agency, 2015). Japan has 175 airports, 16890.11 miles (27182 kilometers) of railway, 0.74 million miles (1.2 million kilometers) of roadways, 10 major seaports (Central Intelligence Agency, 2015). Costa Rica has 161 airports, 172.74 miles (278 kilometers) of railway, 24244.66 miles (39018 kilometers) of roadways, and 2 seaports. Tanzania has 166 airports, 2292.23 miles (3689 kilometers) of railway, 53731 miles (86472 kilometers) of roadways and one major seaport. Thailand has six international deep-sea ports, 39208.52 miles (63100 kilometers) of national highway, 140.43 miles (226 kilometers) of motorway and expressway, 24391.30 miles (39254 kilometers) of rural roads, and 63283.54 miles (101845 kilometers) of local road (Vimolsiri, 2012). Thailand has 2414.02 miles (3885 kilometers) of single-track railroad and 145.40 miles (234 kilometers) of double and third track railroad and 36 airports (Vimolsiri, 2012). Access to infrastructure was determined a possible opportunity if countries had at least 100,000 kilometers of roadway and 1 airport, 1 major seaport, and 1,000 kilometers of railway.

Infrastructure Investment

For the United States both tax revenue and user fees fund infrastructure. Publicly owned infrastructure assets are financed by federal grants and loans, state and local expenditures, and municipal bonds, which makes up tax revenue. Depending on the infrastructure sector, federal, state and local government's role and its size changes, but financing is spread across levels of government (U.S. Department of Treasury, 2014). There has been an increase in private public partnerships (PPP) and between 2007 and 2013 $22.7 billion of both public and private dollars were invested in these PPP transportation projects (U.S. Department of Treasury, 2014). The amount of equity invested in the PPP market from 2008 to 2013 was broken down as such, operators invested 19 percent, 12 percent was by Institutional direct investor, 32 percent by fund manager and 37 percent by contractor-developer (U.S. Department of Treasury, 2014). Brazil in 2012 launched the Energy and

Logistics Investment Program, which was to add 7,500 kilometers of highways, 10,000 kilometers of railways, and invest in airports and seaports (Ministry of Finance, 2013). Demonstrating there has been and continues to be a strong support for investment in infrastructure.

Germany has been ranked second for the quality of their infrastructure in 2011 (Germany Trade and Invest, 2015). It is specialized for highly efficient transportation of goods and passengers and the airports, road, ports and rail are also all included in this ranking. However, there has not been enough reinvestment into their infrastructure over the last decade. The investment in Germany has been lower than most of the European Union. There has not been enough investment in transport infrastructure to maintain the quality (Europäische Kommission, 2014). In 2005 Japan privatized their highway system that was once public corporations because these corporations had incurred huge amounts of debt. The highway system is now made of the Japan Expressways Holding and Debt Repayment Agency (JEHDRA) and six new highway companies. The Japanese government supports JEHDRA and JEHDRA gives financing to the highway companies through grants and debt guarantees, with the government managing the highways, which are not profitable themselves (Library of Congress, 2014). However, there has not been significant reinvestment into the Japanese infrastructure.

Costa Rica in 2013 took a $400 million loan from the China Co-financing Fund for Latin America to pave and repair up to 110 kilometers of road, widen 51 kilometer of roads, and build or repair 19 bridges and close to 400 meters of breakwater ports (Inter-Ameican

Development Bank, 2013). However, even with government support for investment in infrastructure there has not been success for the major infrastructure projects (World Bank, 2014). So this was determined neutral because there is government support, however the projects have not been carried out successfully. Tanzania in 2010 spent $1.2 billion USD per year to meet infrastructure needs and the public sector is the largest financer for infrastructure accounting for 56 percent of the total expenditure (Africa Infrastructure Country Diagnostic, 2010). The private sector accounts for 18 percent and Official Development Assistance (ODA) accounts for 25 percent of the total expenditure. There is a lot of work being done and investment being put into Tanzania's infrastructure. Making this a possible opportunity. Thailand's government as of 2012 was responsible for financing 50 percent of the infrastructure development (Vimolsiri, 2012). Private participation in infrastructure development was 18 percent and State owned enterprises and loans were 32 percent.

Private Industry

The United States has had an estimated $4.85 billion of private investments in biofuel related projects, with $3 billion being invested into biofuel producers and $1.45 billion invested into companies along the value chain (Environmental Entrepreneurs, 2013). The private industry is supportive of biofuels and there is investments being made annually. Brazil's private industry finances most of the research relating to biofuels, whether that be new technologies that can be put into agricultural practice or new varietals of sugar cane to better the plant and protect it from plagues. Also there has been an increase in intellectual patents, which has provided opportunity for private industry to become more active in the biofuel market. There has been investment by private industry in the production and logistics related to biofuels (Marquez, 2007). The government has put into place many policies that create cooperation between private industry, universities and government organization (Marquez, 2007). These all make private industry in Brazil a potential opportunity.

In Germany private industry was the first to realize the potential in the biofuel markets. However, investments for biofuels fell to $8 billion decreasing by 26 percent making it the lowest year for biofuels since 2004. Venture capital and private equity in renewable energy decreased in 2013 by 46 percent (Frankfurt School-UNEP, 2014). Therefore, private industry is a possible barrier for biofuel markets in Germany. There has not been a lot of private industry support in Japan's biofuel market because of their increased focus on other alternative energies (USDA Foreign Agricultural Service, 2014). Therefore this is a possible barrier. Costa Rica's private investment is better than most Latin American countries due to their political stability and high education levels (Embajada de Costa Rica, 2008).

However, there has not been a high amount of private industry support for biofuels. Tanzania's private industry has increasingly invested in the production of crops for biofuels. However, due to the lack of government regulation biofuels it makes biofuel market development difficult (Energy for Sustainable Development, 2008). Thailand's private industry is an important component to their economy. Private industry in 2012 was 67 percent of Thailand's GDP (Asian Development Bank, 2013). However, there has been a decrease in overall investment, which was 28.6 percent of GDP (Asian Development Bank, 2013). So although Thailand has a private sector led economy, due to the decrease in investment this is a possible barrier to biofuel markets.

Government Support

The United States government is supportive of the biofuel industry. This is evident through the Energy Independence and Security Act (EISA) that mandated increased production of biofuels (Environmental Protection Agency, 2013). President Obama created the Biofuels Interagency Working Group in 2009, which is co-chaired by U.S. Department of Agriculture, Department of Energy, and Environmental Protection Agency to establish a comprehensive strategy to accelerating the investment in and production of American biofuels (Environmental Protection Agency, 2013). Additionally there are subsidies and tax incentives for both producers and consumers of biofuels (U.S. Energy Information Administration, 2015). Brazil's government is highly supportive of biofuels. This is demonstrated on the variety subsidies they provide for farmers, for example farmers were severely affected by the drought of 2011 to 2012 and there was a Regional Producer Subsidy put into place. Also ethanol manufacturers were provided with a R$ 0.20/liter of ethanol produced and marketed subsidy (Barros, 2013). There have been ethanol mandates put into place and tax incentives for ethanol (Barros, 2013).

Germany's government is supportive of the biofuel industry and focuses primarily on biofuel blending quotas, but also use tax exemptions. For example, in 2006 the Energy Tax Act created a partial tax on vegetable-based fuel and in 2007 the Biofuel Quota Act induced a mandatory biofuel-blending target for the mineral oil industry. The blending targets do not use direct government payments (Rauch and Thöne, 2012). Japan has focused on alternative energies such as solar, wind and geothermal and has not focused as much on biofuels due to the food versus fuel debate and increasing food prices. However, Japan does plan to introduce 500,000 kiloliters of biofuels by 2017 (Iijima, 2014). Due to the increased focus on other alternative energy sources, the government is not likely to bear possible opportunity for biofuel markets in Japan.

The Costa Rican government is highly supportive of biofuels and has held meetings between the Ministry of Environment and Energy, the Public Services Regulatory Authority, Costa Rican Oil Refinery and processing companies who process biomass that could be used for biofuels. In 2009 the goal of replacing 5 percent of gasoline and diesel consumed with bioethanol and biodiesel was established, making the government a possible opportunity for biofuel markets in Costa Rica (Inter-American Institute for Cooperation on Agriculture, 2014). Tanzania's government does not have policies, strategies or regulations to guide biofuel investments. The government does support biofuel development and created a National Biofuels Task Force to work on promoting biofuel policy (Sulle and Nelson 2009). Therefore, this is a possible opportunity because the government does not oppose biofuels but rather is working on creating more opportunities for biofuels. Thailand's government is working to accomplish their goal of increasing ethanol consumption to 9 million liters and their 100 percent biodiesel consumption to 5.97 million liters by 2021(Preechajarn and Prasertsri, 2014). The government also created an Alternative Energy Plan for the next ten years 2012 to 2021 (Preechajarn and Prasertsri, 2014).

Personal Income

Current household net adjusted disposable income for the United States is $39,531 USD per year (Organization for Economic Cooperation and Development, 2011). Household net adjusted disposable income is the money that a household earns every year after taxes and transfers and is representative of the money a household has to spend on goods or services (Organization for Economic Cooperation and Development, 2011). Brazil's household net adjusted disposable income currently is $10,310 USD per year. In Germany $30,721 USD per year is the household net adjusted disposable income currently. Japan's household net adjusted disposable income per year is $25,066 USD currently (Organization for Economic Cooperation and Development, 2011). Gross national income per capita had to be used for countries that do not participate in the Organization for Economic Cooperation and Development. So, Costa Rica's gross national income per capita in 2013 was $9,550 in USD (World Bank, 2015). For Tanzania in 2013 the GNI per capita was $860 USD (World Bank, 2013). Thailand's GNI per capita in 2013 was $5,340 (World Bank, 2015). Household incomes that were $9,000 USD or more were seen as a possible opportunity because the world median household income is $9,733 (Gallup, 2013). So this seemed to be a reasonable amount to assume would allow households income that could be spent on biofuel for their transportation.

Population Growth

The United States has a population growth rate of 0.77 percent (Central Intelligence Agency, 2015). Brazil's population growth rate is 0.80 percent. In Germany the population growth rate is -0.18 percent. Japan has a population growth rate of -0.13 percent. Costa Rica has a growth rate of 1.24 percent. Tanzania has a population growth of 2.8 percent as of 2014(Central Intelligence Agency, 2015). Thailand has a growth rate of 0.35 percent (Central Intelligence Agency, 2015). It is assumed here that positive population growth is a possible opportunity.

Brazil was ranked first because it had the least amount of possible barriers, with petroleum-based transportation being the only deterrent from biofuel market development. The United States and Costa Rica both ranked second each with two potential barriers. The two barriers the United States had were the cost of gasoline and petroleum based transportation. Costa Rica's two barriers were private industry and access to infrastructure. Ranking third was Thailand, which had three potential barriers. The three potential barriers Thailand had were the cost of gasoline, private land and personal income. Fourth ranked was Germany and Tanzania with four possible barriers and lastly ranked was Japan with five possible barriers. Germany's possible barriers were petroleum-based transportation, infrastructure investment, personal income and population growth. The possible barriers for Tanzania were the cost of gasoline, access to infrastructure, personal income, and private industry. The possible barriers for Japan were petroleum-based transportation, infrastructure investment, person income, population growth and government support.

5. Discussion and Conclusions

The results brought into question the common assumption that biofuels are related to the wealth of a country and countries that are not as wealthy do not have as many potential opportunities for biofuel market development. For example, Costa Rica, a less wealthy country, was ranked second out of the seven countries studied. Thailand was another less wealthy country that brought into question the assumption with its third place ranking. Germany's ranking was not expected because of the amount of support the European Union has had toward biofuel market development, it was assumed Germany would have more potential opportunities for biofuel market development than less developed countries, but instead ended up ranking fourth. By inventorying and comparing the selected characteristics of the selected countries it was found the most common possible barrier in this study for the seven countries was private industry. Private industry was a barrier for five of the seven countries. Petroleum based transportation was the second most common possible barrier in this study, with four out of the seven countries having this as an obstacle. The most common possible opportunity was domestic petroleum. Each country in this study was an importer of petroleum. There is a possible opportunity for increased domestic economic activity if all seven countries began utilizing biofuels or an alternative energy in place of petroleum based fuels because of the amount imported by each country. Even if each country reduced their petroleum use this could lead to a decrease in the country's petroleum imports.

Overall, it was concluded for successful biofuel market development a country needs government support and assistance because biofuel markets still are not self-sustainable, so to increase biofuel market development government support is a tool still needed by countries. Additionally, a society with a household income that allows for expenditures outside of basic needs could contribute to the biofuel sector and this is important because the spending could potentially increase domestic demand for biofuels. Investment in and access to infrastructure are important because these components are possible opportunities to increase biofuel market development. Without infrastructure goods such as biofuel cannot be easily transported. Processors and growers have higher transaction costs to export or import inputs or biofuel when there is not enough or no infrastructure accessible or built. Thus, a lack of infrastructure that increases transaction costs creates more possible barriers for biofuel market development. All factors were found to play an important role in the development of biofuel markets. From the results it was determined that biofuel market development is occurring or at the very least being planned for in the seven countries studied. So although there is more being done and more possible opportunities in Brazil, the United States, Costa Rica and Thailand for biofuel market development, there was action and planning happening in Tanzania, Germany and Japan it just was either preliminary or these countries were focusing more on other alternative sources of energy.

Alternative energies such as biofuels and their market development are complex and dynamic topics. This was a preliminary look into a limited set of potential barriers and opportunities for biofuel market development. There are many other factors that were not accounted for in this study that would need to be considered for a more in depth understanding of biofuel market development. A few of these factors include: the country's current access to alternative fuels, current rates of adoption of alternative energies within each country, the country's preferred alternative energy source, society's perception of biofuels, the elasticity of demand for biofuels in each country and what the country's optimal energy mix would be. In addition, the selected factors could be tested more rigorously with statistical analysis to increase the validity of the conclusions. For example, a general equilibrium model could be used, which would provide a look at the world market for biofuels and the prices of biofuels necessary to create equilibrium. Also an econometric model for the elasticity of demand for biofuel could be used to provide an idea of how much change there would be in the demand for biofuels for a selected country if there were a 1 percent change in the price of biofuel.

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