Economies as Drivers of Deforestation

A study of the soy production in Brazil

by

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Matt Story, Author

What's the Problem?

In the last decade food production has undergone dramatic changes. The introduction of biotechnology and genetic modification has greatly increased crop yields and altered the balance of international agricultural trade. This paper aims to discuss and explore a current global issue involving international trade and its sometimes hazardous environmental impact. Following in the wake of the Mad Cow epidemic in Europe, caused mainly by the use of ground up animal bones in livestock feed, farmers were forced to find a non-animal based protein-rich feed for livestock. Soy meal was found to be a perfect alternative, resulting in a large increase in the demand for soy. Currently, the United States is the world's largest exporter of agricultural products; more importantly, the largest exporter of soy based products. The overwhelming majority of the United States' soy based exports are of the genetically modified variety. Both China and the European Union currently prohibit the importation of genetically modified foods, eliminating the United States from a large foreign market. This large, emerging market opportunity is appealing to many countries currently producing non-genetically modified soy. Few countries however, possess the resources and agricultural infrastructure necessary to take advantage of this opportunity.

The world's second largest exporter of soy based products is Brazil, a country that at present predominantly produces non-genetically modified soy. Brazil has historically committed to producing non-genetically modified soy and has vast amounts of both land and labor to capitalize on foreign markets. In order to satisfy the already large and growing demand for non-genetically modified soy, Brazil would be forced to undertake

large, expansive agricultural projects and convert millions of acres of tropical rainforests into land fertile enough for soy production.

The issue at hand is one of short term benefits and long term consequences. Brazil has access and control over the largest and most unique natural resource in the world, the Amazon rainforest. Though the majority of if lies within the borders of Brazil, the Amazon rainforest affects the global climate, impacting countries thousands of miles away. The decision to exploit the Amazon rainforest lies largely on the shoulders of the Brazilian government, but the consequences of these decisions will travel far beyond Brazil's borders.

Genetically modified foods are the topic of continuous discussion and debate, with numerous pundits on each side of the issue debating their acceptance. The first section of this analysis will concern genetically modified foods and their role in this situation. The second section will discuss Brazil's current economic condition, their motivations for possibly undertaking such a large effort towards fulfilling the non-genetically modified soy demand, and their possible entrance into the genetically modified soy market. The third and final section of this analysis will explain in detail the potential environmental impact of these actions and conclude with a discussion concerning the idea of economic progression as a driver of environmental destruction.

Genetically Modified Foods

Soy is an important commodity, supplying one fourth of vegetable oils and over half of all oil meals globally. In 2004, over 186 million tons of soy was produced, with most largely used in vegetable oils and animal feed (14). Demand for soy, largely in the form of soy cakes for cattle, poultry and pig feed, is expected to increase by more than 60% exceeding 300 million tons per year in the year 2020 (14). Even with impressive yields and record production, the global demand for soy, both genetically modified and non-genetically modified varieties, remains largely unmet. In an effort to produce soy and other crops more efficiently and with higher yields many farmers and agricultural companies have decided that genetically modified crops are the answer.

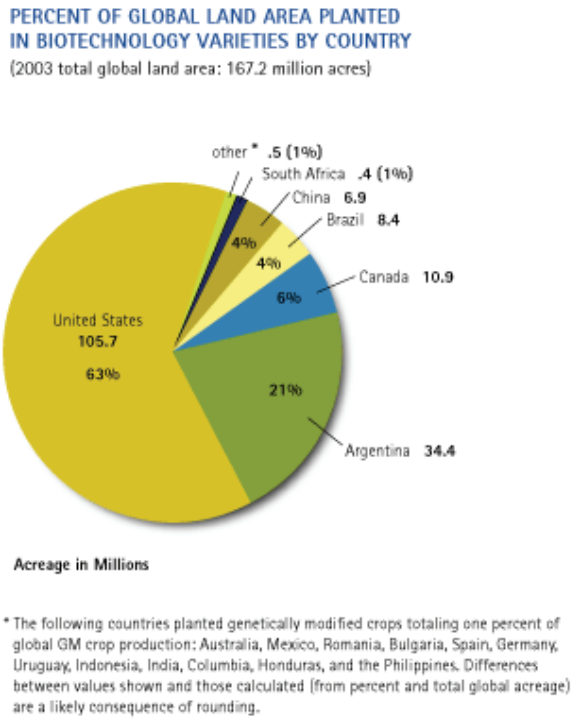
The first significant planting of genetically modified crops took place in 1996, but the revolution of genetic modification first appeared in 1980 as a result of a relatively obscure U.S. Supreme Court decision (51). Ananda Mohan Chakrabarty, a microbiologist employed by General Electric, developed what was at the time a very specific type of bacteria that could ingest oil (9). General Electric first applied for a patent on the bacteria with the U.S. Patent and Trademark Office in 1971. After several years of review, the U.S. Patent and Trademark Office denied General Electric's petition under the traditional doctrine that life forms are not patentable (9). In 1980, General Electric sued the U.S. Patent and Trademark Office and won the right to patent the bacteria. The Supreme Court's decision in *Diamond v. Chakrabarty* was that ultimately biological life could be legally patentable (9). The decision of the highest court in the United States served as precedent for the 1985 ruling by the U.S. Patent and Trademark Office to extend the

Chakrabarty ruling to all plants, seeds and plant tissues (9). This influential decision paved the way for the commercialization of biological life.

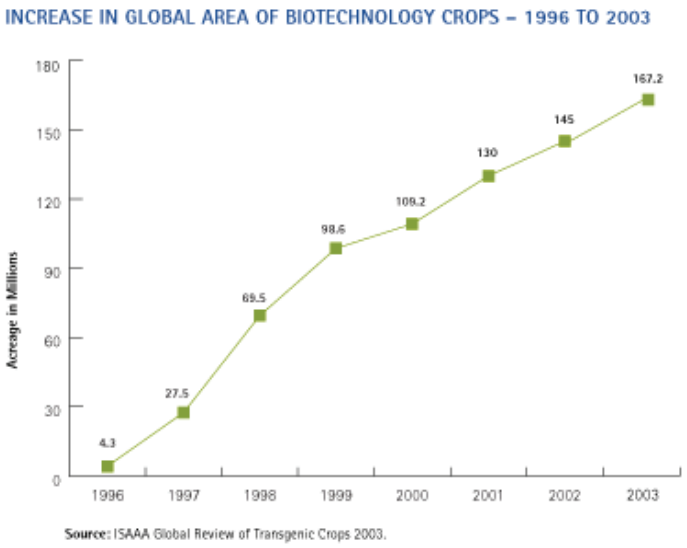
Recent innovations in biotechnology have allowed scientists to select specific genes from one organism and introduce them into another to obtain a desired trait. This technology is largely used to produce new varieties of plants or animals much quicker than conventional breeding methods and to introduce desired traits not possible through traditional techniques (23). Advances in the genetic alteration of food crops have predominately focused on two areas: herbicide tolerance and insect resistance. The leader in agricultural biotechnology, the U.S. based Monsanto Corporation, is responsible for engineering a strain of glyphosphate-tolerant soybean that is highly resistant to the popular herbicide Round-Up, also manufactured by the Monsanto Corporation (51). The benefit of these "Round-Up ready" soybeans is that farmers are able to liberally apply Round-Up on their crops to eliminate unwanted growth anytime during the growth cycle, from the pre-planting stage to the canopy stage, theoretically yielding higher and more efficient crop productions. This method is very productive and popular amongst farmers because as an herbicide Round-Up has proven to be very effective against most annual and perennial weeds that damage crops. "Round-Up ready" soybeans are also believed to be environmentally friendly because their use reduces the amount of necessary tillage which in turn reduces the damage to topsoil (51). In an effort to make crops resistant to insects, scientists have also engineered crops to produce specific toxic proteins, lethal to many insects. Most commonly, pest resistant crops have been engineered to contain a gene for a protein from the soil bacterium, Bacillus thurigiensis (Bt), which has proven

toxic to certain pests (23). Many pest resistant crops have also been genetically engineered to contain genes that make a plant resistant to specific plant viruses as well.

The popularity of genetically modified crops amongst producers continues to grow each year. Worldwide, more than 672 million acres of land are under cultivation of which 25 percent, or 167.2 million acres, consists of genetically modified crops (23). The United States is home to the largest area of genetically modified cropland, more than 105.7 million acres and representing 63 percent of the total global area. The six countries representing the largest areas of genetically modified crops are the United States, Argentina, Canada, Brazil, China and South Africa (23).



In 1996 there was a paltry 4.2 million acres in just six countries that were planted with genetically modified crops. Only eight years later the number of acres of genetically modified crops has risen to 167.2 million acres in 18 countries on six continents. This dramatic increase hit the hardest in the United States where there has been a 27 fold increase in the area of genetically modified crops in the same eight year period, increasing from 3.7 million acres to 105.7 million acres (23).



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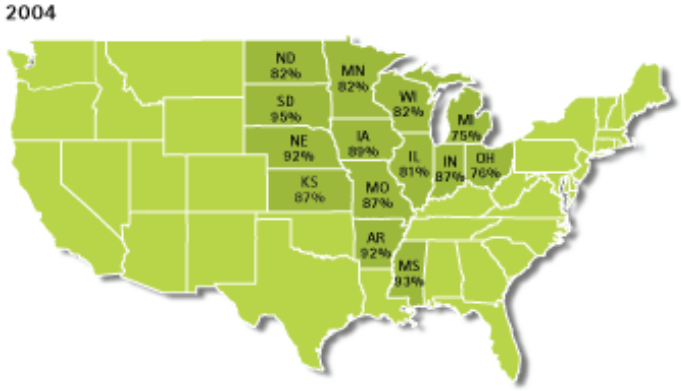
A large percentage of genetically modified crops in the United States are now being planted with Monsanto's Round-Up ready soy. In 2003, U.S. farmers increased genetically modified soy crops to total 59.7 million acres, or 81 percent of all soy crops planted in the United States. There are currently 31 states that produce genetically modified soy varieties, with the top 14 states accounting for 89 percent of the nation's total (23).



The overwhelming popularity and acceptance of genetically modified foods suggests that the recent advances in biotechnology are nothing short of scientific miracles. Genetic alteration to food crops is touted as technology that will aid the

environment by reducing toxic chemical use, increase food production, produce higher crop yields and lead to an agricultural boom (9). With the advantages of genetically modification seemingly so obvious, their adoption and acceptance around the globe would appear to be only a matter of time. Much to the dismay of proponents of genetic modification this is not the case. Serious environmental and health concerns have arisen that have significantly deterred proponents of genetically modified crops from convincing the global audience of their safety.

Genetically modified foods have existed for little more than a decade and due to their infancy the long term effects of their use and consumption have yet to be determined. Scientists are hesitant to either whole heartedly oppose or endorse the use of biotechnology in food crops. Environmentally speaking, genetically modified food crops harness the potential to have dramatic long lasting detrimental effects. One area of great concern is the liberal use of herbicides. While the use of genetically modified foods is supposed to reduce the use of toxic herbicides the reality is that the use of pesticides has generally increased (9). Farmers using Round-Up or similar herbicides are now able to spray indiscriminately over entire fields not just sparingly over certain weeds or problem areas. Furthermore, since these genetically modified crops are tolerant to herbicides they can be sprayed repeatedly without damage, promoting liberal over spraying (9). This large increase in herbicide introduction not only prolongs its rate of breakdown in the soil, but it is also a health hazard to farmers and farm workers. A study conducted at the University of California concluded that glyphosphate, the active ingredient in most herbicides, was the third leading cause of farmer worker illness (9).

The sustainability of genetically modified crops is also an area of increased concern. The problem with evolving only genetically cloned, carbon copy seeds and plants is that historically extreme monoculture has led to a loss of adaptive survival means. Crops that are identical are much more susceptible to devastation through the spread of deadly plant infections. Natural, more diverse crop production is more resistant to plant diseases.

George McGavin, curator of entomology at Oxford University, fears the development of what he calls "super weeds" and "super pests" that may evolve to become highly resistant to the modifications of genetically modified crops. This evolution will promote the use of even more poisonous herbicides such as methyl parathion, a chemical known for its extreme toxicity (9). According to McGavin, "If you replace vast tracts of natural forest with flowerless plants, there will be a serious effect on the richness and abundance of insects. If you put insect resistance in the leaves as well you end up with nothing but booklice and earwigs. We are talking about vast tracts of land covered with plants that do not support animal life as a sterile means to cultivate food crops" (9). The environment is further affected by the unintentional spread of genetically modified seeds, causing genetic pollution. Genetically modified pollen and seeds are carried by the wind, rain, birds, insects, fungus and bacteria affecting the entire chain of life. This type of pollution is unlike simple chemical pollution, there is no specific cleanup possible. Dr. Richard Lacey, a medical microbiologist at the University of Leeds who is known for his prediction of Mad Cow disease, elaborates that "wedging foreign genetic material in an essentially random manner causes some degree of disruption. It is impossible to predict what specific problems could result" (9).

In addition to potential harmful effects on the environment, the effects of genetically modified foods on physical health after consumption are also largely unknown. Dr. George Wald, a Nobel Laureate in Medicine and professor at Harvard University, expresses his feelings about biotechnology and genetically modified foods.

> "Recombinant DNA technology faces our society with problems unprecedented not only in the history of science, but life on Earth. It places in human hands the capacity to redesign living organisms, the products of three billion years of evolution. Such intervention must not be confused with previous intrusions upon the natural order of living organisms: animal and plant breeding working within single or closely related species. Our morality up to now has been to go ahead without restriction to learn all that we can about nature. Restructuring nature was not part of the bargain; this direction may not only be unwise, but dangerous. Potentially, it could breed new animal and plant diseases, new sources of cancer, novel epidemics." (9)

Numerous specific health risks are associated with the increased consumption of genetically modified food. The human body intuitively rejects excess homogeneity, leading to reactions and symptoms commonly identified as allergic reactions. Approximately 25 percent of Americans have food allergies to some extent and the loss of biodiversity in our food supply has grown in parallel with the increase in food allergies (9). The introduction of new varieties of genetically modified foods has the potential to cause large numbers of allergic reactions in individuals that were previously not considered to have allergies. The impacts of genetically modified foods are also suspected to have at least an indirect influence on cancer rates. In the 20th century there was a lowering of infectious disease rates, especially in cases where a single bacterium

was treated with an antibiotic. During this progress of human health there was a simultaneous rise in systemic, immune system breakdowns, such as cancer (9). Cancer rates are affected by the polluted state of our environment, the polluted air, water and food we take in. Hundreds of thousands of chemicals are continuously released into the environment. The majority of these chemicals, including a large amount of both herbicides and pesticides, are diluted and relatively harmless by themselves. The danger lies in the unprecedented combinations of these chemicals that scientists are finding to be 1,000 times more likely to cause cancer than their individual components alone (9).

Genetically modified foods have also been accused of providing less nutrition than foods produced naturally and studies are beginning to emerge concerning birth defects and shorter life spans. A study done by the Russian Academy of Sciences suggests that pregnant women who eat genetically modified foods risk endangering their unborn babies. The study found that more than half of the offspring of rats fed on genetically modified soy died in the first three weeks of life, a figure six times higher than those born to mothers with normal diets. Six times as many offspring were also severely underweight (34). This study, carried out by Dr. Irina Ermakova is the first of its kind to focus on the effects of genetically modified foods on the unborn. Ermakova also suggests that certain genetically modified foods have lower levels of vital nutrients such as phytoestrogen, a compound thought to protect the body from heart disease and cancer. The results of these experiments are so potentially serious that the American Academy of Environmental Medicine has asked the U.S. National Institute of Health to sponsor an immediate, independent follow up study. To date, no human clinical trials have been conducted. Testing on genetically modified foods is a relatively recent occurrence and

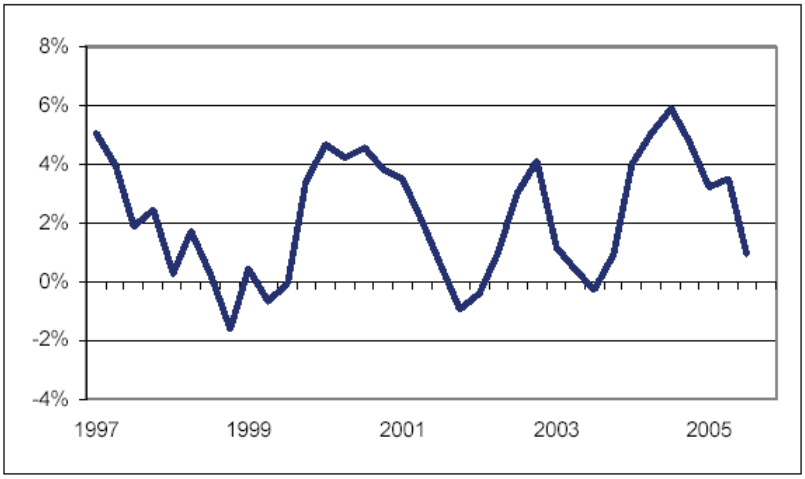
not mandated by the Food and Drug Administration. The FDA requires no regulated health safety testing; only requires firms to conduct their own tests, and makes no review of the results unless voluntarily requested by the company producing the product (9). There is no data to confirm the health safety of genetically modified food, implying a certain measure of unavoidable risk to the consumer. Genetically modified foods are drastically changing the human diet and much of the apprehension and fear surrounding their adoption lies squarely with the fact that little or no knowledge exists of the long term health or environmental impacts.

The Brazilian Economy

In order to better understand Brazil's motivation towards expansion of soy production, one must first understand Brazil's economy. Since Portugal's discovery of Brazil in 1500 the Brazilian economy has relied heavily on the production of goods for exportation. The Brazilian economy has grown exponentially since declaring its independence from Portugal in 1822 due largely to its strong base in agricultural exports. In the 1940's only 31.4 percent of Brazil's 41.2 million inhabitants resided in towns and cities. Today, 75.5 percent of Brazil's 188 million inhabitants reside in cities and Brazil is home to two of the world's largest metropolitan centers: Sao Paulo and Rio de Janeiro. The consolidation of large metropolitan centers suggests a decrease in the importance of the agricultural sector. The share of the agricultural sector declined from 28 percent of the gross domestic product in 1947 to just 10 percent of Brazil's GDP in 2005 (3). In the same time period the contribution of industry increased from less than 20 percent of GDP to more than 39 percent. With strengths in the areas of services and industry (50.6% and 39.4% respectively), Brazil is seeking to reestablish its agricultural export base.

Despite being characterized by large and well-developed agricultural, mining, manufacturing and service sectors, the Brazilian economy has experienced less than impressive growth as of late. In a global economy that has recently seen a vigorous expansion of world trade, high commodity prices and abundant liquidity at low interest rates in foreign markets, Brazil has experienced a GDP growth of 2.2 percent, contrasting the average growth rate of 6 percent for emerging market economies. (3) Brazil's modest economic growth performance in 2005 is due largely to three main domestic problems.

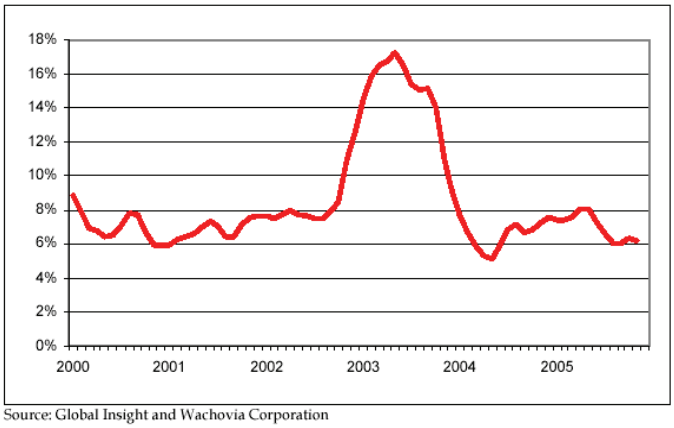
Exhibit 1: Brazilian Real GDP Growth (year-over-year rates)



Source: Global Insight and Wachovia Corporation

First, the need to reduce escalating inflation rates, a problem the Brazilian government has historically battled. In 1986, just 20 years ago, the inflation rate exceeded 100 percent for the second year in a row (1985: 225%) (3). Although inflation fell from a modest 7.6 percent to 5.8 percent in 2005, the Brazilian government still adopted a very tight monetary policy in an effort to reach a target rate of 5.1 percent (27).

Exhibit 4: Brazilian CPI Inflation (year-over-year rate)



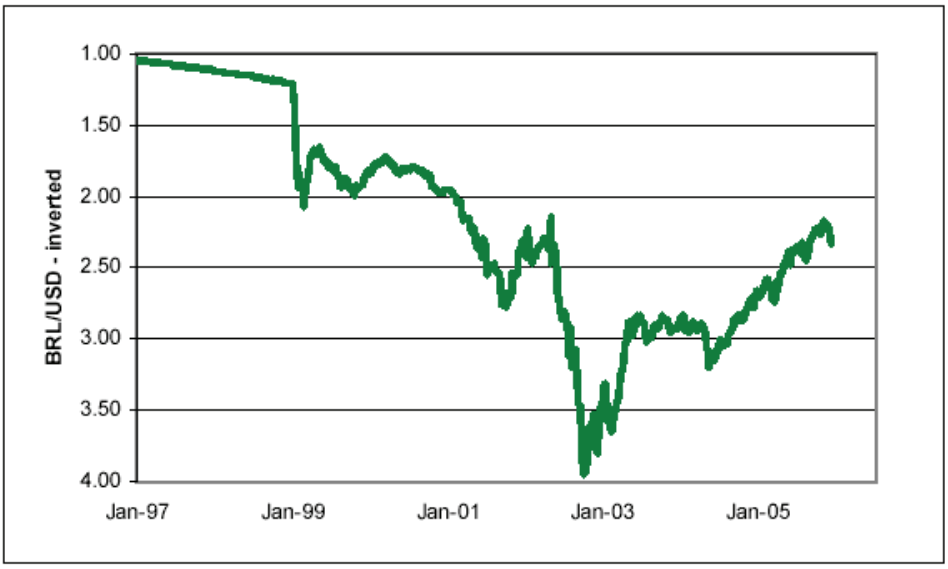
Source: Global Insight and Wachovia Corporation

The second domestic problem that contributed to Brazil's modest economic performance in 2005 was the numerous accusations of corruption against key government officials in President Lula's administration and party. Evidence of the corruption

collected by the Congressional Inquiry Commissions drew the attention of the media and the public and over time threatened to lead to an international crisis and the impeachment of President Lula (27). No such impeachment occurred but the speculation and rumors had a paralyzing effect on the administration and the Congress. The Brazilian economy and financial markets were more or less immune from the political crisis, but the overall uncertainty about Brazil's future caused a more cautious attitude by the markets which greatly discouraged investment. The result of this uncertain economic environment was that gross domestic investment in 2005 ended the year at about the same level as 2004 (27).

The third factor resulting in modest performance is the continuing appreciation of Brazilian currency, the Brazilian Real.

Exhibit 6: Value of Brazilian Real (versus U.S. Dollar)

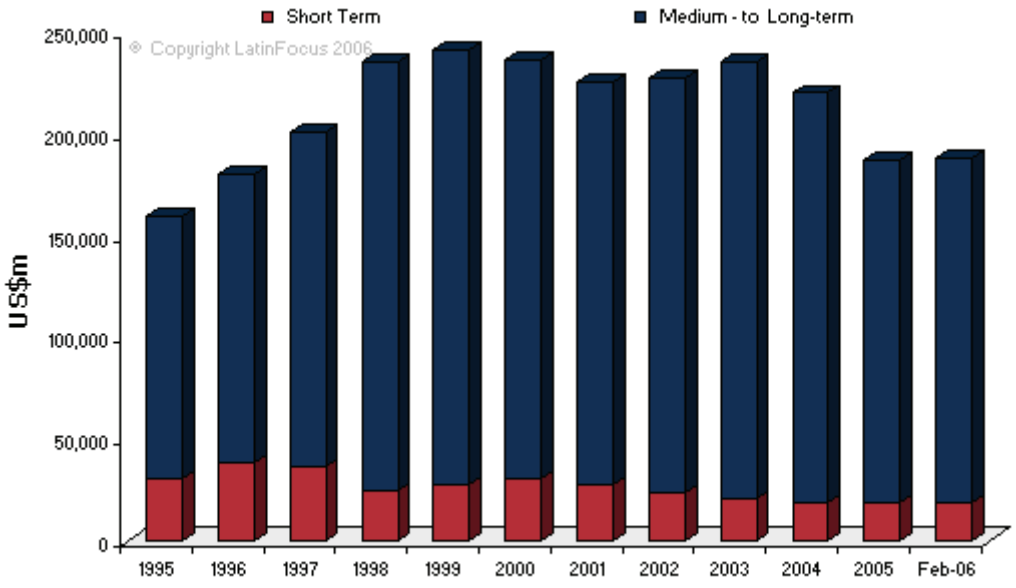


Source: Global Insight

The appreciation of the Brazilian Real throughout the year (2006) has resulted from short term capital inflows, which were attractive to foreign investors because of the large interest rate differential in domestic financial markets and the significantly large trade

surplus currently experienced due to an expansion of exports, particularly agricultural exports (27). In the last three years Brazil has seen continued growth in its export base while simultaneously experiencing a strengthening of its currency. For the majority of Brazil's exports the strong currency will ultimately result in a loss of competitiveness on the world market (36).

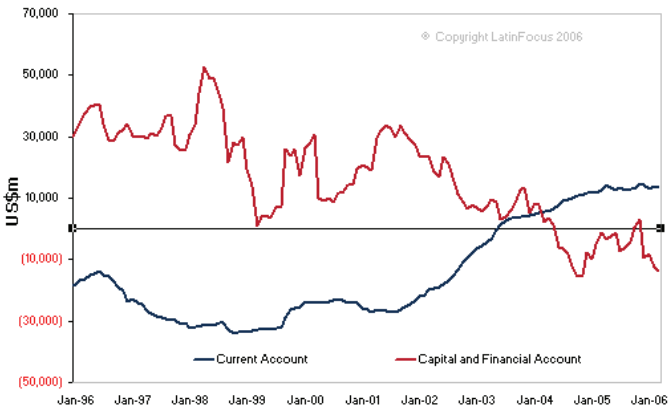
Brazil possesses the aspirations of a world power but still has the problems of a developing nation. Currently, Brazil has an external debt of more than 211 billion U.S. dollars (3).



In an effort to reduce their large external debt, Brazil has accepted a U.S. $30 billion loan from the International Monetary Fund (30). The motivation of this large loan is to persuade Brazil from potentially defaulting on its external debt which would cause great harm to the international credibility of the Brazilian economy. Exchange rates, inflation rates, international flows of funds, availability of future credit, the stability of the stock market on foreign investment all stand to be negatively affected by even a partial default

of Brazil's external debt (29). Brazil's external debt is currently four times larger than its relatively small but growing export base (3). Brazil exported $27.6 billion in agricultural products last year (2005) and only imported products worth $3.2 billion. The agricultural trade surplus of $24.4 billion was the largest in the world and is greatly regarded as the most crucial factor in Brazil's efforts to reduce external debt and bolster GDP (28).

The balance of payments is an effective tool that indicates a country's market potential. Brazil's previously mentioned agricultural export surplus would suggest that in an effort to maintain this surplus Brazil will continue to expand its export base. Brazil's export of primary, semi-manufactured and manufactured goods have all been aided by a high global demand which caused high export prices and increased volumes in all sectors (36). Roughly defined, a country's balance of payments is the record of transactions between its residents and foreign residents over a specified period, most commonly a quarter or a year (19). The balance of payments is determined by a country's exports and imports of goods, services, financial capital and financial transfers. The balance of payments consists of a country's current, capital, and reserve accounts. In 2005 Brazil reported a capital account balance of -$13 billion, a current account balance of $15.5 billion and international reserves of $61 billion (27).

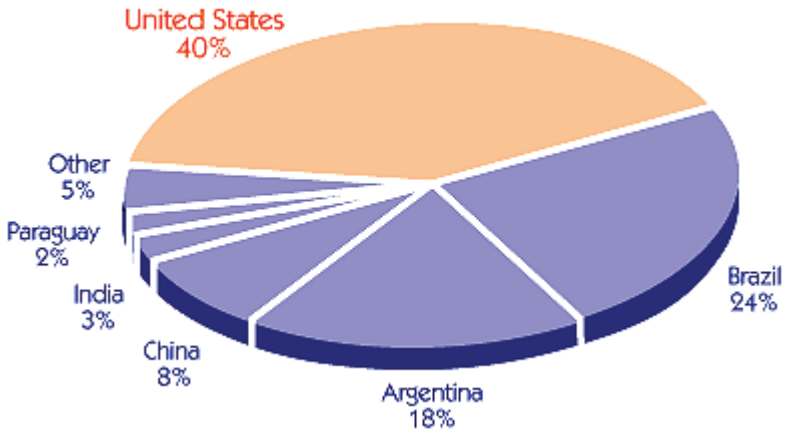


Brazil currently has a balance of payments surplus, meaning more money is flowing into the country than out of it. Brazil's large trade

surplus, increasing from $2.6 billion in 2001 to $44.5 billion in 2005, is the largest contributor to Brazil's balance of payments surplus (27). Maintaining and increasing this surplus has proven the most effective technique in reducing debt and strengthening GDP, and remains the guiding principle of Brazil's economic future.

The European Union is the largest global importer of soy, followed by China which has been experiencing strong import growth. In 2004, the European Union imported 36.9 million tons of soy products, and China imported 16.9 million tons. As mentioned earlier, population growth and an increase in overall per capita income global demand for soy is predicted to increase 60 percent to more than 300 million tons by the year 2020 (14).

The United States has traditionally held the position of the leading supplier of soy to both European and Asian markets. Total soy exports in the U.S. have remained stable over the last few years as a result of growth being absorbed by growing domestic consumption. In 2004 the United States and Brazil combined to produce 64 percent of the world's soybean production, producing 85.5 million tons (40%) and 53 million tons (24%) respectively (45).



Over 80 percent of the U.S. crop is genetically modified, resulting in a decline in the share of the lucrative European import market, which severely restricts the importation of genetically modified food products. Brazil on the other hand, where genetically modified crops are currently restricted, has seen its share increase and is now supplying 63 percent of the European Union's soy imports (45). New labeling requirements in the European Union have reduced the demand for both Argentinean and the United State's soy exports. European consumers have repeatedly rejected genetically modified foods due to concerns of allergenicity and potential harmful effects to human health. A Euro barometer poll conducted by the European Commission in 2001 showed that 94.6 percent of European Union citizens wanted the right to choose whether or not to eat foods with genetically modified ingredients (16). These new labeling standards pose a problem even to Brazil who, as a result of a rigorous certification process, is only able to certify roughly half of its non-genetically modified soy production (17).

As mentioned earlier, increasing global demand is the main driver for the expansion of area planted with soy. Even with production becoming more efficient, evidenced by higher yields per hectare, the current area under soy cultivation will not be sufficient to meet the increasing global demand (14). China alone imported 24.5 million tons of soybeans in 2005, 45 percent higher than the 16.9 million tons of soybeans imported in 2004 (11). The areas most feasible for a significant expansion of soy cropland are in Sub-Saharan Africa and South America. Countries such as Angola, Argentina, Bolivia, Brazil, Colombia, Congo and Sudan all have sizeable amounts of land that could potentially produce soy. Thirty percent of this land is covered in forests. The availability of inexpensive land, a favorable climate and an adequate transportation and

financial infrastructure provides an advantage for South America over Africa as the leading candidate for the expansion of soy cultivation (14).

Favorable market conditions aside, soy production in Brazil may also increase due to a temporary ban on the cultivation of genetically modified soy. The commercial cultivation of genetically modified soy is prohibited in Brazil under a court ruling in June of 2000 (35). In Argentina, Brazil's neighbor to the South, the soy production consists primarily of genetically modified varieties. The extensive border between Argentina and Brazil makes it very difficult to maintain control over shipments between the two countries and, despite the court ruling, genetically modified seeds have made their way across Brazil's borders. It is currently estimated that 60 to 70 percent of the soy produced in Rio Grande do Sul, Brazil's southernmost state, is genetically modified (35). To avoid a major disruption in the market, President Lula enacted a provisional measure allowing farmers to cultivate the genetically modified soy. Since the initial measure, Lula has enacted similar provisional measures three times during his presidency, leading farmers to believe a permanent lift on the ban is near (25). Brazil now stands to become a major player in both genetically modified and non-genetically modified soy markets. Non-genetically modified soy warrants a premium price and large profit margins, but with a perceived weakening of Brazil's strict ban on genetically modified crops, more farmers will be attracted to the cheaper, less labor intensive, genetically modified seeds. From an economist's point of view, the decision to expand soy production is simple and clear. Favorable market conditions, soy prices at a fifteen year high, and large amounts of arable land provide Brazil with a very lucrative opportunity to decrease external debt and

maintain a large trade surplus. The issue quickly becomes not one of economic feasibility, but one of land use and environmental impact.

Environmental Impact

Brazil's decision to significantly expand soy production would have its greatest impact on the stability of the environment. As mentioned earlier, the Amazon rainforest is the world's largest and most unique natural resource, the majority of which lies within the borders of Brazil. The Amazon rainforest makes up more than half of South America, covering 2.3 million square miles (20). The Amazon rainforest has evolved over millions of years to turn into the most incredibly complex environment on the planet (48). An individual square mile of Amazon rainforest can easily be home to over 75 thousand types of trees and 150 thousand species of plant, providing habitats for thousands of creatures (20). The rainforest represents a store of living and breathing renewable natural resources that have contributed to the survival and well-being of humankind (48). The Amazon rainforest has provided mankind with basic food supplies, clothing, shelter, fuel, spices, industrial raw materials and medicines (48). Tropical rainforests like the Amazon cover only two percent of the earth's surface but it is estimated that they are home to over 50 percent of all the life on our planet (20). Representing the most biodiverse area on the planet, the Amazon rainforest is currently experiencing destruction at an alarming rate. Since 1978 over 200 thousand square miles of the Amazon rainforest have been destroyed (13). The destruction of the Amazon rainforest is not a new phenomenon,

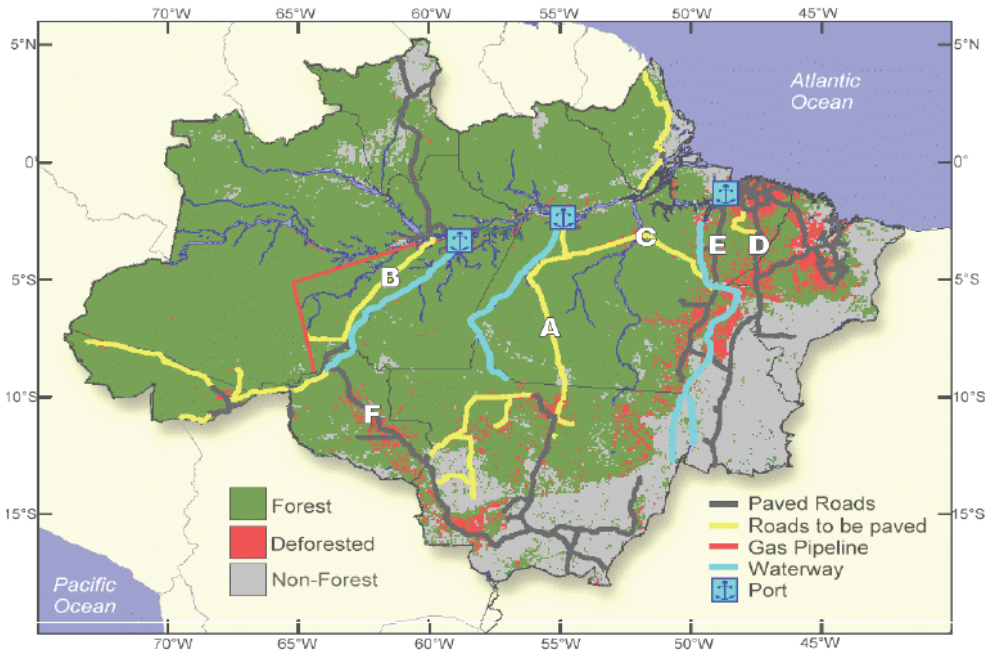
Year	Deforestation [sq mi]	Deforestation [sq km]
1978-1988*	8,158	21,130
1989	6,944	17,985
1990	5,332	13,810
1991	4,297	11,130
1992	5,322	13,786
1993	5,950	15,410
1994	5,751	14,896
1995	11,219	29,059
1996	7,013	18,160
1997	5,034	13,040
1998	6,501	16,840
1999	6,663	17,259
2000	7,658	19,836
2001	7,027	18,130
2002	9,845	25,500
2003	9,500	24,605
2004	10,088	26,129
TOTAL	**203,882**	**528,005**

having been impacted by a multitude of factors for decades. Historically, the Amazon rainforest has been destroyed to clear land for cattle grazing to satisfy the United States' and Europe's insatiable appetite for beef. While Brazil maintains the world's largest number of commercial cattle, a new driver of deforestation has emerged: soy. William Laurence of the Panama-based Smithsonian Tropical Research Institute has claimed on record that, "soy farming is emerging as the critical driver of Amazonian deforestation (5). In South America soy acreage has expanded exponentially. In 1995 there was a mere 18 million hectares of soy planted. That number had skyrocketed to more than 35 million hectares in 2004. In Brazil, soy now accounts for more than 70 percent of the total increases in agricultural acreage (44). Environmental analyst Jan Maarten Dros, contributor to the World Wildlife Fund (WWF), states that "soy, at this moment, is the most important driver for deforestation, directly and indirectly. Directly because the rainforest and cerrado is being converted from natural vegetation to soy fields. Indirectly, because in this region a lot of cattle farms are being replaced by soy farmers buying or renting the land from cattle farmers. The cattle farmers tend to advance into new forest area causing more deforestation" (14). With soybean prices at a 15 year high (25), Brazilian farmers are rushing into the jungles of the Amazon to take advantage of cheap land. Farmland in Brazil is currently selling for 4,800 Brazilian Reals per hectare (US$650 an acre). Uncleared forest is even cheaper, around 300 Brazilian Reals per hectare (US$41 an acre), making illegal deforestation especially tempting and economically attractive (28).

The development of soy farming in Southern Brazil has contributed to the near extinction of Atlantic forest in this region. 8.2 million hectares were planted with soy in

Brazil's three Southern states in 2004; areas that were originally covered with Atlantic forest (14). In Northern Brazil, where the Amazon and transitional forests are found, soy production began in the late 1990's. Between 1996 and 2004 the soy planted area in the Amazon states in the Northern Region increased from 25 thousand hectares to 317 thousand hectares. For the 2002/2003 season, 2.37 million hectares of the Amazon rainforest and transitional forests were destroyed to accommodate the expansion of soy farming and cattle ranching (14). Most of this deforestation occurs in transitional forests because they experience a longer dry season with soils more suitable for agriculture. Brazilian Forest Code states that 50 percent of a property under transition forest can be cleared and only 20 percent of a property under rainforest can be cleared (14), indirectly causing farmers to purchase even larger amounts of land.

Soybean farming has also provided an economic and political motivation for new roads and other large infrastructural projects. Soy is the main agricultural export and a very important source of foreign currency for Brazil. As a result, numerous federal government programs exist to support and maintain its growth (14). To remove infrastructural restraints, the previous Brazilian government implemented a plan known as the *Avanca Brazil,* designed to lower transportation costs from the Brazilian interior to main domestic and export destinations. This plan includes the development of roads, waterways, and railways that link the interior of Brazil with major ports in the North (14). Road construction gives developers and farmers access to previously inaccessible lands in the Amazon (13). These roads have often been referred to as "the arteries of deforestation", and are historically the Amazon's worst enemy (49).



The greatest example of road construction contributing to deforestation is the two thousand mile long Trans-Amazonian highway that bisects the Amazon rainforest (13). The highway effectively opened rainforest lands to migrating peasants from the drought plagued north who have destroyed the forest for timber, grazing and farming. Road construction has also wreaked havoc on the unique species of trees, plants, animals and indigenous peoples of the Amazon rainforest. Five centuries ago there were an estimated ten million indigenous Indians living in the Amazon rainforest. This number has massively decreased as a result of deforestation and previously un-introduced pollutants and diseases, leaving an estimated indigenous population of less than 200 thousand today (Fulbrook). The Yanomani tribe has been arguably hit the hardest, decreasing from 20 thousand in 1986 to a population of less than nine thousand in 2006, the decrease primarily resulting from poor water quality and abnormally high infection rates of malaria (48). Access to previously undisturbed rainforest lands has also led to the estimated loss of 137 plant, animal and insect species every day due to rainforest

deforestation. That equals more than 50 thousand species a year (48). More than half of the world's estimated 10 million plant, animal and insect species live in the Amazon rainforest and are threatened by deforestation. The Amazon rainforest also contains immeasurable potential for scientific discovery. Currently, 121 prescription drugs sold worldwide come from plants from sources in the Amazon. 25 percent of Western pharmaceuticals are derived from ingredients found in the rainforest yet less than one percent of the tropical trees and plants found in the Amazon have undergone intensive scientific testing (48). Edward O. Wilson, Harvard's Pulitzer Prize winning biologist accurately described the situation over two decades ago:

> The worst thing that can happen during the 1980's is not energy depletion, economic collapses, limited nuclear war, or conquest by a totalitarian government. As terrible as these catastrophes would be for us, they can be repaired in a few generations. The one process ongoing in the 1980's that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive us for.

The destruction of the Amazon rainforest will have its greatest impact on the climate. Known as "the lungs of the world", the Amazon rainforest is estimated to be responsible for the production of 20 percent of the world's oxygen (20). The Amazon is known as a "carbon sink" because of the amount of carbon dioxide its plants remove from the earth's atmosphere during the photosynthesis process (20). The recent acceleration of deforestation in Brazil's tropical rainforest has contributed to an increase of 60 to 80 million tons of carbon in the atmosphere (1). Studies have also suggested that the amount of photosynthesis occurring in the Amazon rainforest is currently soaking up

as much as eight percent of man's annual carbon dioxide emissions (5). The result of large amounts of forested lands being destroyed is that less carbon dioxide is being absorbed and even more greenhouse gasses are being released. These large areas of rainforest are typically cleared and then burned and the heavy equipment and fire releases even more carbon into the atmosphere. The greenhouse effect is a major concern amongst scientists who believe deforestation is a major contributor to the problem. Large scale deforestation of the Amazon rainforest can produce up to 2.4 billion tons of carbon dioxide per year, accounting for 25 percent of the annual global emission (20).

The effects of the deforestation in Brazil as a result of increased soy farming can be felt far beyond the borders of South America. Andrew Negri and Robert Adler, research meteorologists of NASA's Goddard Space Flight Center, have found that during the Amazon dry season temperatures over deforested regions are warmer than temperatures found over forested regions (37). Negri and Adler found that land in deforested areas contained less moisture and heated up faster, causing increases in temperatures (37). Climatologists predict that large scale deforestation in the Amazon basin could raise global temperatures one to four degrees Celsius as a result of a decrease in the energy required to evaporate water at the canopy and soil surface (40). These increased temperatures have the potential to change weather patterns, raise sea levels and increase rates of flooding and erosion. Precipitation levels have been shown to decrease over deforested regions, and the decrease of a process known as evapotranspiration also occurs. Evapostranspiration is a process in which moisture is absorbed from the environment by plants, and that moisture is then evaporated before ever reaching the soil (40). Climatologists have tracked weather patterns and have concluded that the moisture

absorbed in the Amazon falls as rain thousands of miles away. New mathematical simulations of climate behavior by Duke University researchers indicate that the deforestation in the Amazon can cause a reduction of rainfall in the Midwestern United States in the summer when precipitation is most needed for agriculture (42). Roni Avissar, chairman of the Department of Civil and Environmental Engineering at Duke University, found that "this reduction of precipitation occurs most of the year but is most significant in the summer months. Of particular interest is that we see a correlation with climate changes, primarily reduced precipitation, in other parts of the world" (42). The impact of the deforestation of the Amazon will ultimately not only affect the environment on a global scale, but it will also have significant impacts on the economies of other countries by diminishing or destroying foreign agricultural production.

Conclusion

The Brazilian government is in a unique position to attempt to satisfy the large, growing demand for naturally produced soy. The uncertainty surrounding the safety and long term effects of genetically modified foods in both Europe and China has created a very stable demand for natural soy. The demand for soy is increasing on a global scale and the relatively low competition amongst producers of natural soy has presented Brazil with a lucrative economic opportunity. The decision to take advantage of this opportunity has both positive and negative consequences.

The motivations for Brazil pursuing this opportunity are plentiful. As previously mentioned, soy prices are at a fifteen year high and both the European and Chinese markets offer favorable conditions such as high demand and low competition. These conditions combine to present Brazil with an opportunity to obtain large profits on their proposed investment. Brazil has further motivation towards seizing this opportunity because of their large external debt and commitment to maintaining and increasing their export base.

The negative consequences of Brazil expanding their soy production are both alarming and possibly unavoidable. Clearing tropical rainforest lands for the production of soy has the potential to be devastating on the environment. Aside from the obvious consequences of destroying the world's most unique resource, the potential negative impacts these actions could have on the global climate may be catastrophic.

The Brazilian government must approach this issue very carefully and with a long term perspective. On a balance sheet, the numbers are impressive. The profits to be made are large and maintaining an already large trade surplus is very appealing. For a country

with a very strong economy like that of Brazil, recognizing and capturing market opportunities are what elevate a country out of debt. In the short run, Brazil stands to be a first mover in the natural soy market in both Europe and China. In the long run, Brazil stands to be the single largest contributor to the already alarming epidemic of global warming. No one can tell Brazil which action to take, but in my opinion sacrificing the amount of rainforest lands to significantly expand natural soy production is a mistake. Converting large amounts of lush rainforest into arable farmland is effectively and irreversibly destroying thousands of years of natural growth. Brazil must understand that the decision is not black and white, it is green. Destroying large areas of the Amazon rainforest will not only impact the climate of Brazil, but also every country on Earth, dramatically impacting food production and weather patterns on a global scale.

Brazil stands to make a significant amount of money from expanding soy production and some form of incentive is necessary for them to forego this opportunity. Other countries must become aware of this situation and become involved. Short term debt relief and favorable trade agreements are just two of the ways foreign countries may relieve the pressure on Brazil, thus preventing or delaying the decision to exploit the world's largest natural resource to expand soy production. Brazil must adopt a more sustainable attitude and utilize current farmland for the production of natural soy. The potential approval of the planting of genetically modified crops is a step in the wrong direction. The competition in the genetically modified soy market is saturated and Brazil should focus their efforts on decreasing the occurrence of genetic contamination from the south and maximizing natural soy output.

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