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"Brazil, the USA and the trade-off between ethanol and food production"

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1. Introduction

The United States of America has been dependent on foreign oil for a long time. According to President George W. Bush, diversifying America's energy supply is one of the United States' vital interests. Through technology, such as biodiesel fuel as well as ethanol, the United States believes it is possible to reduce its dependence on hostile regimes' oil producers. The "Energy Independence and Security Act" of 2007 mandates that fuel producers use at least 36 billion gallons of biofuel by 2022.

Even being one of the greatest world ethanol producers, the United States does not have the capacity to provide all the ethanol it will need to reach that goal. Perceiving a huge opportunity for the Brazilian economy, Brazilian Government officials have held several talks with American counterparts trying to ease the United States' trade barriers for Brazilian ethanol exports. In that sense, the two countries signed the "Memorandum of Understanding Between the United States and Brazil to Advance Cooperation on Biofuels"[1], which expressed the intention of both countries to cooperate on the development and deployment of biofuels.

These two above-mentioned facts ignited a number of arguments from environmentalists, demographists, politicians and economists around the world. Concerns about alleged deforestation due to a possible increase in sugar cane planted area in Brazil have been widely broadcasted on television. Warnings about a reduction of food production have been published by some important journals[2] suggesting that farmers would focus their cultivation on crops to produce fuel. External dependence on oil from politically unstable countries could be reduced, granting better security conditions to developed countries, has been considered. On the other hand, some developing

1 Memorandum of Understanding Between the United States and Brazil to Advance Cooperation on Biofuels, signed in Sao Paulo, Brazil, on March 9, 2007.

2 Haskins, Chris. "Profecia de catástrofe alimentar ainda pode se realizar." Universo On Line, www.noticias.uol.com.br/midiaglobal/prospect/2007/12/30/ult2678u135.jhtm, accessed on December 30, 2007.

countries have perceived a chance to increase their macroeconomic well being through bio-fuel exports to the main consuming markets.

Ethanol production has generated a number of controversies. Most of the time, ethanol seems to be the key solution for the different challenges that we are facing nowadays. On the other hand, ethanol production and its increasing demand worldwide have been seen as a negative phenomenon as well.

In the world's current scenario, some issues have been debated exhaustively, like climate change, food security and free trade. In addition, there is a worldwide trend to seek sustainable development, in other words how can we manage to keep a balance between attending human needs and at the same time maintaining the quality of the natural environment for future generations. This framework addresses the relevance of this paper's subject, which is about whether ethanol production harms food production.

The first issue is climate change. It is known that coal and oil have been burned in huge amounts causing a serious impact on the environment, such as the greenhouse gas effect. Burning so much fuel to produce power for homes, cars and factories pollute the atmosphere and, at the same time, intensify the greenhouse effect. As a result we have global warming. According to scientists, temperatures are rising. This situation causes climate change and a lot of different phenomena throughout the world. Drought is one of them, which affects the production of crops, causes shortages, raises prices and consequently diminishes the availability of food. The melting of glaciers is another phenomenon that also affects the environment in at least two ways: higher sea levels and flooding, both jeopardize wildlife by causing the destruction of their habitats. The greenhouse effect and global warming are such serious issues that we need to face them. These issues are about the relationship between humans and the environment. It depends on us: governments, policy makers, and scientists to study in order to discover and develop new technologies like biofuels, which is a

renewable source of energy and also helps to reduce the greenhouse effect. It is one way to face climate change.

Another important issue is food security. How food production has been affected by biofuels production is a question that has been discussed exhaustively. Since the beginning of time, famine has been a huge concern. Thomas Malthus has established one relationship between food and population. "Population will grow geometrically and food will grow arithmetically"[3]. In other words, food will not be sufficient to feed everyone. This statement demonstrates the concern about scarcity, or how best to allocate scarce resources: land, labor and capital. But this statement has been the subject of many controversial debates[4]. Nowadays, seeking to end dependency on non-renewable sources of energy, ethanol appears to be a good alternative source. It comes most from sugar cane in Brazil, and from corn in the United States, the two biggest producers in the world with 70%[5] of the world production. How can ethanol production be harmful to food production in terms of sugar cane in Brazil and corn in the USA? In order to answer that question, this paper will show Brazil's sugar production from 1975 to the present and also the USA's corn production and compare them. It will then see if crops were diverted from food production to ethanol production and also the effects these crops have had over time on prices.

Although recognizing that there are a great number of variables regarding this subject, this work will concentrate only on the trade-off between biofuel and food production. It will analyze the land cultivation aspects in both the United States and Brazil. Others factors of production, as labor and capital goods, will not be addressed due to the fact that this work considers those two factors have no significant impact on the already mentioned trade-off. On the other hand, land is a critical factor, because the earth's existing available arable land is relatively scarce.

[3] Goodstein, Eban S. "Economics and the Environment." 5th ed. 2008, p. 120.
[4] Idem.
5 Brazil-U.S. ethanol agreement to have global impact: Brazilian FM, http://english.peopledaily.com.cn/200703/11/eng20070311_356420.html.

The last issue is trade. To mention trade off between ethanol and food production, markets and trade need to be considered. Trade, and more specifically free trade, has been another controversial subject worldwide. The last series of global meetings was the Doha Round. Big economies must face through conferences such as the Doha Round as a way to establish agreements that promote freer trade[6]. It is a way to diminish the disparities among nations by helping developing countries to achieve better economic conditions.

The preceding framework about climate change, food security and trade gives us some insights into what is going on worldwide. From now on, this paper will develop and show how food production has been affected by the ethanol production in Brazil and in the USA, the two biggest producers of ethanol in the world. It also will try to clarify these concerns, seeking to establish a foundation, looking through the Brazil numbers: volume of sugar cane and ethanol production, price of sugar and areas planted to sugar cane from the 1970's. And the USA numbers: volume of corn and ethanol production, price of corn and areas planted to corn during the same period and analysis of what has really been going on over time. In its conclusion, this paper will present the position that it is possible to achieve the goals established in the Energy Independence Act.

[6] World Economic News. http://www.sonic.net/~schuelke/FreeTradeAreas.htm.

2. Biofuels: definitions, opportunities, and risks.

a) Definitions:

Biofuels are seen nowadays as a suitable alternative source to reduce oil dependency. According to the Longman Advanced American Dictionary, biofuels are defined as a combination of the prefix "bio", which is related to living things, and "fuel", which could be a substance such as coal, gas or oil that can be burned to produce energy. In addition, the concept of "biomass" – a technical plant or animal matter used to provide fuel or energy – can also help to develop a more complete definition of what biofuels are.

Based on these definitions, one can assume that biofuels are a source of energy that can be solid, liquid or gas derived from plants and animals and their by-products. There are some agricultural products that have been grown for biofuels, like corn and soybeans in the United States; sugar beet, rapeseed, wheat in Europe; jatropha seed[7] in India; palm oil in South- East Asia, and sugar cane and others like cassava (manioc), cashew fruit, sweet potatoes, palm oil in Brazil. According to a Brazilian scholar "whatever can be squeezed in sugar and oil can be transformed in to biofuels or biodiesel."[8]

After this overview about biofuels, ethanol, the main subject of this paper, needs also to be defined. According to the U.S. Department of Energy " Ethanol is an alcohol-based alternative fuel produced by fermenting and distilling starch crops that have been converted into simple sugars." Crops like corn, barley, wheat, sugar beet and sugar cane are common sources of ethanol and bio-ethanol can be produced from "cellulose biomass"[9] such trees and grasses. Another common use for ethanol is to increase octane and improve the emissions quality of gasoline. Under the Energy Policy Act of 1992 (EPACT), ethanol can be blended with gasoline to create E85, a blend of 85% ethanol

[7] Centre for Jatropha Promotion. http://www.jatrophaworld.org/
[8] Professor Doctor Denise Alves Gomes from University of Tocantins, Brazil.
[9] Chen, Chengci. "Biomass for ethanol and crop ping system for energy." Assistant Professor of Agronomy, University of Montana. http://www.harvestcleanenergy.org/conference/HCE5/HCE5_PPTs/Chen.pdf.

and 15% gasoline and even with higher concentration like E95. Vehicles that run on this mixture are called flexible fuel vehicles [10] (FFVs).

Many concerns have come up about the trade-off between ethanol and food: Whether this substitution really exists and how it comes to harm food production. In response to these concerns, this analysis will focus on the land as a factor of production. Showing the area planted to sugar cane, the production and prices of sugar and ethanol in Brazil and the area planted, the production and prices of corn and ethanol in the United States over the years of 1975 to 2007.

b) Opportunities in producing biofuels:

First of all, as regards climate change, biofuels are a way to reduce carbon emissions and to help to end the dependency on oil. At the same time, they can be considered as an important element for sustainable development. Ethanol, a good alternative and renewable source of energy, can be very important for future generations. Being derived from a labor-intensive culture, ethanol can bring development to rural areas and can expand trade. Another point is that it can be well managed in degraded and infertile lands, improving their use.

c) Risks in producing biofuels:

As the demand for biofuels has increased worldwide, there is a huge concern about food security, i.e., about diverting resources from the production of crops for food to the production of crops for ethanol.

Another important concern is about the indiscriminate use of land to produce crops for biofuels. Areas have been deforested, which can lead according to United Nations Food and Agriculture Organization[11], to much more carbon emission.

[10] Otto Cycle (1876) was the first combustion engine designed to use alcohol and gasoline, followed by Henry Ford's Model T (1908), which was designed to use ethanol, gasoline, or any combination of the two fuels. Energy Information Administration/ Renewable Energy Annual 1995.

[11] Incentives to curb deforestation needed to counter climate change - http://www.fao.org/newsroom/en/news/2005/1000176/; accessed in March 25th, 2008.

Subsidies[12] are another concern. It is known that subsidies are a powerful tool of governments to protect infant industries. But in the corn-based ethanol industry, this practice can be a big barrier to the development of trade agreements among countries.

Therefore, we have to be aware about these opportunities, concerns and risks before taking a look at the situation, experience and strategies of the two biggest producers of ethanol, Brazil and the USA.

[12] Federal Subsidies Turn Farms into a Big Business. The Washington Post, Thursday, December 21, 2006; Page A01.

3. Strategies of ethanol in the two biggest world markets: Brazil and the USA

3.1 Brazil's experience and strategies

With the first crisis of oil, at the beginning of the seventies of the past century, Brazil saw its prospect of economic development collapse quickly, thanks to the great dependence on oil imported for internal consumption. To reduce its external vulnerability, the Brazilian government, following its economic policy of substitution of importation to develop its own industry, implemented an ambitious program of alcohol production. The National Alcohol Program (PROALCOOL)[13] had the objective to introduce alcohol, produced from sugar cane, in the country's energy matrix, and especially for the automotive sector.

Public sector subsidies and tax breaks helped get PROALCOOL started: farmers planted more sugar cane, investors built distilleries to convert the crop to ethanol and automakers designed cars to run on 100 percent alcohol. The government financed a distribution network to get the fuel to gas stations and to keep alcohol prices low to entice consumers. In the 1990s, the government gradually withdrew its subsidies and lifted price controls on ethanol when cheap oil prices and ethanol shortages caused consumers to switch back to gasoline. Today, the Government defines the price difference between gasoline mixed with ethanol and hydrated alcohol (minus 30% for hydrated alcohol). The percentage of the mixture of ethanol with gasoline is set at 25%.

Although Brazil's initiatives were known worldwide, they never received as much attention as now. Some reasons for this fact can be pointed out. First of all, Brazil is far away from the major centers of decision and with a small domestic market has contributed to keep a certain indifference to the production in scale of the alternative fuel. Another reason cannot be forgotten is that despite the incentives to alcohol production, Brazil became a big food exporter, occupying market space among other nations, and starting to be considered one of the biggest world producers.

[13] Brasil. Decreto Nº 76.593, de 14 de Novembro de 1975, "Institui o Programa Nacional do Álcool". http://www6.senado.gov.br/legislacao/ListaPublicacoes.action?id=123069

During the past thirty years, Brazil has developed the capacity to contribute to the American fuel dependence reduction goal.

3.2 United States of America's experience and strategies

The biggest world power possesses a voracious domestic market, with almost all countries supplying American needs. Foods, clothes, toys, shoes, services and, notably oil, find in the country eager consumers, accustomed to demanding the best that exists in the world, guaranteeing comfort, stability, security and good living conditions. So, for the United States as a country, food security is not a huge concern, however for the rest of the world it is.

Beyond being a great consumer, the United States also is a great world agricultural producer. From its lands, one gets soy, meat, milk and maize in ratios hardly equaled by other producing countries. Its food production, beyond taking care of its domestic market, has had its excess exported to other countries, which have become dependent on the United States, and on American food prices.

When the subject is oil, one of the first regions that come to mind is the Middle East, which is a politically unstable region, with a different culture than the Western one, and possessing the biggest world reserves of the so-called "black gold". Even though, according to the U.S. Department of Energy, most US oil imports come from Canada, Mexico, Saudi Arabia, Nigeria, and Venezuela[14], the United States imports a part of the necessary oil for its consumption and internal reserves from politically unstable countries. It could not be forgotten that in the Middle East, in the last twenty years, the United States has been involved in at least three wars.

> "High world oil prices, firm government support, growing environmental and energy security concerns and the availability of low-cost corn and soybean feedstock provide favorable market conditions for biofuels" (Energy Information Administration 10/15/2007).

With the intention to reduce its oil dependence, the United States adopted legislation that requires that, by 2022, 20% of the fuel consumption in the United States must be from alternative

[14] According to the US Energy Information Administration, the USA imported in 2007: **Crude Oil Imports (Top 5 Countries) (Thousand Barrels per Day)** Canada – 1,848; Mexico – 1,398; Saudi Arabia – 1,382; Nigeria – 1,085; Venezuela – 1,031.
http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports/current/import.html.

sources. In this matter, alcohol appears as one available tested source, ready to occupy a large slice of that huge needed quantity of combustibles. Although American alcohol production is one of the largest in the world, it alone is not enough to provide the country's needs. Moreover, the produced American alcohol is derived from maize, facing competition of both the food industry and the cattle market, which are great consumers of this grain in the domestic market. This dispute for maize can create a deadlock situation.

The solution for the impasse might consider the following two alternatives. The first one is related to American scientific and technological capacity to reduce internal fuel consumption, making more economic automobiles, for instance. The other one is to reduce the financial incentives to the agricultural sector, at the same time that it begins to consider the reduction of the import tariffs, in order to permit alternative fuel to provide 20% of fuel consumption.

4. Food market versus Ethanol market

To analyze the food and ethanol markets, this paper will focus on three major points: The first one is the use of land, as one of the important factors of production in both markets; second is the volume of sugar, corn and ethanol produced, and the third point will be about the behavior of prices of sugar and ethanol in Brazil and of corn and ethanol in the United States. The analyzed period of time will be from 1975 – the beginning of the Brazilian Ethanol Program – to 2007 [15].

Comparing sugar cane areas planted in more than 30 years and how the practiced prices have been affected in part of this period will be possible to conclude if Brazil has prioritized ethanol instead of sugar production. On the same token, the variation of maize prices in the United States would indicate whether the areas planted to corn were destined more to ethanol than for maize's dietary array.

4.1 Brazil - Analysis of sugar cane, sugar and ethanol production.

Brazil with its 850 millions hectares of area is the fifth largest country in the world. Its territory is covered by 440 millions hectares of equatorial forest. From the more than 410 millions hectares remained, according to the IBGE (Statistics and Geography Brazilian Institute) there are 152.5 millions hectares of **potential arable land** in Brazil.

From **Table 1**, it is possible to get that 62.5 millions hectares of arable land is already destined to a number of permanent as well as temporary plantations. In 1975, the amount of arable land occupied for agricultural purpose corresponded to 27.54% of the total Brazil's potential arable land, which was 152.5 millions of hectares. Last year, with 62.5 millions ha, the occupied arable land percentage was 40.98%. Those numbers demonstrate that in 32 years Brazilian's planted area has increased 48.8%, which correspond to almost two times of the 1975's amount. Even with this augment of used areas, there still remaining 89,5 millions hectares available for agriculture purpose.

[15] Due to many changes in the Brazilian currency over the years, the data about prices in both countries will be analyzed just from part of that period.

Table 1 – Used Arable Land of Brazil.

	Brazil Used Arable Land				
	1,000 ha		1,000 ha		1,000 ha
1975	42,000.00	**1986**	49,000.00	**1997**	57,740.00
1976	43,000.00	**1987**	49,500.00	**1998**	57,640.00
1977	44,000.00	**1988**	49,800.00	**1999**	57,640.00
1978	44,000.00	**1989**	49,900.00	**2000**	57,640.00
1979	44,900.00	**1990**	50,681.00	**2001**	58,865.00
1980	45,000.00	**1991**	51,998.00	**2002**	58,980.00
1981	45,600.00	**1992**	51,803.00	**2003**	59,000.00
1982	47,000.00	**1993**	52,264.00	**2004**	59,000.00
1983	47,000.00	**1994**	52,745.00	**2005**	59,000.00
1984	47,100.00	**1995**	58,059.00	**2006**	61,000.00
1985	47,300.00	**1996**	57,858.00	**2007**	62,500.00

(Source: Food and Agriculture Organization)

Table 2 shows three importants points about sugar cane, which are quantity of land utilized, productivity and percentage of sugar cane destinated for sugar.

The first one is the factor of production land, in this case, the quantity of land used for sugar cane production has increased over the years.

Table 2: Comparative table with planted, harvested areas and the percentage of sugar cane production designated for sugar.

Year	Planted Area 1,000 ha	Harvested Area 1,000 ha	Sugar-Cane Production 1,000,000 ton	Yield (ton/ha)	% Sugar-Cane for Sugar Production
1975	1,900	1,900	88.92	**46.82**	**86.15**
1976	2,080	2,080	102.77	49.43	86.28
1977	2,270	2,270	120.01	52.93	85.69
1978	2,390	2,390	129.06	54.04	76.39
1979	2,540	2,540	139.27	54.79	63.19
1980	2,610	2,610	146.23	56.09	54.16
1981	2,800	2,800	153.78	54.86	55.01
1982	3,080	3,080	186.38	60.47	52.84
1983	3,480	3,480	216.45	62.16	46.69
1984	3,860	3,860	241.39	62.55	40.26
1985	3,900	3,900	246.54	63.22	35.88
1986	3,950	3,950	238.49	60.44	27.87
1987	4,350	4,310	268.58	62.31	31.25
1988	4,150	4,120	258.45	62.78	29.00
1989	4,010	4,070	252.29	62.02	28.80
1990	4,290	4,270	262.60	61.49	26.50
1991	4,240	4,210	260.84	61.94	26.86
1992	4,200	4,200	271.43	64.61	28.50
1993	3,970	3,860	244.30	63.24	31.68
1994	4,360	4,340	292.07	67.23	32.57
1995	4,620	4,570	303.56	66.49	35.03
1996	4,900	4,830	325.93	67.52	37.92
1997	4,950	4,880	337.20	69.10	35.55
1998	5,000	4,970	338.97	68.18	35.92
1999	4,860	4,850	331.71	68.41	42.83
2000	4,820	4,820	325.33	67.51	46.23
2001	5,020	4,960	344.28	69.44	**45.36**
2002	5,210	5,100	363.72	71.31	N/A
2003	5,380	5,370	389.85	72.58	N/A
2004	5,570	5,630	416.26	73.88	N/A
2005	5,620	5,760	419.56	72.83	N/A
2006	7,040	6,190	457.98	**74.05**	44.4

(Source : Ministry of Agriculture - Secretary of production and agroenergy. Department of Sugar cane and Agroenergy).

The area planted to sugar cane increased from 1.9 million hectares (ha) in 1975 to 7.04 million ha in 2006. The sugar cane planted area in 1975 was equivalent to 4.52% of the used arable land described on **Table 1** in that year (42 millions ha). Considering the 2006 amount of utilized land

(61 million ha), it can be observed that the sugar cane planted area grew to 11.54% of the arable land used for plantations. The 2006 sugar cane planted area is almost four times that of 1975.

The production of sugar cane increased from 88.92 million tons in 1975 to 246.54 million tons in 1985, and then in the following years, from 1986 to 1993, it went up and down. From 1994 to 1998 it increased and, in 1999 and, 2000 it decreased from 338.97 million tons in 1998 to 331.79 (1999) and 325.33 in 2000. In 2001 it started to increase again, reaching 457.98 million tons in 2006. From 1975 to 2006, there was an expansion of more than four times in the sugar cane production. At the same period of time, the growth of the sugar cane planted area matches with the growth of sugar cane production.

The second important point showed by this table concerns productivity; comparing production of sugar cane with planted area we have the productivity or ton/ha. It increased from 46,82 ton/ha in 1975 to 74,05 ton/ha in 2006.

> "Average productivity in Brazil is around 65 tons per hectare (t/ha), but it can be higher as 100 to 110 t/ha in São Paulo State. Since the beginning of PROALCOOL, yields have improved by about 33% in São Paulo, with the development of new varieties and the improvement of agricultural practices". (IAEA, 2006)[16]

Those numbers demonstrate that new technologies have been used and also that this activity has become less intensive in labor or has utilized more capital. In this analisis, the third very impressive concerns the relationship between sugar cane and the production's percentage destinated for sugar. In 1975, 86.15% of the sugar cane production was destined for sugar. And after some ups and downs, decreased to 45.36% in 2001. These numbers show a reduction of almost 50% of the sugarcane production destinated for sugar. In other words, this table reveals the increase in the demand of ethanol and, consequently, the rise in its production. According to UNICA[17] on average, 55% of Brazilian sugarcane is turned into alcohol and 45% into sugar".

[16] World Energy Outlook, Box 16.4: Technological developments in Sugar Cane and Ethanol Production.
[17] UNICA – União da Indústria de cana-de-açúcar (São Paulo Sugarcane Agroindustry Union)

Table 3: Sugar production

Brazil Sugar Production					
1,000 Ton		**1000 Ton**		**1000 Ton**	
1975	**6,673**	1986	7,819	1997	13,467
1976	6,071	1987	8,157	1998	14,845
1977	6,851	1988	7,983	1999	17,961
1978	8,306	1989	8,070	2000	19,380
1979	7,476	1990	7,301	2001	15,700
1980	6,980	1991	7,365	2002	18,994
1981	7,844	1992	8,665	2003	22,381
1982	7,912	1993	9,249	2004	24,944
1983	8,843	1994	9,326	2005	26,632
1984	9,086	1995	11,696	2006	26,214
1985	8,849	1996	13,235	**2007**	**30,735**

(Source:1975 – 2001: Datagro - Ano 2000 - Nº 24
2002 – 2007: Ministry of Agriculture)

Table 3 presents tons of sugar produced from 1975 with 6.673 million tons to 30.375 million tons in 2007. Although, there was a reduction of sugarcane destined to sugar production, as already described in Table 2, the sugar production has increased more than five times in 32 years. Relating data from Table 2 and Table 3, it is possible to deduce that in **1975**, there was around **1.600 million** hectares of sugarcane planted **destined to sugar production**. In 2001, when **2.277 million hectares of sugarcane planted area** were dedicated to produce **sugar,** there was an increase of 42% in the planted area dedicated to sugar production. In that period of time, sugar production increased more than 135%. Once more, technology was the key factor for that increase.

It's easy to conclude from those tables above that there is enough area for the production of sugar cane. In other words, the factor of production land is abundant, so one need not worry about that, even though the reduction in the percentage of sugarcane destinated to sugar was impressive, from 86.15% to 45.36%.

After the analysis of planted areas of sugarcane from tables 1, 2 and 3 and its destination to sugar in Brazil, it's important to see how the prices of sugar have behaved over the years. After some dificulties in converting the Brazilian's currencies[18] into dollars, we have gotten some prices.

Table 4: Sugar average prices[19]

Brazil Sugar Average Prices (US$/50Kg bag)					
	US$		US$		US$
1975	N/A	1986	5.64	1997	10.98
1976	N/A	1987	4.03	1998	9.71
1977	N/A	1988	2.54	1999	6.87
1978	N/A	1989	1.94	2000	10.83
1979	N/A	1990	3.37	2001	10.27
1980	N/A	1991	2.83	2002	7.34
1981	N/A	1992	2.37	2003	10.58
1982	N/A	1993	2.12	2004	9.80
1983	N/A	1994	7.18	**2005**	**13.39**
1984	N/A	**1995**	**9.85**	**2006**	**21.16**
1985	**4.23**	**1996**	**12.55**	**2007**	**20.25**

(Source: Esalq/ESALQ /CEPEA - Estado de São Paulo)

From **Table 4**, one can see that taking the year of 1985, the price was U$ 4.23 per 50 kg/bag, but after some ups and downs, ten years later, in 1995, the price reached US$ 9.85 per 50 kg/bag, showing a rise of 132%. The following year, 1996, the price reached US$ 12.55 and after some ups and downs, in 2005 was US$ 13.39, changing only 6.6%. And then in 2006, the bag of 50kg of sugar reached the highest price US$ 21.16 and decreased a bit to US$ 20.25 in 2007. So, in twenty-two years, from 1985 to 2006 the prices have increased by 400%.

[18] Brazilian currencies utilized: Cruzeiro(CR$) Jan /1980 to feb/ 1986; Cruzado(CZ$) Mar/1986 to Feb/ 1989; Cruzado Novo(NCZ$) Mar/1989 to Apr/1990); Cruzeiro CR$(May 1990 to Jun/1994) and the current currency Real (R$).Esalq/USP – Escola Superior de Agricultura "Luiz de Queiroz"/ Universidade de São Paulo. (Agriculture Superior School Luiz de Queiroz/ University of São Paulo.

[19] To convert the Brazilian sugar historical prices serie into US dollar currency, due to the inflation period that Brazil had been under of, it was initialy necessary to update all prices into Real (the current Brazil's curency) according to the FGV's IGP-DI (Prices General Index – Internal Availability) referent to December 31st, 2007. Following, it was converted all prices into US dollar according to the comercial exchange rate practiced in December 31st of every year. Atualização Monetária de Valores – FGV. IGP-DI (Índice Geral de Preços - Disponibilidade Interna). Valores Correspondentes a 31/12/2007. Real R$ .http://www.fgvdados.fgv.br/bf/frm_atualizacao_monetaria.asp. Valor US$ correspondente a 31/12 de cada ano. Conversão de Moedas – FGV.
ttp://www.fgvdados.fgv.br/bf/dsp_conversao_moeda.asp.

The conclusion reached from tables 1, 2, 3 and 4 is that even with the growth of area planted to sugarcane, and the use of new technologies, the production of sugarcane designated for sugar decreased from 86.15% in 1975 to 45.36% in 2001, a significant reduction of 40.79%. It can be easily reflected in the rise in prices by 400% from 1985 to 2007. Even though, it's clear that ethanol production affected the sugar production in some way. It's not the same to consider that the ethanol production can jeopardize the sugar industry. The most important thing to affirm is that Brazil has abundant arable land available with 89.5 million ha.

Table 5: Ethanol production

Brazil
Ethanol Production

	1,000,000 liters		1,000,000 liters		1,000,000 liters
1975	**625**	1986	11,820	1997	14,234
1976	556	1987	10,506	1998	15,408
1977	664	1988	11,457	1999	13,928
1978	1,470	1989	11,704	2000	13,069
1979	2,491	1990	11,898	2001	10,931
1980	3,384	1991	11,783	2002	11,468
1981	3,706	1992	12,752	2003	12,485
1982	4,163	1993	11,687	2004	14,640
1983	5,823	1994	11,296	2005	15,208
1984	7,861	1995	12,692	2006	15,808
1985	9,252	1996	12,671	**2007**	**17,939**

(Source:1975 – 2001: Datagro - Year 2000 - Nº 24
2002 – 2007: Ministry of Agriculture)

Table 5 shows how much the production of ethanol has increased over the years. In 1975, the beginning of PROÁLCOOL Program, Brazil's production was 625 million liters and reached 17,939 million liters in 2007, corresponding to an expansion of almost 3,000%. Relating Table 5 to Table 2 data, from 456,000 hectares of sugarcane planted in 1975, 625 million liters of ethanol were produced which is equivalent to 1,370 liters per hectar. In 2001, when 2,761,000 hectares of sugar

cane planted area was destined to ethanol production, there was 10,931,000,000 liters of ethanol produced in Brazil. In that year, every hectar of sugar cane produced almost 4,000 liters of ethanol.

Table 6: Ethanol prices[20]

Brazil Hydrated Fuel Ethanol Producers Prices					
	US$/liter		US$/liter		US$/liter
1975	N/A	1986	0.18	**1997**	**0.37**
1976	N/A	1987	0.13	1998	0.25
1977	N/A	1988	0.08	1999	0.16
1978	N/A	1989	0.06	2000	0.24
1979	N/A	1990	0.11	2001	0.22
1980	N/A	1991	0.10	**2002**	**0.15**
1981	N/A	1992	0.09	2003	0.23
1982	N/A	1993	0.07	2004	0.22
1983	0.75	1994	0.25	2005	0.32
1984	0.71	1995	0.33	2006	0.42
1985	**0.14**	1996	0.37	**2007**	**0.46**

(Source: ESALQ /CEPEA - Estado de São Paulo)

Table 6 shows the evolution of ethanol's prices already converted into US dollars, from 1985 to 2007. We had two impressives periods of growth in prices. The first period was from 1985 to 1997 when prices drove up from US$ 0.14 cents to US$ 0.37 cents, an increased of 164%. After some ups and downs, in 2002 the price decreased to almost the same price as in 1985 or US$ 0.15. And then, the second important period was from 2002, when prices were US$ 0.15 cents and went to US$ 0.46 cents in 2007. The price increased 207%.

[20] Idem. Endnote 5.

4.2 United States - analysis of the corn production and the Ethanol corn-based industry.

The States of Illinois, Indiana, Iowa, Minnesota, Nebraska, Ohio, and Wisconsin are the biggest US corn producers. They accounted for 75% percent of all corn for grain production in 2006[21].

Once more, as was done with the analysis of sugarcane in Brazil, land is an important variable in this study. As one of the important factors of production, land and its relationship: arable land available and used arable land versus the volume of production for corn/ethanol and its prices over the years can clarify a bit what is happening in the corn and ethanol markets.

According to David Pimentel[22]

> Of the 2.3 billion acres of U.S. land, only 20% is sufficiently fertile for crop production. Most land is either too dry, wet, steep, or cold for crop production. Approximately 26% of our land is used to pasture livestock, 25% for forestry, while the remaining 29% is deserts, mountains and devoted to urbanization and highways.

United States has 465,388,265.3 acres available for agricultural purpose.

Table USA 1: Used arable land in the United States[23]

United States
Cropland Used for Crops

	1,000,000 acres		1,000,000 acres		1,000,000 acres
1975	367	**1986**	357	**1997**	349
1976	369	**1987**	331	**1998**	345
1977	378	**1988**	327	**1999**	344
1978	369	**1989**	341	**2000**	343
1979	378	**1990**	341	**2001**	340
1980	382	**1991**	337	**2002**	340
1981	387	**1992**	337	**2003**	342
1982	383	**1993**	330	**2004**	336
1983	333	**1994**	339	**2005**	336
1984	373	**1995**	332	**2006**	330
1985	372	**1996**	346	**2007**	N/A

(Source: Major Uses of Land in the United States, 1997.)

[21] Source United States Department of Agriculture.
22 FOOD, LAND, POPULATION and the U.S. ECONOMY – by David Pimentel of Cornell University and Mario Giampietro Istituto of Nazionale della Nutrizione, Rome
[23] By Marlow Vesterby and Kenneth S. Krupa. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Statistical Bulletin No. 973

Table USA 1 presents a very interesting aspect: the American cropland area used for crops has decreased from 1975 to 2006. Almost 40,000,000 acres were diverted from agricultural purposes to others uses. In 2002, the last year in which total cropland was inventoried by the Census of Agriculture, about 340 million acres, or 77 percent of the Nation's cropland base, were used for crops. Those numbers demonstrate that the remaining USA cropland, around 115,000,000 acres (around 46,000,000 hectares), correspond to almost half of the Brazilian remaining cropland (89,500,000 hectares).

Table USA 2: Planted Area of Corn

United States

Corn Planted Area

	1,000,000 acres		1,000,000 acres		1,000,000 acres
1975	**78.719**	1986	68.907	1997	72.671
1976	84.588	1987	59.505	1998	72.589
1977	84.328	**1988**	**58.250**	1999	70.487
1978	81.675	1989	64.783	2000	72.440
1979	81.394	1990	66.952	2001	68.768
1980	84.043	1991	68.822	2002	69.330
1981	84.097	**1992**	**72.077**	2003	70.944
1982	81.857	1993	62.933	2004	73.631
1983	60.207	1994	72.514	**2005**	**75.117**
1984	80.517	1995	65.210	**2006**	**70.648**
1985	**83.398**	1996	72.644	**2007**	**86.542**

Source: (US Department of Agriculture)

Table USA 2 shows that in ten years, the planted area for corn in the USA increased from 78.719 million acres (corresponding to 21.4% of all cropland used for crops) to 83.398 million acres in 1985. In the following three years it decreased to 58.250 million in 1988. It increased again by 1992 to 72.077 million, then after that, it had some ups and downs and reached 75.117 million in 2005; 70.648 million in 2006 corresponding to almost 21.5% of all cropland used for crops. The year of 2007 has a unique figure: 86.542 million acres used for corn. So, the planted area of corn increased almost 10% in 32 years.

Table USA 3 reveals the production of corn in the United States from 1975 to 2007. From 5,956,844,000 bushels in 1975, it increased to 8,352,883,000 bushels in 1982. In 1983, it decreased impressively to 4,270,489,000 bushels. In the following years of 1984 to 1985, the production was 7,776,621,000 and 8,978,117,000. It decreased again to 5,007,592,000 in 1988. Then, it reached 9,564,361,000 in 1992, and in 1994 the total produced was 10,140,690,000. After some ups and downs, it reached 11,914,379,000 in 2004, and 13,180,221,000 in 2007. So, the production of corn augmented by 121% over those years.

Table USA 3: Corn Production

United States

Corn Production (Grain + Silage)

	1,000 bushels		1,000 bushels		1,000 bushels
1975	**5,956,844**	**1986**	8,315,991	**1997**	9,304,024
1976	6,407,716	**1987**	7,217,742	**1998**	9,854,164
1977	6,622,784	1988	5,007,592	**1999**	9,526,245
1978	7,386,059	**1989**	7,618,064	**2000**	10,017,207
1979	8,042,938	**1990**	8,020,848	**2001**	9,604,572
1980	6,751,386	**1991**	7,555,981	**2002**	9,069,080
1981	8,236,541	**1992**	**9,564,361**	**2003**	10,196,600
1982	8,352,883	**1993**	6,418,861	**2004**	**11,914,379**
1983	**4,270,489**	**1994**	**10,140,690**	**2005**	11,220,568
1984	**7,776,621**	**1995**	7,478,232	**2006**	10,639,997
1985	8,978,117	**1996**	9,319,138	**2007**	**13,180,221**

Source: (US Department of Agriculture)[24]

Table USA 4 is very important because it shows the amount of corn production that was diverted to the ethanol industry. Comparing the data available from 1980 to 2007, in 1980 the total volume of corn (see Table USA 3) produced was 6,751,386,000 bushels. From this amount, 70,000,000 bushels was destined to ethanol production, corresponding to 1.04% of the total corn

[24] Note: 1 bushel = 8 gallons = 30.28 liters; 1 gallon = 3.785 l (US Department of Agriculture)

production. In 1980, the USA destined almost 99% of its corn production to the food industry. Ten years later, in 1990, 4.49% of the 8,020,848,000 bushels of corn production or 360,000,075 bushels was diverted to the ethanol industry. Continuing the same trend, in 2000, 627,000,000 bushels or 6.26% was used to produce ethanol. In 2003, 10.56% and in 2007 the amount of corn production destined to the ethanol industry reached 17.45% of the 13,180,221,000 bushels. So, during the 27 years, corn production designated to ethanol reached 17.45% of corn production. In the same period of time, the percentage of corn production destined to the USA food industry decreased from 99% to 82.55%. It's important to remember that corn is a basic ingredient in the US' dietary array and also serves to feed many different animals in the meat industry as well, like chicken, pork, etc.

http://www.ibge.gov.br/home/estatistica/populacao/contagem2007/popmunic2007layout TCU14112007.xls

Table USA 4: Corn Utilized in Ethanol Production

United States

Corn Utilized in Ethanol Production

	1,000 bushels		1,000 bushels		1,000 bushels
1975	N/A	**1986**	284,000.00	**1997**	500,000.00
1976	N/A	**1987**	332,000.00	**1998**	538,000.00
1977	N/A	**1988**	338,000.00	**1999**	565,000.00
1978	N/A	**1989**	348,000.00	**2000**	627,000.00
1979	N/A	**1990**	360,000.00	**2001**	681,000.00
1980	70,000.00	**1991**	380,000.00	**2002**	819,000.00
1981	86,000.00	**1992**	440,000.00	**2003**	1,077,000.00
1982	140,000.00	**1993**	480,000.00	**2004**	1,260,000.00
1983	150,000.00	**1994**	540,000.00	**2005**	1,430,000.00
1984	172,000.00	**1995**	560,000.00	**2006**	1,800,000.00
1985	244,000.00	**1996**	423,000.00	**2007**	2,300,000.00

Source: Renewable Fuels Association - Ethanol Industry Outlook 2008

Looking through the prices in **Table 5**, we see that in 1975 the price of a bushel of corn was US$2.54 dollars, which was more expensive than in the following years, i.e., it reflects the effects of the first oil crisis. After some ups and downs, the price of corn reached US$3.11 in 1980, decreased to its lowest price of US$1.50 bushel in 1986. It increased to an impressive value of US$3.24 in

1995, US$1.82 in 1999, US$ 2.42 in 2003 and finally in 2007 the price reached US$ 4.00 dollars a bushel. Due to strong lobbying in agriculture, the US policy toward this sector has been characterized by subsidizing the corn producers, which contribute to lower those prices.

> "Even though lobbying is a legitimate process of information transfer between constituents and government decision-makers, it also produces some obvious disparities. Whenever policy actions generate concentrated benefits and dispersed costs, the incentives and abilities to lobby are significantly different across groups."25

After some ups and downs, the price of corn reached to US$3.11 in 1980, decreased to its lowest price of US$1.50 bushel in 1986. Increased to an impressive value of US$3.24 in 1995, US$1.82 in 1999, US$ 2.42 in 2003 and finally in 2007 the price reached US$ 4.00 a bushel.

Table USA 5: Corn Producers' Prices

United States

Producers' Prices

	Dollar / bushel		Dollar / bushel		Dollar / bushel
1975	**2.54**	**1986**	**1.50**	**1997**	2.43
1976	2.15	**1987**	1.94	**1998**	1.94
1977	2.02	**1988**	2.54	**1999**	**1.82**
1978	2.25	**1989**	2.36	**2000**	1.85
1979	2.52	**1990**	2.28	**2001**	1.97
1980	**3.11**	**1991**	2.37	**2002**	2.32
1981	2.50	**1992**	2.07	**2003**	**2.42**
1982	2.55	**1993**	2.50	**2004**	2.06
1983	3.21	**1994**	2.26	**2005**	2.00
1984	2.63	**1995**	**3.24**	**2006**	3.04
1985	2.23	**1996**	2.71	**2007**	**4.00**

Comparing Table US 4 with Table US 5, we see that after twenty-seven years 17.45% of the corn production was diverted to ethanol producers. On the other hand, the prices of corn during the same period increased almost 29%. In a partial conclusion we can say that even the price of corn has increased over 1980 to 2007, almost 29%, the US ethanol production can jeopardize the corn

[25] Suranovic, Steven. "The Lobbying Problem in Democracy." International Trade Theory and Policy Lecture Notes: 1997-2006.

industry. There is no doubt that corn production has also increased over the years helped by the support of the subsidies, but maybe not sufficiently to not be harmed by the ethanol production. And land is also an important aspect to be considered.

Table USA 6: Hydrated Fuel Ethanol Market Prices

United States Hydrated Fuel Ethanol Market Prices								
	US$/gallon	US$/liter		US$/gallon	US$/liter		US$/gallon	US$/liter
1975	N/A		1986	N/A	N/A	1997	1.20	0.32
1976	N/A	N/A	1987	N/A	N/A	1998	1.12	0.30
1977	N/A	N/A	1988	N/A	N/A	1999	1.00	0.26
1978	N/A	N/A	1989	N/A	N/A	2000	1.25	0.33
1979	N/A	N/A	1990	N/A	N/A	2001	1.50	0.40
1980	N/A	N/A	1991	N/A	N/A	2002	1.30	0.34
1981	N/A	N/A	1992	N/A	N/A	2003	1.15	0.30
1982	N/A	N/A	1993	N/A	N/A	2004	1.80	0.48
1983	N/A	N/A	1994	N/A	N/A	2005	2.25	0.59
1984	N/A	N/A	1995	N/A	N/A	2006	3.15	0.83
1985	N/A	N/A	1996	N/A	N/A	2007	2.25	0.59

Due to difficulties in finding data, **Table USA 6** presents the prices of ethanol in the United States from 1997 to 2007. Ethanol has become so important in the market, as a commodity and an alternative to scarce and expensive oil that people are trying to sell its historical series data prices for a very expensive amount. So, our analysis will cover the last ten years. Due to the rise in petroleum prices, the demand for ethanol, and ethanol prices have increased over the years. In 1997 the liter was US$ 0.32 cents, and then after ups and downs reached US$ 0.48 in 2004; US$ 0.59 in 2005; and reached the highest value in 2006, which was US$ 0.83 cents and decreased to US$0.59 cents in 2007. So, in those ten years there was a rise of 159% if considered to the year of 2006, and 84.3% if taken until 2007.

5.Conclusion

Regarding the mix of debates that have taken place worldwide about climate change, food security, and free trade, this paper has tried to clarify that debate by studying just a few aspects of the ethanol and food markets in the biggest producers of ethanol, the USA and Brazil. High prices of oil have pushed the ethanol industry all over the world. Ethanol has been seen as an alternative way to get out of oil dependence. "Everything that can be squeezed in sugar and alcohol can become ethanol". So, it's a renewable source of energy that can be easily produced from different types of crops, fruits, grass, etc. But, at the same time, there are some negative points as well.

One negative aspect of the ethanol industry that has been discussed addresses the challenge ethanol production faces not to compromise food production. The ethanol industry has been described as harmful for food markets. Causing shortages and consequently driving prices up, so ethanol production has been the main subject in lots of different ways.

Facing this situation, this paper tried to analyze the situation in the USA and Brazil. It started with the factor of production land, how was its utilization over the years, also the production and prices of sugar/ethanol in Brazil and corn/ethanol in the USA were analyzed.

The Ricardian Model [26], according to Suranovic, comparative advantages can be cited as a way to exchange what each country has better. Brazil has advantages in ethanol production or many characteristics necessary to be part in this process helping to develop or expand its technology around the world. Brazil has developed its technologies since 1975 with the PROALCOOL program, which enabled Brazil to export its technologies to other markets.

For Brazil, a huge tropical continental country, land, as a factor of production is not a concern. Table 1 showed that the area planted has increased 48.8%, but there still remains 89.5 million hectares available for agriculture purpose.

[26] Suranovic, Steven M. "International Trade Theory and Policy." Chapter 40, http://internationalecon.com/Trade/Tch40/Tch40.php.

The area planted to sugarcane has also increased, from 1.9 million hectares (ha) in 1975 to 7.04 million ha in 2006. The sugarcane planted area grew to 11.54% of the arable land used for planting. The productivity of sugar cane production, another important factor, has increased from 46.82 ton/ha in 1975 to 74.05 ton/ha in 2006 due to the utilization of new technologies. With the growth in the planted area, and increased productivity, it was observed that the percentage of sugar cane destined to sugar fell almost 50%, from 86.15% of total sugar planted in 1975 to 45.36% of total planted in 2001.

Looking just at sugar production, Tables 2 and 3 showed that, in 1975, 86.15% of total sugar cane planted area (1,900,000 ha) was destined to sugar production (1,600,000 ha). In 2001 (which is the last year with available percentage of sugar cane for sugar production), that percentage felt to 45.36%, corresponding to 2,277,000 hectares of sugar cane planted area for sugar production. So, the sugar cane planted area for sugar production increased from 1,600,000 ha to 2,227,000 ha, corresponding to 42%. In that period of time, sugar production increased more than 135%. Once more, technology was the key factor for that increase.

It's easy to conclude from those Tables mentioned above that there is enough area for the production of sugar cane. In other words, the factor of production land is abundant, so there is no need to worry that ethanol production can be harmful to the food industry, even though the reduction in the percentage of sugar cane destined to sugar was impressive, from 86.15% to 45.36%.

From Tables 1, 2, 3 and 4, one can see that the rise in sugar prices by 400% reflects that sugar production has not matched Brazilian internal market demand. On April 10th, 2008, the President of Brazil recognized the need to increase food production in order to supply on world demand[27]. Having almost 90,000,000 hectares still available for crop production, Brazil can easily increase both its food and ethanol production simultaneously.

[27] Reuters 2008. "Lula defende maior produção de alimentos para diminuir preços." http://br.reuters.com/article/topNews/idBRN1036010420080410, April 10th, 2008.

Ethanol production in Brazil has really increased over the years. From 456,000 hectares of sugar cane planted area in 1975, some 625 millions liters of ethanol were produced, which is equivalent to 1,370 liters per hectar. In 2001, when 2,761,000 hectares of sugarcane planted area was destined to ethanol production, there was 10,931,000,000 liters of ethanol produced in Brazil. In that year, every hectar of sugar cane produced almost 4,000 liters of ethanol. Analysing the ethanol prices from 1985 to 2007, the years from 1985 to1997, when prices rose from US$ 0.14 cents to US$ 0.37 cents, an increase of 164%, in 2002, prices were US$ 0.15 cents and went to US$ 0.46 cents in 2007. The prices increased 207%.

In the United States of America, the situation is different, because the ethanol comes from a very important source of the dietary array, which is maize or corn. Lots of products in the USA depend on corn. According to the Department of Agriculture "corn is almost everywhere you look in the food supply, from salad dressing to soft drinks". So, the subject becomes more sensitive than sugar cane in Brazil, which is versatil and in terms of food supply is more related to sugar. And another important point, looking to the USA, is about the factor of production, land. Even though there are 465,388,265,000.3 acres available for agriculturure purposes, according to the Department of Agriculture, "farmers are expected to plant 86 million acres of corn this year, predicted on Monday March 31st, down 8% from 2007, which was the highest since the World War II". If this really happens, the supply will be smaller. The data in Table 2 show that in ten years, the area planted to corn in the USA increased from 78.719 million acres to 83.398 million acres in 1985. For the following three years decreased to 58.250 million in 1988. The decrease in the planted area can be explained by areas that have been converted to cattle and to infrastructure such as roads, bridges, etc. Then in 2007, 86,542 million acres were used for corn. While the area planted to corn increased almost 10% in 32 years, the production of corn, from 5,956,844,000 bushels in 1975 to 13,180,221,000 in 2007, has risen around 121% over those years.

Another important point is about subsidies. The US ethanol program is weak in terms of Government support to farmers to grow corn. It's known that subsidies are not always the best solution. As subsidies increase, a false impression that farmers are being productive can be perceived by regular people. In fact, subsidies overshadow incapacity, inefficiency, and at last subsidies are paid by American taxpayers. Farmers become dependent and less productive as well. Another thing is about the environment. As subsidies increase, farmers need more fertilizers and the environment becomes more and more polluted from inefficient production. So, these concerns must come up in this study. One way for the US become freer in terms of trade is to open more its frontiers to countries which have more efficient conditions, such as in ethanol from sugarcane from Brazil.

Table USA 4 shows the amount of corn production that was diverted to the ethanol industry. In 1980 the volume of corn produced was 6,751,386,000 bushels and just around 1.04% was destined to ethanol production. Ten years later, in 1990, 4.49% of the 8,020,848,000 bushels of corn produced or 360,000,000 bushels were diverted to ethanol industry. Continuing with the same trend, in 2000, 627,000,000 bushels or 6.26% was used to produce ethanol; in 2003, 10.56% and in 2007 the amount of corn production destined to ethanol industry reached 17.45% of the 13,180,221,000 bushels. Comparing Table USA 4 with Table USA 5, after twenty-seven years 17.45% of the corn production was used for ethanol. On the other hand, the prices of corn during the same period increased almost 29%. In a partial conclusion, it can be said that even the price of corn increased from 1980 to 2007, almost 29%, the ethanol production is far away from harming the corn industry. So, there is no doubt that corn production has also increased sufficiently to not be harmed by the ethanol production. Even though the land is an important aspect to be considered.

The ethanol industry has become so important that it was very hard to get the series of prices, but even that, the behavior of corn prices were seen through ten years. In 1997 the liter was US$ 0.32 cents, and then after ups and downs reached US$ 0.48 in 2004; US$ 0.59 in 2005; and reached the

highest value in 2006, which was US$ 0.83 cents and decreased to US$0.59 cents in 2007. In those ten years there was an augment of 159% if considered to the year of 2006, and 84.3% until 2007.

Finally, even though there are lots of discussions about the ethanol industry harming the food market, from this study there is no need to be worried.

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