

Horizontal consolidation and vertical integration in a growing industry: security of supply and market access in fuel-ethanol value chain

Jin Hooi Chan

PhD Candidate, Judge Business School & EPRG, University of Cambridge, UK

David Reiner

Senior Lecturer, Judge Business School & EPRG, University of Cambridge, UK

Introduction

The global bio-ethanol industry expands rapidly in the past decade. The production increases at an average rate of 15% over the past 10 years. About 80% of the production is supplied to the fuel-ethanol market, the rest is for industrial and beverage uses. The fuel-ethanol market is growing rapidly but the other markets are rather stagnated. Fuel-ethanol is used as an additive/substitute for gasoline. In 2009, the global market share of fuel-ethanol in otto-cycle transport fuel was about 6%.

Besides increasing competitiveness due to high oil price, government policy and supporting instruments have played a key role in the development of this industry. Several governments provide various types of subsidises and actively create mandated market for fuel-ethanol. Governments have different motivations and objectives such as energy independent, diversity and security, rural economy and agribusiness development, and carbon emission reduction. This paper acknowledges a number of controversies surrounding bio-ethanol industry but will only focus on examining its industry structure.

The global biofuel chain, which bio-ethanol is a part of it, has three distinct segments - the upstream agri-commodity segment, the midstream ethanol producing segment, and downstream transport fuel

segment. There are many types of industry player entered into bio-ethanol industry at various segments along the value chain, and especially in the producing segment. These players are such as engineering company, major oil & gas giants, agri-food processors and agri-commodity traders. These companies have their respective competitive advantages and drivers to enter the ethanol industry. The fast growing ethanol industry with its special characteristics of combining agriculture with energy provides a different platform for firms. In this industry, other than the creation of giant horizontal consolidated firms, there is also an evidence of increasing vertical integration along the chain.

This paper provides an overview of the current production, consumption and trade in the bio-ethanol industry. Then, it examines the horizontal concentration in ethanol producing segment in two major producing countries i.e. USA and Brazil, and in global scale. The top 20 producers are ranked and their market shares are estimated. The concentration ratios are then calculated and discussed.

The next section examines the vertical integration of top 30 global producers and some major players in the value chain. The ethanol value chain is illustrated and then factors that influence governance structure at all the segments are discussed. A classification of the producers is then proposed based on their corporate background. The papers examines the drivers in both directions of vertical integration in the industry. The two important factors, that motivate the industry to vertically integrate, are the quest to security of feedstock supply and the effort to penetrate transport fuel market. Finally, a discussion is offered to compare the empirical reality of ethanol industry with various theories of vertical integration. The authors propose that a wider perspective to include socio-political factors into the analysis of governance structure is important to understand the trends in this new and fast growing fuel-ethanol industry.

Global Production, Consumption and Trade

The total world ethanol production nearly tripled in the last decade with 87.26 billion litres in 2007, increasing from 32.17 billion litres in 1988. **Figure 1** shows the global bio-ethanol production from 1975 to 2009. The USA and Brazil are the leading producers with 47% and 31% of global production respectively. Other producing countries are European Union (6.8%), China (5.1%), India (2%), Canada (1.3%), Thailand (0.8%), Columbia (0.4%) and Australia (0.3%). Production is also expected to increase not only in the USA and Brazil but across many countries in Latin America, Africa and Asia as many distilleries will come on stream in the next few years.

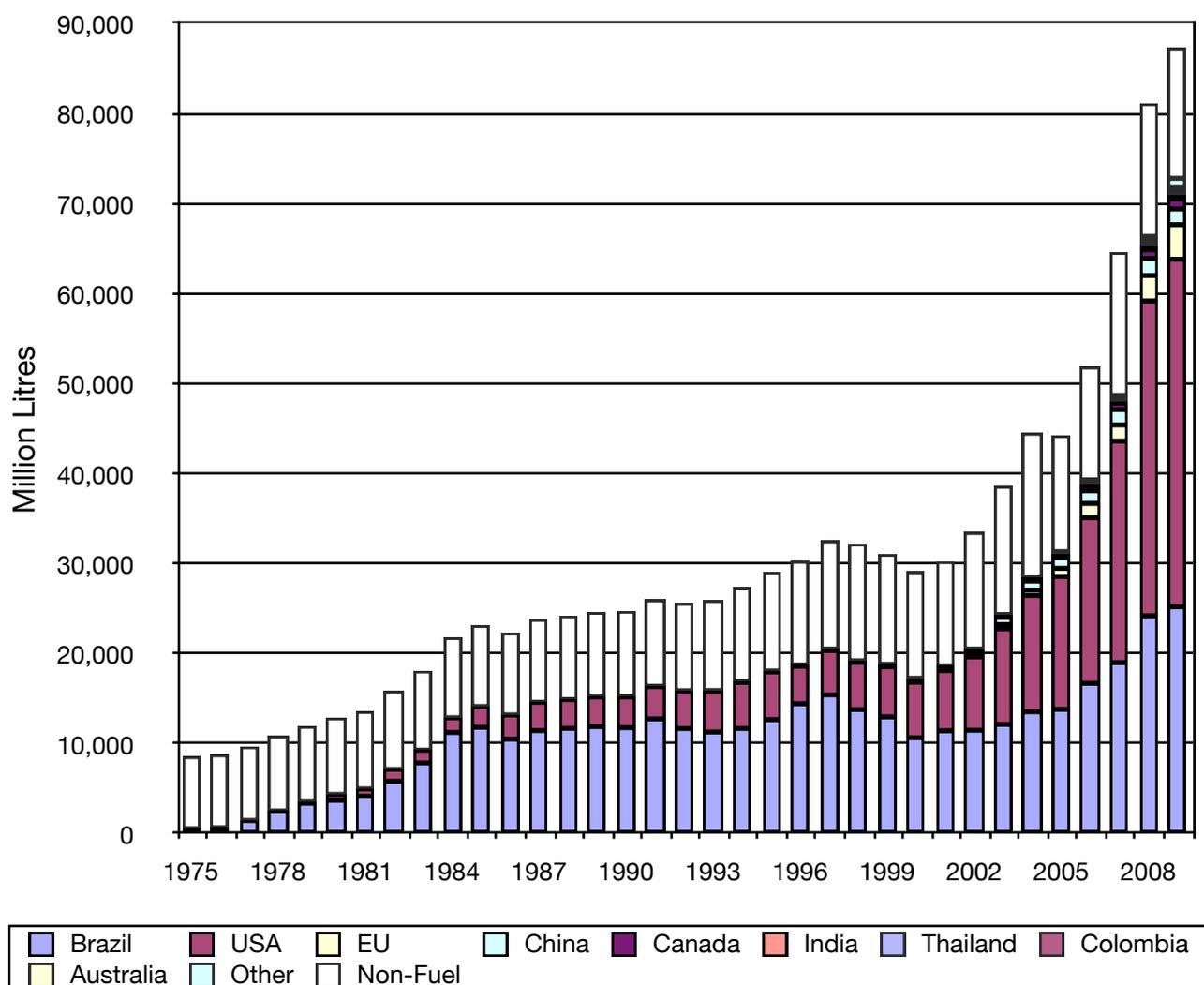


Figure 1: Global Bio-ethanol Production, 2009

There are a number of agricultural feedstock used to produce bio-ethanol. **Table 1** shows the main feedstock used in major producing countries. The traditional feedstock are sugarcane and beet molasses. Molasses has been used to produce beverage and industrial grades alcohol in many countries for a long time. But there are increasing use of corn, sugarcane juice, wheat and cassava. Nevertheless, besides the traditional feedstock - molasses, the percentage of all other feedstock used for bio-ethanol production are relatively low compared to for other uses as shown in **Figure 2**.

The majority of bio-ethanol produced is to supply to rapidly expanding fuel-ethanol market. In 2009, about 84% (73 billion litres) of bio-ethanol was produced for fuel-ethanol market compared to 60% a decade ago. On the other hand, the beverage and industry markets are relatively stagnated, fluctuating between 13 and 16 billion litres.

The majority of fuel-ethanol produced is meant for domestic consumption. Brazil is the main exporter but its export was only 13% of the 25.2 billion litres production in 2009. The two major importing entities are USA (2.15 billion litres in 2009) and EU (~2 billion litres in 2009). Other major importing countries are Japan, South Korea and Canada.

Table 1: Main Feedstock used in major Producing Countries

	Country/Region	Main Feedstock
1	USA	Corn
2	Brazil	Sugarcane, Cane Molasses
3	EU	Beet, Beet Molasses, Wheat, Corn
4	China: Northern Central Southern	Corn Corn, Wheat, Imported Cassava Chip Cane Molasses, Local & Imported Cassava Chip
5	India	Sugarcane Molassess
6	Canada	Corn
7	Thailand	Sugarcane Molassess, Cassava
8	Columbia	Sugarcane, Cane Molasses
9	Australia	Sugarcane Molassess

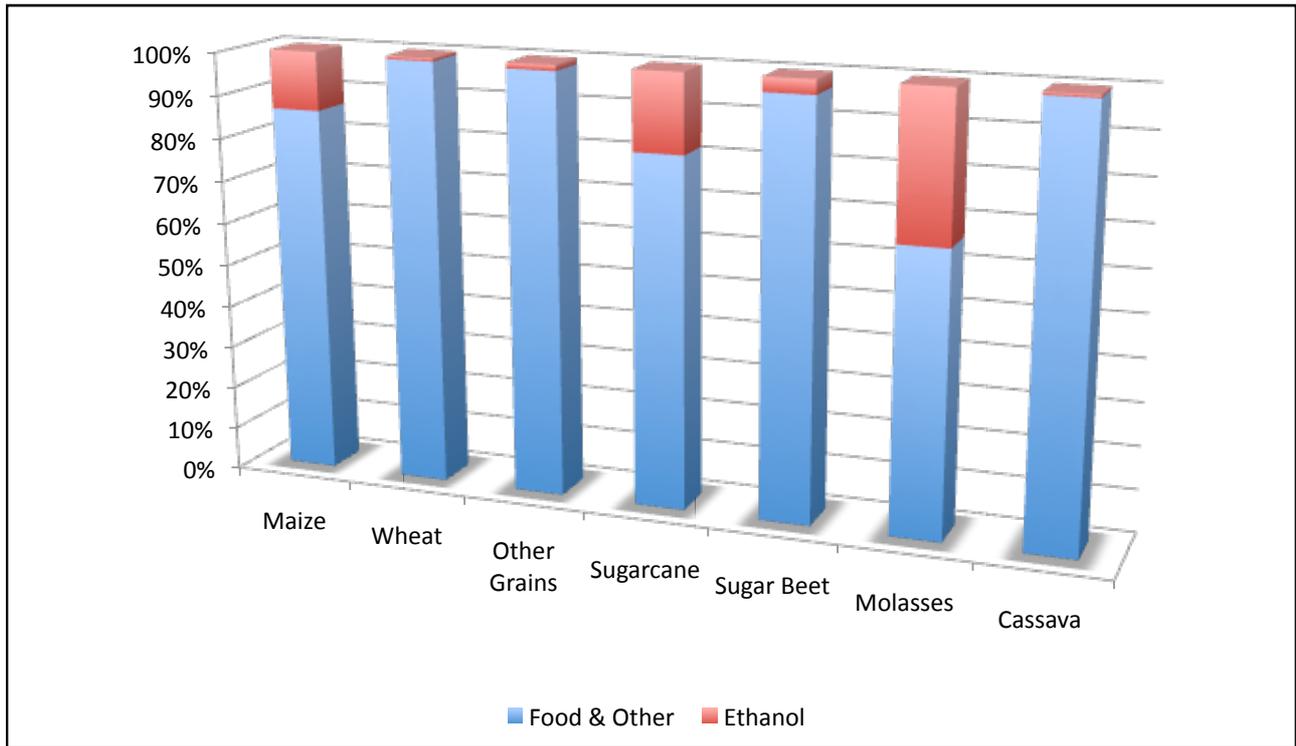


Figure 2: Percentage of Various Agricultural Produces used for Bio-ethanol Production
 Sources: F.O. Licht's Vol. 7 No. 5 and FAO Online Statistics

Bio-ethanol share of global oil supply was about 1.4% in 2009. For otto-cycle transport fuel, ethanol contributed 5.7% by volume. The USA consumed 42 billion litres of fuel-ethanol which was about 7.4% vol. of total motor gasoline. It was followed by Brazil (22.65 billion litres), over 55% vol. of total motor gasoline. The EU27, China, Canada and Thailand respectively consumed 4.2, 1.7, 1.5 and 0.46 billion litres as shown in **Table 2**. Fuel-ethanol is increasingly penetrating into gasoline market as a substitute. The market share is very much depending on government targets and mandates but it is also depending on the relative price of ethanol to gasoline. There are other factors that could increase or be barriers for the expansion of ethanol market share. These factors will be discussed later in this paper.

Table 2: Estimation of Ethanol Share in Otto-cycle Transport Fuel in 2009

Country	Gasoline (million litres)	Ethanol (million litres)	% Ethanol by Vol.
Global	1,227,000	74,443	5.7%
USA	524,444	42,026	7.4%
Brazil	18,462	22,650	55.1%
EU	131,500	4,187	3.1%
China	72,730	1,730	2.3%
Canada	40,853	1,500	3.5%
Thailand	7,063	460	6.1%

Source: Gasoline data based on Euromonitor, Ethanol data based on US EIA & F.O. Lichts

Figure 3 shows the market cycle of bio-ethanol industry. It is currently at the Growth stage with rapid increase in market penetration. Nevertheless, the potential in further growth depends on a number of factors such as land and feedstock availability and price, price of oil, sustainability performance, government policies, and technological breakthrough. There are many governments, research institutes and private companies which invest heavily into the 2nd generation fuel-alcohol research. A breakthrough in this research could have a disruptive effect on the production processes and feedstock requirement as well as pushing the market penetration further.

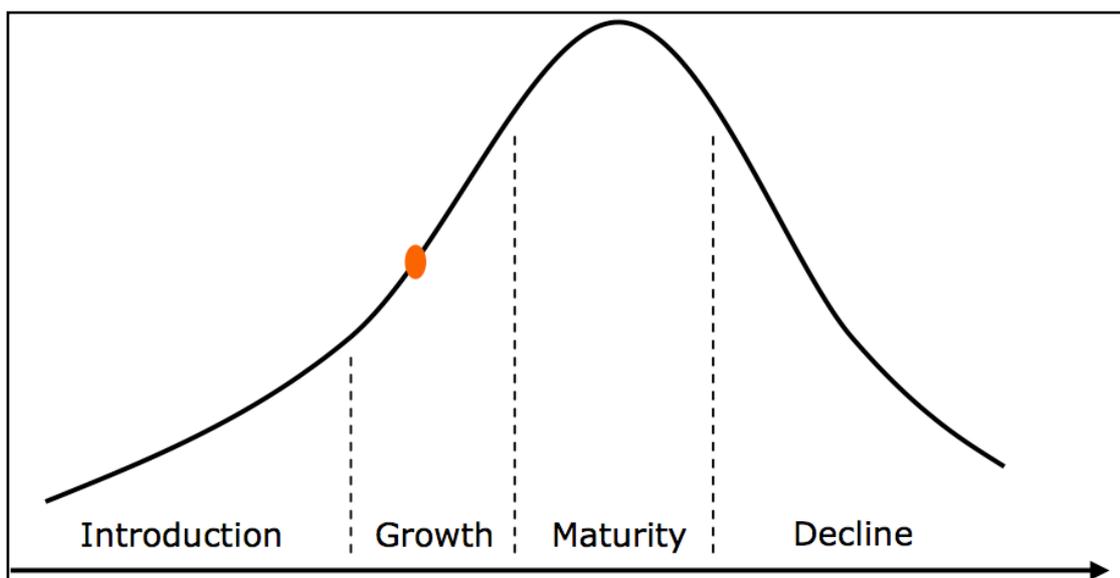


Figure 3: Bio-ethanol Market Cycle

Horizontal Concentration in the Ethanol Producing Segment

Market concentration analysis is commonly done to determine whether there is sufficient competition among industry players. The result is used in the administration of anti-trust regulation, to avoid price-setting and other anti-competitive opportunistic behavior. This section performs a market concentration analysis of ethanol producing segment which is one of the most important segment of ethanol value chain. Since the last decade, there has been a strong trend of merger and acquisition in the global ethanol producing segment. In addition, the analysis in this paper is also done to understand the trend of horizontal concentration, the degree of concentration and the big businesses that involve in global consolidation of ethanol production.

The analysis is based on 3 levels of concentration ratio i.e. four-firm, eight-firm and twenty-firm. The ratios were calculated on global scale and for the top two producing countries (USA and Brazil). Global concentration ratios would be able to give a picture of the level of involvement by multi-national corporations which are active in a number of regions.

The measure of concentration is based on the market share of the production capacity of each nameplate producers. Production capacity includes the design capacity at the year of interest, the capacity of new plant and expansion of existing plants under construction. It is a good indicator of a producer's capability and competitive significance. Ethanol is an undifferentiated product, a commodity and thus a firm's capacity is likely the best measure of its competitiveness.

Nevertheless, the measurement of plant/distillery's capacity is not a good indicator for most of the producers in Brazil. The distillery is normally an integral part of a sugar mill in Brazil. The mill adjusts the ratio of sugar to ethanol based on the prices signal of both commodities.

The data is from publicly available information. The Renewable Fuel Association (RFA) of the USA published annual production capacity of each producer, capacity expansions or new plant

under construction. The Brazilian Sugarcane Industry Association (UNICA) publishes annual ethanol production of producers in Brazil. Other sources of data include public announcements, industrial magazines, and producers' websites which provide information on the capacities and expansion/construction plans.

Concentration in the USA Ethanol Producing Segment

The ethanol producing industry in the USA is rather concentrated in the last decade. The combined market shares of the top four firms were 40 to 50% in 2001 and 2002 (**Figure 4**). However, the four-firm concentration ratio dropped to below 40%, the oligopolistic level since 2003. With a clearer policy direction in the USA in 2005, an increasing trend of concentration from merger and acquisition is observed from 2006. However, there was a reduction in horizontal concentration after 2008 due to the financial crisis and collapse of some ethanol producers as a result of corn hedging. Anyhow, the concentration ratios for four-firm and eight-firm suggest that the industry is near oligopolistic and further M&A will result in the emerging of powerful producers in the market.

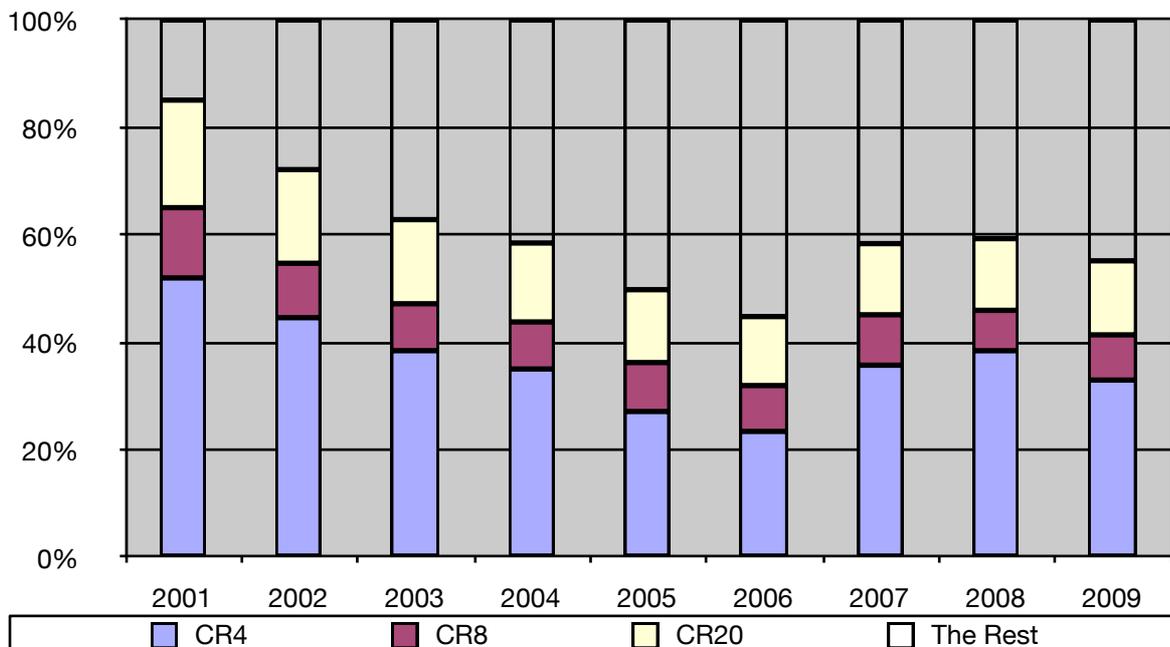


Figure 4: Concentration Ratio of the USA Bio-Ethanol Industry, 2001 - 2009
 Source: Ethanol Industry Outlook. RFA. (Year 2002 to 2008) & Producers' website

Table 3 lists the top 20 producers in 2009. The American agribusiness giant, Archer Daniels Midland Co. (ADM) controlled more than 30% of the total US production capacity during the earlier years of this decade. In 2002, ADM brought the Minnesota Corn Processors, the then 3rd largest ethanol producer, increasing its total capacity to 4.15 billion litres (33.5% market shares) of ethanol. But it was eroded after the boom of the ethanol industry in 2003 and 2004 when a lot of smaller producers such as farmers' cooperatives, entrepreneurial start-ups entered the market. A few bigger players entered into the producing segment during the middle of the decade, including some international firms like the Spanish conglomerate Abengoa and UK's sweetener giant Tate & Lyle.

However, ADM is still the largest producer with more than 11% market share in 2009. POET comes second with 10.7%. Even though POET does not really have controlling equity stake in all its name-plated distilleries, it manages the facilities and markets the ethanol produced. Valero, the oil refiner, becomes the third largest producer will acquisition of assets from the bankrupted firms, mostly those of Verasun.

After the successfully merged with U.S. Bioenergy (the 4th largest producer) on 31 March 2008, Verasun Energy (the 3rd largest producer) became the then largest ethanol producer with 11 operating plants and another 6 new plants in construction or development. Verasun was also involved in blending and marketing its own brand of E85 ethanol to 150 retailing station over 15 states. However, Verasun have gone into Chapter 11 administration after it hedged corn at the height of corn price and unable to commit to the purchase after the dip of corn price in July 2007.

Table 3: Top 20 Producers in the USA, 2009 (CR4=33.0, CR8=41.4, CR20=55.6)

Rank	Company	Capacity (million litre/year)	National Share (%)
1	Archer Daniels Midland	6,276	11.2%
2	POET	5,974	10.7%
3	Valero Renewable Fuels	4,378	7.8%
4	Green Plains Renewable Energy	1,860	3.3%
5	Abengoa Bioenergy Corp	1,449	2.6%
6	Hawkeye Renewables LLC	1,201	2.1%
7	The Andersons Ethanol LLC	1,065	1.9%
8	White Energy	1,000	1.8%
9	Pacific Ethanol	961	1.7%
10	BioFuel Energy LLC	891	1.6%
11	Tate & Lyle	814	1.5%
12	Aventine Renewable Energy Inc	802	1.4%
13	Glacial Lakes Energy LLC	802	1.4%
14	AltraBiofuels	711	1.3%
15	Global Ethanol	600	1.1%
16	Louis Dreyfus Commodities	562	1.0%
17	Cargill Inc	465	0.8%
18	Golden Grain Energy LLC	446	0.8%
19	Panda Ethanol	446	0.8%
20	Heartland Grain Fuels LP	446	0.8%
	The rest	25,100	44.8%
	Total of the Year	56,021	100.0%

Source: Ethanol Industry Outlook, RFA, 2010, & Firms websites.

Note: Based on capacity installed and under-construction

Concentration in Brazilian Ethanol Producing Segment

Ethanol industry is more complicated in Brazil as it is strongly related to the sugar industry. In Brazil, most of the ethanol distilleries are annexed to a sugar mill. The proportion of sugar to ethanol varies according to the dynamics of both markets. However, in aggregate, sugar-ethanol ratio is about 50-50% divide on cane crushed nationwide in the last few years.

General perception is that the sugar-ethanol industry in Brazil is not concentrated, where about 350 plants are being controlled by more than 200 firms. The biggest firm controls not more than 8% of the total national capacity and the top four or five firms do not have more than 15% of market share

as commented by Eduardo Pereira de Carvalho, director of ETH Bionergia, which is actively involved in merger & acquisition (M&A) activities in order to expand their market share.

However, the industry has been undergone waves of concentration in the last decade. In 2007, deals executed were almost doubled, compared to 2006, with 10 acquisitions, nine minority stake purchases and 15 joint ventures in sugar-ethanol sector as reported by Fabio Niccheri Director of M&As at Pricewaterhouse. Another wave of acquisition occurred after the financial crisis. A number of foreign firms purchase large sugar-ethanol groups which faced liquidity problem due to over-expansion and low producer margin.

Table 4 shows the top 20 producers in Brazil in 2009. Cosan SA Industria e Comercio, the world's largest sugarcane processor, owned 23 cane processing plants increased from 17 in 2007. The mills crushed 44.2 million tonnes of cane, about 10% of total Brazilian harvested in 2008/09 session. In the same year, Cosan produced more than 2.4 billion litres of ethanol, up from 1.4 billion litres in 2007. The second largest ethanol producer is ETH Bioenergy, which is a new subsidiary of Odebrecht, the largest Latin American construction conglomerate, formed in mid 2007. It later attracted Sojitz, the Japanese commodity trading multinational, to take up 33% of stake and acquired Brenco, a sugar-ethanol group on 18 Feb 2010. A few of its units are still under construction. Upon commissioning expected in 2012, the ethanol production capacity will reach 1.7 billion litres.

Some major foreign players are now active in Brazil sugar-ethanol industry such as India based sugar company, Shree Renuka which purchased Equipav on 21 Feb 2010, Bunge which brought Moema Grupa on 11 Feb 2010, Louis Dreyfus which acquired Santelisa Vale in Oct 2009, BP which invested in Tropical BioEnergia in 2008, Hong Kong based supply chain manager Noble Group and France Tereos.

The market share calculation is based on the production in 2008/09 session but adding the capacities of distilleries under-construction. The four-firm concentration ratio is below 30%, compared to a higher concentration ratio of 33% in the USA. However, eight-firm and twenty-firm concentration ratios in Brazil are higher than those in the USA. If the trend of horizontal consolidation continues in Brazil, especially the inroad of foreign giants to acquire Brazilian sugar-ethanol groups, the ethanol production segment will be heading toward higher concentration and might surpass the situation in the USA.

Table 4: Top 20 Producers in Brazil, 2009 (CR4=29.1, CR8=41.8, CR20=62.5)

Rank	Company	Production/Capacity (million litre/year)	National Share (%)
1	Cosan	2,468	9.8%
2	ETH Bioenergia	1,748	6.9%
3	Shree Renuka/Equipav	1,636	6.5%
4	Bunge/Moema	1,486	5.9%
5	Louis Dreyfus/Santelisa Vale	1,364	5.4%
6	Sao Martinho	676	2.7%
7	Pedra Agroindustrial	586	2.3%
8	Moreno	569	2.3%
9	Zilor	559	2.2%
10	Noble Group	500	2.0%
11	Tereos/Guarani	496	2.0%
12	Tercio Wanderley	486	1.9%
13	Santa-Terenzinha	479	1.9%
14	Tropical Bionergia/BP	435	1.7%
15	Carlos Lyra	416	1.7%
16	Aralco	414	1.6%
17	Virgolino de Oliveira	411	1.6%
18	Vale do Verdao	360	1.4%
19	Colombo	340	1.3%
20	Farias	322	1.3%
	The rest	9,451	37.5%
	Total of the Year	25,200	100.0%

Source: UNICA Stats, 2008/09. Producers' websites.

Note: Based on production in 2008/09 session and distilleries capacity under construction. The distillery capacity does not reflect the actual production because of the practice of mills to balance the production of sugar and ethanol according to market.

Concentration in Global Ethanol Producing Segment

In this globalised era, there are some international ethanol producers operating across a few regions. For example, Abengoa Bioenergy which, hitherto, is the only global multinational, which has significant presence in the production segment of fuel-ethanol industry in the three important continents of ethanol production and consumption. In terms of production capacity, Abengoa is the largest ethanol producer in Europe with 2.5 billion litres, one of the largest in the USA with 1.45 billion litres, and 140 million litres in Brazil. The total installed capacity expected is 4.1 billion litres by the end of 2009. It is the 4th largest producer globally with 5.5% of market share.

In global terms, the top 3 producers are all domestic players in the USA i.e. ADM, POET, and Valero, controlling 7.95%, 6.83% and 5.51% respectively as shown in **Table 5**. Cosan, the largest producer in Brazil is in the 5th place with 2.83% share. Shree Renuka is in the 6th place with 2.13% share.

The four-firm concentration ratio is 25% suggesting no oligopolistic in the global ethanol industry. However, if consolidation trends continue in the USA and Brazil, there is a possibility of the creation of fuel-ethanol production giants which have significant global market power. **Figure 5** shows a comparison of concentration ratios for Brazil, the USA and in global scale. As expected, global concentration ratios mimic those in the USA and Brazil as both are the major producers, supplying more than 80% of global ethanol demands. It should be noted that the twenty-firm concentration ratio in Brazil is much higher than in the USA.

Table 5: Top 20 Global Producers in 2009 (CR4=25.0, CR8=34.3, CR20=49.3)

No	Holding Company	HQ Location	Main Ethanol Producing Location	Production/ Capacity (million litre/year)	Global Share(%)
1	ADM	USA	USA	6,937	7.95%
2	POET	USA	USA	5,957	6.83%
3	Valero	USA	USA	4,806	5.51%
4	Abengoa	Spain	USA/Europe	4,094	4.69%
5	Cosan	Brazil	Brazil	2,468	2.83%
6	Shree Renuka	India	Brazil/India	2,020	2.31%
7	GPRE	USA	USA	1,860	2.13%
8	ETH Bioenergia	Brazil	Brazil	1,748	2.00%
9	Hawkeye	USA	USA	1,628	1.87%
10	Bunge	USA	Brazil	1,486	1.70%
11	Tereos	France	France/Brazil	1,415	1.62%
12	Louis Dreyfus	France	Brazil	1,364	1.56%
13	Andersons	USA	USA	1,066	1.22%
14	White Energy	USA	USA	1,000	1.15%
15	Pacific Ethanol	USA	USA	961	1.10%
16	COFCO	China	China	925	1.06%
17	Biofuel Energy	USA	USA	891	1.02%
18	Tate&Lyle	USA	USA	814	0.93%
19	Glacial Lake Energy	USA	USA	802	0.92%
20	Aventine RE	USA	USA	802	0.92%

Source: Producers Websites, RFA & UNICA statistics.

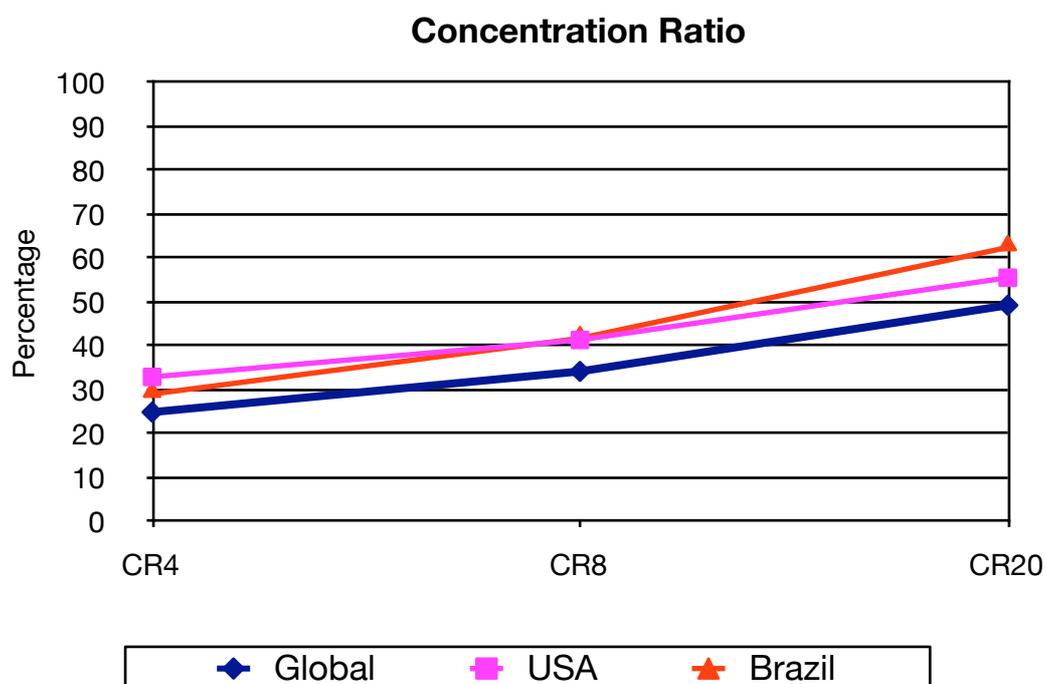


Figure 5: Concentration Ratio of the Global, USA & Brazil Bio-Ethanol Industry in 2009

Vertical Integration in the Ethanol Industry

This section investigates the degree and drivers for vertical integration in the bio-ethanol industry. An analysis of the value chain is performed to provide insight into critical segments along the value chain, various important factors and stakeholders involved, and some example of major firms operating in a particular segment. Then, global 30 largest producers of ethanol are selected. Investigation is performed on the corporate background of the producers and their vertical involvement in the ethanol value chain. In order to capture specific aspects of the integration trend, additional 10 players in the value chain has been selected. These 10 players are either major regional producers or oil and gas corporations which have involvement in the ethanol value chain.

Bio- Ethanol Value Chain

Bio-ethanol is an industry with a complex value chain. The upstream of the industry is the traditional agriculture value chain. A representation of these segments of value chain and various factors that will have an effect on the structure of chain governance is provided. Some examples of major players in these segment are also given.

Figure 6 is an illustration of the upstream section of the ethanol value chain, which could be further categorised into three segments. Socio-political aspects of land such as land right and ownership structure in a specific country are important factors that shaping governance structure of this segment. For example, there is minimum land ownership restriction for individual or corporations, local or foreign, to control large piece of land for cultivation in Brazil. But this not the case in countries such as China, the Philippines and Indonesia. Corporations will have difficulties in integrate upstream to landownership in these countries.

At the cultivation segment, types of crop is an important factor. Some crops requires substantial input such as seedings, fertiliser and pesticide. Other such as cassava requires only one off seeding

purchase and the next planting material is obtained from previous harvesting. On the other hand, farm size, farm management, and farm labour have also a great effect on how upstream integration could or could not happen. Small size family cassava farming in centre Thailand somehow prohibits equity or even contract farming type of downstream integration. However, the traditional sugar-ethanol industry in Brazil owned substantial portion of their sugarcane land and cultivation.

The next segment is storage, transport and trade of agriculture produces. In a widely disperse small size cassava farming in Vietnam, 1st tier traders or transporters will have access to information about harvesting schedule of farmers. They gather the harvest and sell to 2nd tier for local or export markets. On the other hand, there are also global commodity giants such as Louis Dreyfus and Bunge, who have accessed to credits, owned storage facilities and transportation logistics. More importantly, they hold information about and have relationship with sellers and buyers throughout the the world. They are able to track pricing in different markets and identify trading opportunities. In the USA, some firms are farmer cooperatives which pool and market agriculture produces. Glacial Lakes Energy in the USA is an example of ethanol producers owned by cooperatives.

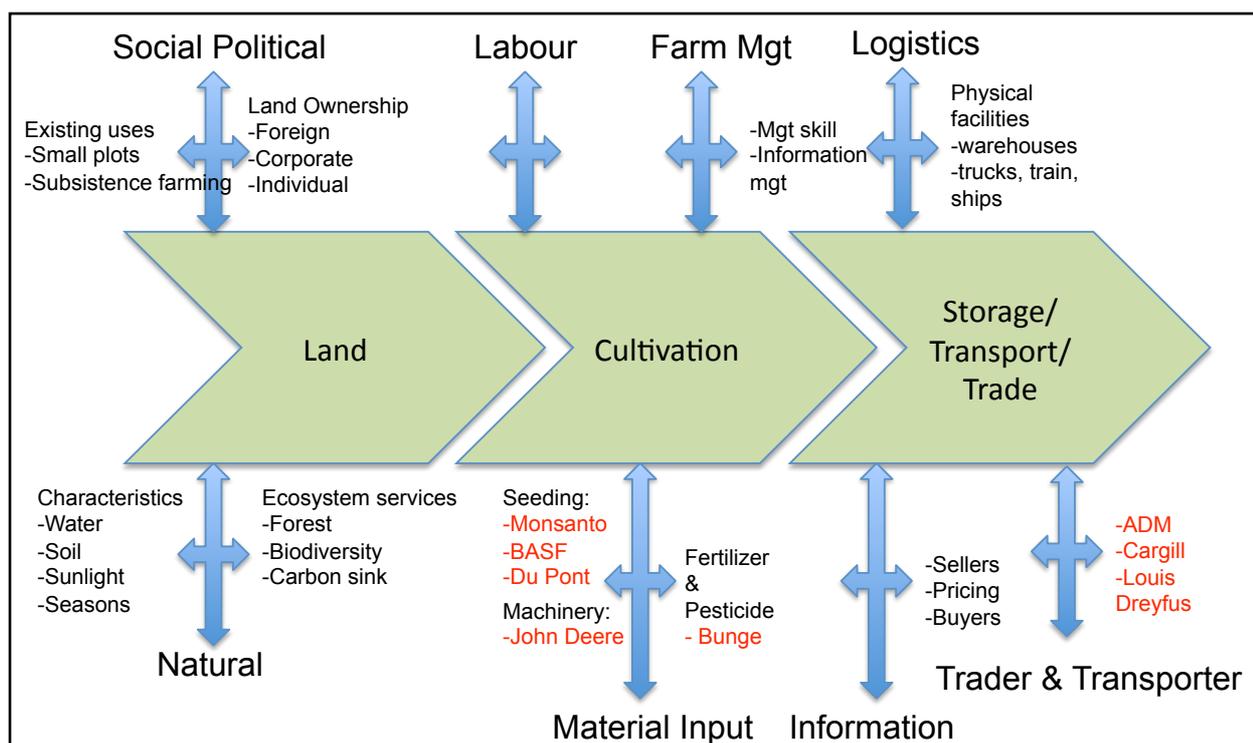


Figure 6: Upstream Bio-ethanol Value Chain: Agriculture

The midstream chain is also divided into three segments as shown in **Figure 7**. The pre-processing & service segment is an auxiliary segment involving the supply of technology and services before and during construction of the distillery. There are global engineering firms who provide the Engineering, Procurement, & Construction (EPC) services to build the distillery for producers. Some of these firms hold key proprietary patents and technologies. For example Delta-T owned an important patent on dehydration technology. Some ethanol producers have involvement in this segment. In the USA, POET and ADM both design and construct their own distilleries. Abengoa is coming from an engineering & construction background who builds distilleries all over the world. A new comer into this segment is Shree Renuka of India. Shree Renuka is a sugar-ethanol company based in India and have operating units in both India and Brazil. It has just acquired KBK, an engineering and construction company based in India who builds distillery throughout Asia.

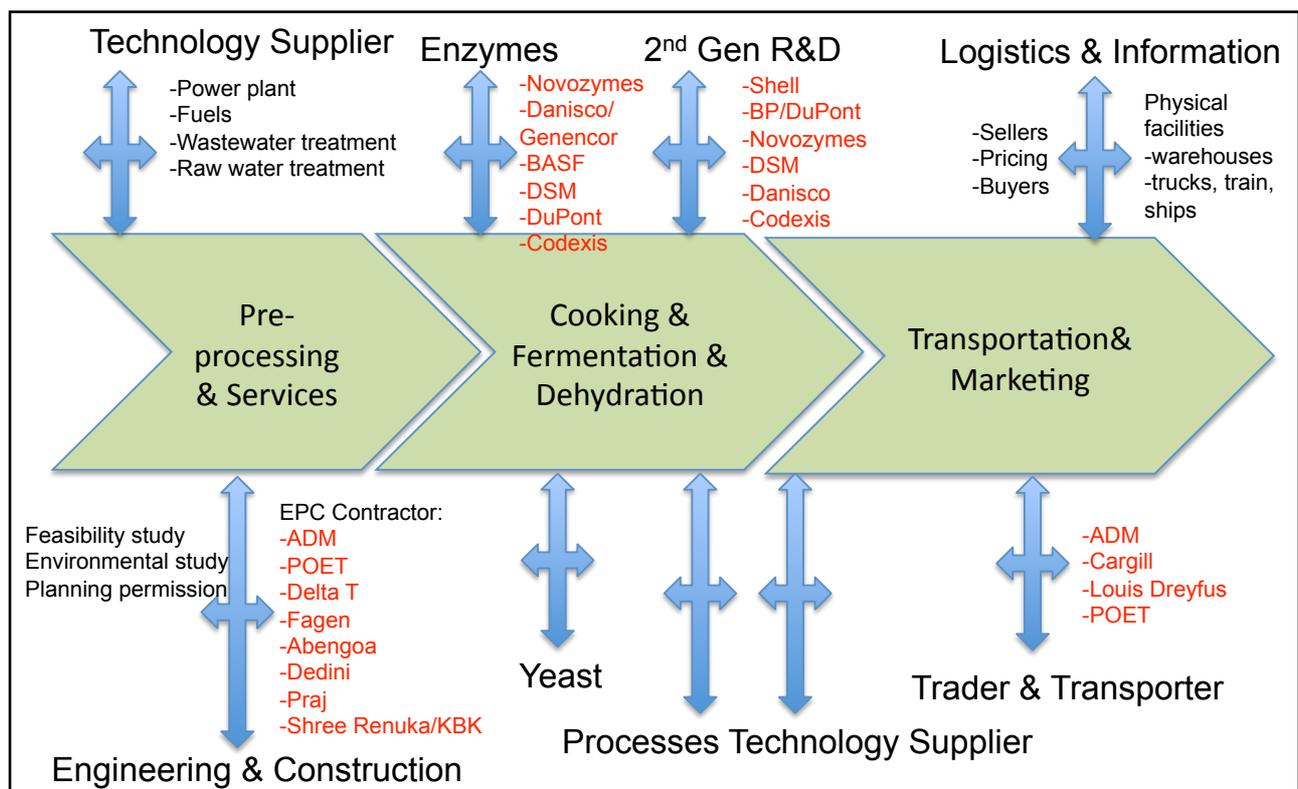


Figure 7: Midstream Bio-ethanol Value Chain: Processing

The second segment is the producing segment which incorporates core processing activities of ethanol production. The major players and concentration of this segment have been presented in

previous sections. Moreover, there are many important players that supply crucial production inputs at this segment. The supply of yeast for the fermentation of sugar is a rather mature market. But for starch and ligno-cellulosic based feedstock, special strains of enzymes or in some case bacteria are required to increase the efficiency and conversion ratio. Enzymes supply is dominated by two global giants, Novozymes and Danisco/Genencor, which have over 40% of the market share. In addition, biotechnology research into 2nd generation technologies, such as new enzymes and bacteria, are extremely vibrant. There are various types of research organisations and commercial firms venturing into this research including oil&gas giants BP, Shell and Total.

The third segment is the storage, transportation and marketing of the ethanol. The players in this segment requires substantial credits, supply chain logistics and market capabilities. There are various type of marketing arrangement for smaller plants in the USA. Shane and Kindler (2003) identified four types, i.e. marketing agreement, consortium among producers, exchange agreement to serve short distanced market, and time trade agreement to reduce storage requirements. On the other hand, there are evidence of larger producers venturing into this segments, coordinating and marketing ethanol. In the USA, Green Plains Renewable Energy (GPRE) are involved substantially in marketing of ethanol from pooling agreements with smaller producers. This kind of pooling practice is also very common in the Brazilian sugar-ethanol practices. Copersucar is created in 1959 by the producer members of the sugar and ethanol cooperative (Cooperativa de Produtores de Cana-de-Açúcar, Açúcar e Alcool do Estado de São Paulo). It has 36 associated mills with a total crushing capacity of 67.7 million tonnes of sugarcane in 2008/09 crop. Copersucar marketed 3.66 billion litres of ethanol, the largest in Brazil with about 24.5% market share. Another cooperative marketer in Brazil is Crystalsev Group. In 2008/09 crop, Crystalsev marketed 1 billion litres of ethanol. Louis Dreyfus is currently holding the controlling stake in the group after its acquisition of Santalisa Vale.

The downstream value chain of ethanol includes three segments i.e. blending of ethanol with gasoline, distribution and retailing as shown in **Figure 8**. In many countries except Brazil, these segments are dominated by the downstream oil&gas businesses. The ethanol volume is relatively small compared to gasoline in the blend. As refining capacity is in access in most part of the world, refiners are mostly reluctant to pursue ethanol blending and putting barriers to government mandate on blending, such as during the last decade in Japan. Most ethanol producers and marketers who venture into these segments have to overcome technology and market barriers. At a market with 5% ethanol blending mandate, they have to source 95% of gasoline base-stock with the right quality and price. Some firms integrated downstream into these segments are trying to access the market and penetrate into higher blend market, such as SEKAB in Sweden, the late Verasun (in administration since 2008) in the USA. On the other hand, some gasoline refiners and distributors are moving upstream to source and market blended products such as Valero and Suncor in the USA, and Greenergy in the UK.

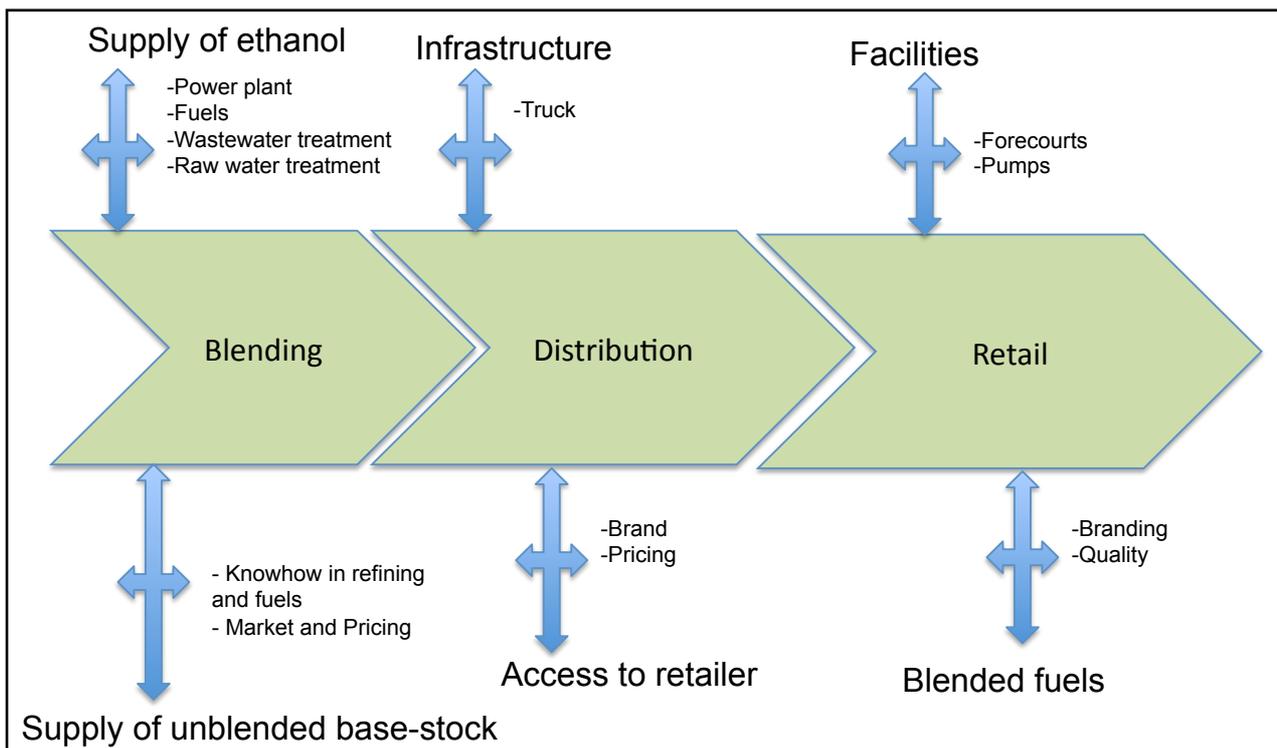


Figure 8: Downstream Bio-ethanol Value Chain: Transport Fuel Supply

Categorisation of Producers and Vertical Integration in Ethanol Industry

In order to understand the trend of vertical integration in the ethanol industry, this section analyses the world top 30 producers and additional 10 players as shown in **Table 6**. These firms have been categorised into five main groups, with colour coded in **Table 6**, based on their corporate background. These five main groups of firm are:

- i) Group 1: Technology, engineering and construction firms;
- ii) Group 2: Food & Sweetener Producers, with a long history in food/sweetener production, and some in ethanol production;
- iii) Group 3: Agriculture commodities traders & farmer cooperative marketers. Their main activities are sourcing and market agriculture commodities. But some firms have diverse extensively or involved in food processing industry for a long time;
- iv) Group 4: Entrepreneurial start-up with minimum or no background in the supply chain;
- v) Group 5: Oil and Gas firms and downstream marketers.

The green coloured cell indicates the involvement of a particular firm in the segment along the ethanol value chain.

It is observed that Group 1, engineering firms, are not only involved in R&D activities of 2nd generation technology but also expanded vertically into the production and downstream of the value chain. The most vertically integrated firm is Abengoa.

The traditional food processors of Group 2 are involved heavily in ethanol producing segment as this is their natural competitive advantage with long history of the knowledge and security of feedstock supply. However, there are a few firms further integrated into downstream activities. Cosan is the most vertically integrated ethanol firm in the world as its involvement in all the segments along the sugarcane based ethanol value chain. In 2007, Cosan acquired Exxon's downstream operation in Brazil. In early 2010, it has announced the signing of MOU with Shell to form a giant ethanol group in Brazil.

Table 6: Major Players in Bio-Ethanol Value Chain, 2009

Global Rank	Firm	Eng/Const	2nd Gen/Enzymes	Plantation	Ag service/Trade/Transport	Agri Processing		Ethanol Market/Transport (MLY)	Blending	Refine/Wholesale	Retail
						Food	Ethanol (% of Global)				
2	POET, US						7.95				
4	Abengoa, ES						1.70				
8	ETH Bioenergia, BR						1.56				
5	Cosan, BR						1.22				
6	Shree Renuka, ID						1.06				
11	Tereos, FR						0.92				
18	Tate&Lyle, UK						0.92				
24	Sudzucker, DE						6.83				
25	Sao Martinho, BR						4.69				
26	Cristal Union, FR						2.00				
28	PedraAgroindustry, BR						2.83				
29	Moreno, BR						2.31				
30	Zilor, BR						1.62				
	Petro Green, TH						0.93				
1	ADM, US						0.80				
10	Bunge, US						0.77				
12	Louis Dreyfus, FR						0.74				
13	Andersons, US						0.67				
16	COFCO, CN						0.65				
19	Glacial Lake Energy, US						0.64				
21	Noble, HK						0.28	1163			
	Verasun						9.26				
7	GPRE, US						2.13	3255			
9	Hawkeye, US						1.87				
14	White Energy, US						1.15				
15	Pacific Ethanol, US						1.10				
17	Biofuel Energy, US						1.02				
20	Aventine RE, US						0.92				
22	Jian Shenghua, CN						0.86				
23	AltraBiofuels						0.81				
27	Global Ethanol, AU						0.69				
	TPK Ethanol, TH						0.41				
	Greenfield Ethanol, CA						0.52				
	SEKAB, SE						0.11				
	Greenergy, UK										
3	Valero, US						5.51				
	CNPC/Jilin, CN						0.57				
	BP, UK						0.50				
	Husky Energy, CA						0.41				
	Shell, NL						0.00				

Note: Colour Code

	Engineering and construction company who builds plants and supplies technology
	Food Producer, with long history in sweetener production, and some in ethanol production
	Global/National agri-commodity trader
	Entrepreneurial start-up with minimum or no background in the supply chain
	Oil & Gas company, either integrated or in downstream business
	Company with liquidity problem, in insolvency or in the process of debt restructuring
	Involvement in a segment of the ethanol value chain

Source: Producers Websites, RFA & UNICA statistics.

The agriculture commodity traders are also venturing into the ethanol industry primarily in producing and marketing segments, leverage their knowledge in feedstock supply and marketing capabilities. However, they are shy away from the downstream blending, distribution and retailing businesses.

In Group 4, these new start-ups are primarily have little corporate background in the ethanol industry. They entered the market due to government favourable policies for ethanol production. Some firms moves extremely fast to expand horizontally by raising equity in the stock market or from private equities fund. Many of these firms in both USA and Brazil expanded too fast and are facing liquidity problem during the recent global credit crisis. A few firms in the USA have also employed vertical integrated strategy especially into downstream to gain market access. Before collapse, Verasun was marketing its own branded E85 fuel with 85% ethanol content, selling to a network of retailers. GPRE has acquired Blendstar to penetrate into downstream blending and distributing markets.

The last group are oil&gas corporations. Many oil&gas corporations with downstream businesses have to compliance with the national policy to blend ethanol. Their involvement in ethanol industry is depending on their existing present in whichever downstream segments in a particular country. However, there are many interests from the oil&gas corporations in moving upstream in the ethanol value chain. Their involvement in sourcing and trading of ethanol has been very substantial. Greenergy is one of the largest ethanol or ethanol blended fuel supplier and distributor in the UK. Shell and BP have been moving and trading large quantity of ethanol globally. Total and Statoil markets substantial of ethanol blended fuel respectively in their domestic market. In addition, there are interest in further upstream to the production of ethanol and feedstock. BP has invested in 2 major greenfield projects in Brazil. BP has invested in a 420 million litres distillery in a joint venture with British Sugar and Du Pont in the UK. BP is expected to have a total installed capacity of 1.42 billion litres if all projects materialised. BP has also claimed that it has blended and distributed 2.89 and 0.34 billion litres of fuel-ethanol in 2007 respectively in the USA and Europe, which in total is about 6.5% of the world's downstream market share in 2007. In 2008, BP has also

committed to purchase and market 103 million litres of fuel-ethanol in Australia. On the other hand, Shell claimed to distribute more than 5 billion litres of ethanol in 2007. In Feb 2010, Shell has announced its intention to joint venture with Cosan, forming the biggest producer group in Brazil. Valero, one of the largest refiner in the USA, has invested substantially in ethanol production units and disposing some of its refining facilities. It is the third largest ethanol producer in the USA and the world. The oil&gas giant corporations have also heavily invested in the R&D of various 2nd generation technologies in bio-alcohol fuels.

Drivers for vertical integration

Bio-ethanol industry is not a new industry but fuel-ethanol industry is a rather new industry in many markets. Furthermore, it is growing in a rapid rate. Firm, as a rent seeking entity, ventures into this new market trying to occupy and extract rents along the ethanol value chain. It should be also noted that firms at downstream are integrating to upstream and vice versa. The two ways directional movement in integration negates the theory of firm seeking to occupy a segment with higher value. **Table 7** summarises the drivers for firm to vertically integrated upstream or downstream. Some of the important barriers in integration are also explained.

The downstream integration into producing segment by engineering firm, traditional food processor and commodity trader could be understood through resource-based view. The strategic resources available to the firm could be utilised by the firm to transform to a long-term competitive advantage (Wernerfelt, 1984). The firm utilises its resources, e.g. technological knowhow or feedstock supply, to develop a new line of businesses in an expanding market.

On the other hand, upstream integration into producing segment by oil&gas firms is not yet prevalent. Oil&gas firms are not familiar with traditional agriculture sector and agriculture commodity trading market. BP and Shell chosed to invest in producing segment in Brazil rather than USA. The reason could be sugarcane based ethanol delivers more environmental and carbon

emission reduction benefits than their corn-based counterpart in the USA. Nevertheless, one of the crucial factor is the security of supply for sugarcane (site-specific due to bulkiness of cane) could be more easily enhanced.

Upstream integration of oil&gas firm into producing segment will of course enhance security of supply of ethanol as the firm is required to fulfill regulatory targets. On the other hand, firm in the refining sector is also moving out of this increasing lower margin business. This type of firm is venturing into a new substitute, ethanol, and seek to obtain rent in the new business. A typical example is Valero. Valero a Fortune 500 oil refiner closed down unprofitable refineries and acquired 10 ethanol producing units in the USA in 2009 and 2010. Valero suffered huge losses due to low refining margin but gained substantial profit from its ethanol producing business in 2009 (Valero, 2010).

The primarily factor that motivates ethanol producing firms to integrate upstream is security of supply for feedstock. Security of supply is in terms of quantity required as well as at a stable price. As shown in **Figure 2**, various feedstock for ethanol production have their existing markets which are far more larger. Under most circumstances, ethanol producer is a price taker.

On the other hand, the price of gasoline has some sort of bearing on the price of the ethanol. Producer could be squeezed in between and its margin will suffer. Ethanol producer integrating downstream especially into the higher blend market segment might in long-term provides a solution to the above situation. However, the main purpose for ethanol producer to integrate downstream is in order to gain access and to expand to the market. As a substitute to existing product, it is rational that the gasoline refiner and supplier, as well as upstream oil&gas players, are putting up barriers for ethanol.

Table 7: Drivers and Barriers for Vertical Integration in Ethanol Industry

Segment of Value Chain	Type of Firm	Driver/Barriers for Integration	Comment
Upstream agriculture production	Ethanol producing firms	<p>Ensure security of supply & feedstock cost stability</p> <p>But there are socio-political prohibitors for integration</p>	<p>In the USA, governance structure in this segment is primarily market based. Therefore, firms suffer from in-security of supply and volatility of feedstock price.</p> <p>In Brazil, governance structure is more hierarchical. It has to do with the land and farming policy in Brazil. Furthermore, there is a factor of site specific of cane and ethanol distillery. Sugarcane cannot store for more than a few days and transportation cost could be prohibitive for long distance.</p>
Midstream ethanol producing	Engineering	Technological knowhow	<p>Resource-based view:</p> <p>Firms capitalised on its inherited knowledge from parent company such as in technological knowhow, feedstock supply and the capabilities to secure feedstock.</p>
	Commodity traders/farm cooperative marketers	Controlling supply of feedstock	
	Food processors	Familiar with feedstock supply	
	Start-up	New opportunity in a growing market	Rent seeking
	Oil&gas/refiner	<p>Ensure security of supply</p> <p>Involvement in renewables is a public relation gesture</p> <p>But contradicting as ethanol is a substitute of one's product</p> <p>Growing market</p>	<p>Downstream oil&gas firms are mandated by policy to consume ethanol.</p> <p>But, under certain market conditions, marketing ethanol could bring substantial rent especially refining margins are low or negative.</p>
Downstream blending/ distributing/ retailing	Ethanol producing firms	<p>Market access and penetration</p> <p>Low volume of ethanol compared to gasoline in low blend fuel</p> <p>Lack of technological knowhow and base-stock supply at required quality and price</p>	<p>Due to the reluctant of downstream oil&gas firms to expand the ethanol market, ethanol producing firms need to penetrate the market themselves. For example SEKAB and Verasun.</p>

Discussion and Conclusion

Neoclassical economists like Coase (1937) viewed that firms and markets are mutual substitutable governance mechanism. Transaction will be organised within the firm, that is vertically integrated, when cost of doing so is lower than the cost involved when using market. Developing from this concept, the transaction cost economists such as Klein *et al.* (1978) and Williamson (1979) suggests that due to the prohibitive cost of contracting, firm tends to integrate vertically especially there exist asset specificities. This propounds that the choice of governance structure is a decision based on the aim to achieve higher efficiency.

Furthermore, Bain (1956, 1959) proposed from an industrial organisation perspective that firm only expands horizontally or vertically, in the absence of technological reason, in order to response to external market power or to create and exploit market power.

Joskow (2005) proposed that there are substantial empirical literature support for various efficiency motivations compared to much more minimum support for market power exploitation motivations in vertical integration.

However, the analysis of ethanol industry indicates that two important motivations of vertical integration are security of supply and market access and power. It has to be acknowledged the evolutionary dynamic of an industry where the growing ethanol industry is a considerably smaller in the feedstock and fuel markets. Ethanol producer has to compete for feedstock supply with a much larger and mature food industry. And ethanol producer has to fight for market share as a substitute for gasoline in a giant firms dominated downstream oil&gas segment.

As demonstrated above, there are social politic factors that prohibit or influent firm's decision to vertically integration. Firms in some countries do not integrate upstream to agriculture production and land ownership. It is not because of there is neither no rents in the segment, nor market

arrangement does not increase transaction cost, nor no issue of security of supply. It is because of social politic of the society in terms of regulation on land ownership, rural social structure, and farm size and practices. In analysing the governance structure of ethanol firms, a wider perspective beyond pure economic theories might be required.

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