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ANALYZING THE CALIFORNIA FINISHED MOTOR GASOLINE SUPPLY AND DISTRIBUTION

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Abstract
Gasoline is necessary for the lives of many Americans in carrying out many of their daily tasks. In 2018, according to the U.S. Energy Information Administration (EIA), Americans consumed 142.86 billion gallons or 3.4 billion barrels of finished motor gasoline. For the most populous state in the U.S., California, the financial burden of purchasing gasoline per gallon compared to the national average is mind-numbing. As of 2019, the average California price per gallon of all grades of gasoline was $3.677, while the national average was $2.691. This research intends to get to the root cause of the discrepancy between the gasoline prices in California and the national average through analyzing the supply chain distribution of fuel in California. Since 2012, the United States has produced almost double the gas than any other country in the world, yet the prices for California continue to rise. Discounting the fact that taxes influence the price, the analysis will be adjusted based on a tax-free system to compare the prices of gasoline fully. By use of Supply Chain Analysis, we will pinpoint the demand and where to optimally deliver the gasoline tankers to effectively lower the price of gas in California to align more with the national average.

Keywords
Petroleum Industry, Supply Chain Management, Motor Gasoline, California.

Introduction
With the growing demand placed on the petroleum industry, the gasoline supply chain has developed into a complex and challenging environment. The area of interest currently has everything to do with the supply chain, specifically in the California gasoline and oil market. Over the years, gasoline prices have fluctuated significantly. Ever since the early days of 2012, when fracking was introduced into the United States, the country has become a net exporter of oil. With all these new developments, one could be confused as to why the gasoline prices have remained statistically higher in California when compared to the rest of the United States. California itself has the second-highest gasoline tax rate in the United States. At the time of this research, the per-gallon California average gasoline price is $4.20. The average US-wide gas price is $2.65. It would make sense if the highest gas pressed price state of Pennsylvania had the highest gas price. But even though Pennsylvania has the highest tax rate of gasoline, California is still more expensive by roughly $1.20 per gallon. Additionally, seeing the average gasoline price in Hawaii be more than $0.10 less than the average gas price in California. At the same time, Hawaii is a group of islands in the Pacific rather than connected to the lower 48 continental United States is quite puzzling. For all these reasons, the authors decided to dive deeper into the supply chain of gasoline, considering that now tax is not the main issue of what most people think is increasing the gasoline prices. Specifically, we will investigate the supply chain network design, complications, as well as environmental regulations, and then, will take us into our solution of how to fix this problem.

Supply Chain Network
For the purpose of this paper, the supply chain network for the petroleum industry can be broken into two separate sections. The first section will deal with the supply chain network design and each component of the network. This will provide an understanding of the different levels of production that are required to provide tangible finished products to the end-users. The next portion of the supply chain network will address complications and limitations that have been identified as inhibitors to the overall success of the supply chain. These complications are some of the

key identifiers that have been recognized as the reasons for the complex and challenging nature of the petroleum industry.

Design

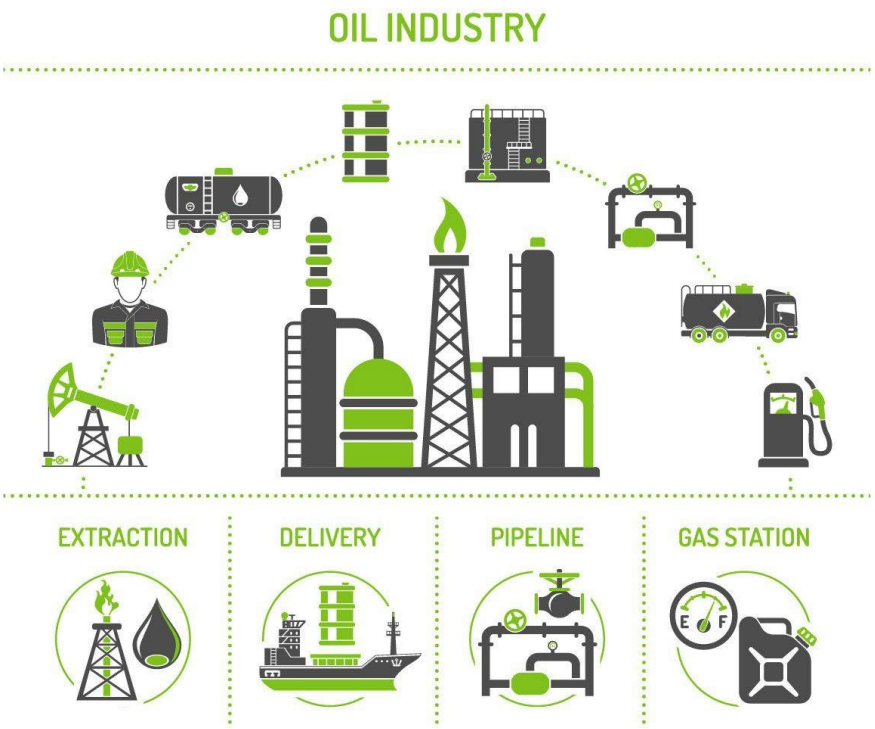
As Werner Paratorius, president of BASF's petrochemicals division, stated, "Supply chain management is the backbone of a business where logistics costs can be greater than manufacturing costs (Whitfield, 2004)." The understanding of the importance of how supply chain network designs can impact profoundly logistically-reliant supply chain networks is crucial for recognizing just how important the petroleum industry's supply chain is.

The petroleum industry begins upstream with the acquisition of raw materials. The raw material for this supply chain network is the crude oil that is extracted from oil reserves across the globe. Depending on geographical capabilities, this crude oil can either come from localized suppliers or foreign, international suppliers. A large amount of crude oil supply even comes from offshore oil rigs that extract oil from deep in the ocean. This crude oil is collected and transported to locations where the next process can then be completed, refinement.

As the crude oil deliveries are received into the refineries, the distillation process occurs. The oil is put into a furnace, and the crude oil begins to boil. Crude oil is comprised of many different hydrocarbons, each with different chemical properties and boiling points. Starting with the lower boiling points in the furnace and increasing by ranges until reaching the highest boiling point present allows the crude oil to separate into different chemical makeups. These distilled products are separated and split into separate paths, based on the hydrocarbons present in each section. Depending on the type of product that was formed from the distillation process, the resultant is either hydrotreated or cracked and ready to be shipped out to the next supply chain network node.

Once the refinement process has been completed, the finished product can then be transported over to the end-users. This can range depending on the purpose of the finished product. The petroleum industry is very interesting because the raw material, crude oil, can be useful for multiple purposes. This can vary from fuels such as propane, butane, petroleum gasoline, and diesel, as well as other uses such as waxes, plastics, and lubricants. These different products are transported accordingly to the respective customers to be conformed or used for the desired purposes. In the example of petroleum gasoline, this would be delivered to gas stations where it is then stored underground and made accessible to consumers through gasoline pumps. See Exhibit 1 below for an illustration of this process.

Exhibit 1. Illustration of the Petroleum Industry Supply Chain (Young, 2005).



Complications

As mentioned briefly in the design section, industries that require extensive logistical and manufacturing rely heavily on the success of the supply chain network management. Petroleum is a remarkable example of an industry that relies heavily on the supply chain network design. As noted earlier, the petroleum industry requires a large number of transportation methods to be made available to get products transported, and managing these logistical methods is both complex and challenging.

The first complication that can be found in the petroleum industry's supply chain stems from the transportation requirements of crude oil. As previously mentioned, there are several different locations that companies can purchase crude oil from. Since the petroleum industry is such a widely globalized and international industry, countries and governments may choose to purchase crude oil from very distant regions. This requires specific transportation methods that can safely span and transport over global areas, mainly shipping vessels. Shipping vessels are a common way to transport large quantities of items over vast distances. Shipping, however, is a very inflexible means of transportation, given that it has a considerable lead time, and there is a large variability in the lead time of shipments. It can take multiple weeks and even up to months for large shipping vessels to make international voyages to deliver imported crude oil to refineries.

The next complication in the petroleum industry stems from the barriers of entry regarding crude oil extraction reserves. A common methodology in tackling logistical constraints is to increase the number of distribution centers or locations that can provide for improved transportation of production supplies and inventory. Unfortunately, this cannot be easily achieved in the petroleum industry. Oil reserves are in specific geographical regions that allow for oil extractions. If there were any feasibility in the ability to acquire or develop more reserve locations closer to customer clientele, it would come at a very high price. This complication results in companies maintaining higher inventory levels. They do that to ensure that there is a readily-available supply for customer demand. This increase in inventory levels leads to higher inventory costs, which are directly reflected in the prices of the final products sold to end-users.

California Supply Chain Network

To understand why gasoline is so expensive in California compared to the rest of the United States, a comparison must be made between California's oil supply chain and the rest of the country's oil supply chain. This comparison will be an attempt to determine any discrepancies that can account for the significant increase in price for the end consumer. A distinction must be made between the different facets that contribute to a whole supply chain of oil in California—these include the production, refinement, and transportation of gasoline. In each of those facets, problems will be examined to determine any correlation with the increase in the price of gasoline. The causes will be identified so that potential solutions can be researched.

Production

Gasoline is a substance that is refined from a natural product called crude oil that needs to be extracted from the earth (Marshall, 2002). Two main ways in which this is done are drilling and fracking. Drilling is a method whereby rigs, both on-shore, and offshore, drill deep into the ground or seabed to pump up pockets of crude oil under the earth's surface. Fracking is a method of extracting crude oil from sedimentary rocks called shale where a high-pressure fluid is pumped into these rocks, fracturing them to allow the release of crude oil (Gandossi and von Estorff, 2015). This method is more efficient and cost-effective than traditional drilling, as it requires less expensive equipment and machinery.

Though California is slowly transitioning from traditional drilling to hydraulic fracking, only around 10% of new wells use fracking, even though the supply of crude oil through fracking is more plentiful and more easily accessible (DOGGR, 2014). Furthermore, due to outdated equipment and methodology, only around 4% of crude oil extracted through fracking in California is considered usable, resulting in 96% of that crude oil being wasted (Sahagun, 2014). As a result, oil production in California is costlier than oil production elsewhere, giving California a competitive disadvantage for oil production.

California is still an oil-producing state, despite the fact that production levels had decreased from around 400 million barrels in the 1980s to approximately 200 million barrels in 2018), as is shown in Exhibit 2 (California Energy Commission, 2019). Because of this, California has become a net importer of oil instead of a net exporter of oil. This means that California-based refineries now import around two-thirds of their oil from other states and foreign countries. The importing oil not only means that Californians must spend more money acquiring it, but it also means that they must transport oil longer distances—resulting in increased cost of the end product, gasoline, to the consumer.

Refinement

After the oil is extracted from the ground, it is then transported to refineries to be turned into gasoline. As crude oil yields almost half its volume to gasoline for motor vehicles through refinement, it is safer and more financially beneficial to locate refineries nearer to population centers like the San Francisco Bay Area, Los Angeles-Orange County-San Diego area, or the Central Valley. However, between 1984 and 2019, the number of refineries operating in California has decreased from 43 refineries to only 15 refineries with no plan to open new ones, shown in Exhibit 3 (U.S. Energy Information Administration, 2019). Studies show that there is a direct correlation between the number of refineries and the price of gasoline. The explosion of an Exxon-Mobil refinery in Torrance, California, increased the price of gasoline one dollar per gallon in the ensuing month—from $2.44 to $3.44 (U.S. Energy Information Administration, 2018). Because of this, it is possible to link the decline in the number of refineries in California to increasing prices of gasoline for the end consumer.

Exhibit 2. Crude Oil Supply Sources to California Refineries (California Energy Commission, 2019).

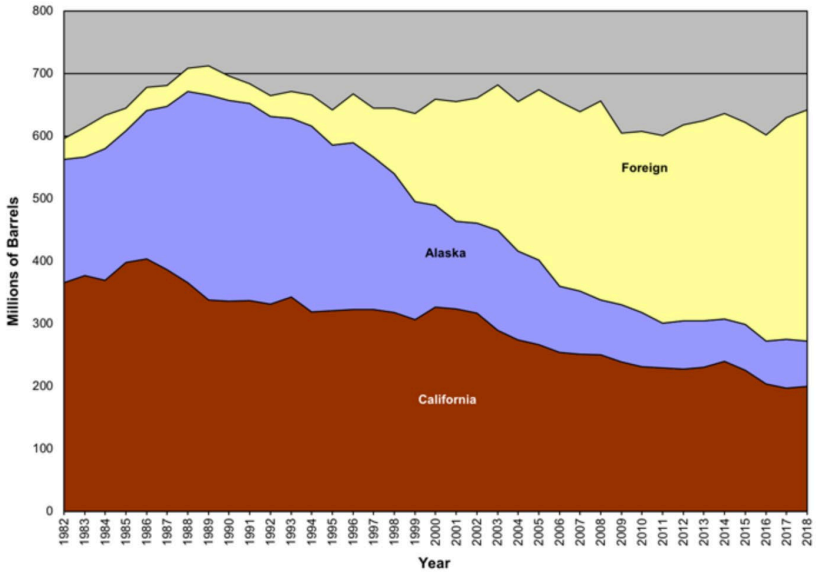
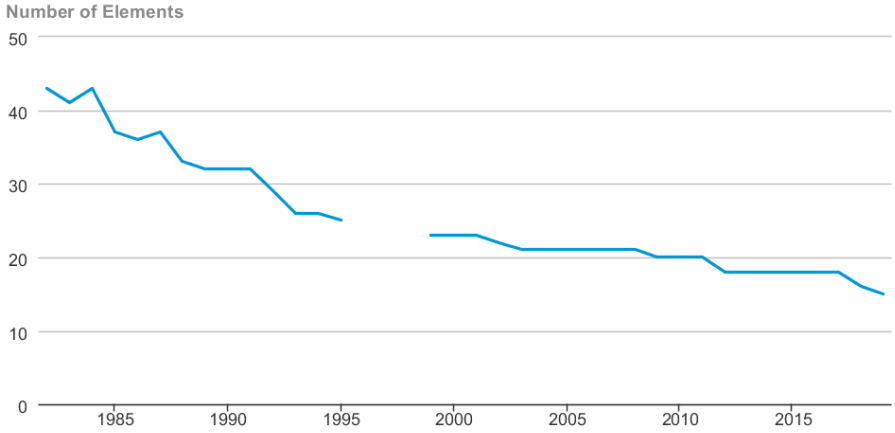


Exhibit 3. Number of Operating Oil Refineries in California between 1980 and 2020 (U.S. Energy Information Administration, 2019).



Transportation

As more and more gasoline is imported to California from out-of-state and foreign sources in addition to the declination in the number of refineries, transportation becomes more of a significant factor in the price of gasoline to the end consumer as it poses a constraint in the logistics and supply chain of California gasoline. The most economical

method for transporting crude oil long distances is using pipelines as they only require a small cost to pump on top of the one-time investment. The average cost of transporting oil by pipelines can be converted to around $5 per barrel or $0.12 per gallon (Fritelli, 2014).

California, however, is a "fuel island" (Los Angeles Times, 2015), meaning that no pipelines are linking it to crude oil sources. California's refineries, therefore, must import an increasing share of crude oil using a combination of other methods such as trucks and trains. The use of trains adds an average of around $15 per barrel or $0.36 per gallon to the retail price of gasoline for the end consumer (Fritelli, 2014). The use of trucks adds an average of around $66 per barrel or $1.57 per gallon for the end consumer (Forkenbrock, 2001). Though the increased cost for the consumer is not going to be $1.57 per gallon, it can be said that this increased cost falls somewhere between $0.36 per gallon and $1.57 per gallon depending on the combination of trucks and trains used. Nonetheless, this remains a very significant increase in the cost of gasoline for the end consumer in California.

Causes

The most significant cause for the decline in the production of gasoline and the number of refineries can be attributed to environmental and state regulations. These regulations result in an increasing amount of oil having to be imported and due to more regulations, having to be transported using inefficient and costly trucks and trains instead of pipelines. Due to these regulations, private companies are restricted from fracking in a significant portion of the state's oil deposits and must do so using outdated methods. Furthermore, private companies are unable to open new refineries or build pipelines due to health and safety concerns that block any proposal these companies may have. Because of this, California customers must pay around one dollar more per gallon to fill up their cars at the pump. On top of this, The California Air Resources Board (CARB) enforces a rule that requires California gasoline to contain a special blend that is more expensive than conventional gasoline. This reformulated gasoline is estimated to cost between five and fifteen cents more per gallon for the end consumer than conventional gasoline.

Solutions and Recommendations

Through careful consideration and thoughtful analysis, we can propose five solutions will have a positive effect on efficiency and make gas prices cheaper. The first solution is to utilize more efficient methods of extraction. California has one of the most plentiful supplies of oil and gas in the United States, employing a more modern method of extraction will cut costs and tap into more wells to increase the supply. The second solution involves pipelines. As stated above, the average price to transfer a gallon of gasoline through a pipeline is $0.12 compared to $1.57 per gallon in a truck. Since there are no crude oil pipelines connecting California to the rest of the states, obtaining more approval of the use of pipelines in California will significantly reduce the cost compared to the alternatives in the long run. Consequently, pipelines can leak, and because of that, the third solution is to increase oil railway infrastructure and use modern, safer carriages when transporting crude oil.

The fourth solution would solve a big issue within the California supply chain network of gasoline. This solution consists of vertical integration of the supply chain, a one-stop shop to get everything done throughout the gasoline process. Now many services are outsourced; integrating in-house management can save up to 30% for gasoline prices. As gas is currently transferred and refined, it changes hands more than five times before it gets to the pump. The final solution is to have new equipment in service models throughout the gasoline process redesign equipment with more modular designs to drive out the inefficiencies that could significantly affect lowering the price in the gasoline market in California. With California having its own special blend of gasoline, the refineries need to be updated to keep up with the extra steps compared to the other states in the United States.

Conclusion

California has the highest gasoline prices in the United States. As evidence shows, this is not just because of the high taxes. The supply chain management of the oil and gas industry within California is the cause of the price difference between the state and the rest of the country. The cause of this lies within California's specific regulations; motor gasoline in California is made of a unique blend. California sits on one of the biggest oil reserves in the United States, yet the connotation of drilling, although some, is not up to standards within the politics of the state. Gasoline transportation is also increasingly expensive into California, with the lack of efficient railways and no pipelines. Gasoline must be transferred mostly by trucks which is the most costly method. With these reasons, it is evident that the supply chain network in California is much more complicated than it is in the rest of the United States. This results in an increase in the cost of gasoline at the pump. Bringing about supply chain solutions will fix this problem and make the whole process function to its peak efficiency.

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