

Anti-knock Gasoline AKA Leaded Gasoline AKA Gasoline treated with Tetraethyllead (TEL) (TEL is a gasoline additive, it cannot be put in an automobile by itself).

Uncertainty

Overview:

*The nature of technological development*

*How will the technology evolve to solve a useful problem? Where will the bottlenecks be in a technology's subcomponents?*

Leaded gasoline was developed out of a specific chemical process. It required little adjustment of the underlying engine and was quickly viewed as a superior product because it reduced engine knocking and was more efficient - leading to lower operating costs. Health concerns associated with the technology did not arise until much later.

*The speed of technological development*

*How quickly will a common design be established and margins eroded?*

The technology developed quickly - as it was a relatively straightforward chemical process. The order of the reactions (which was patented) that was needed to make in leaded gas could not be altered without huge amounts of research and experimentation.

Below is an excerpt from the December 1939 issue of Industrial and Engineering Chemistry (Edgar 1939) that discusses the exact process used to produce leaded gas:

*“Salt, obtained from the adjoining works of the Solvay Company, is electrolyzed to produce sodium and chlorine. The sodium is melted with lead to form the alloy which, after grinding, is ready for the final reaction. The chlorine formed in the electrolysis is burned with hydrogen, obtained from the adjoining refinery of the Standard Oil Company of Louisiana, to form gaseous hydrochloric acid.*

*“Ethyl chloride is produced from hydrochloric acid by two distinct processes. The first is the familiar reaction with ethyl alcohol. The second is by reaction with ethylene. In this process, refinery stabilizer gases consisting largely of propane are cracked and the cracked gases fractionated at low temperatures to separate the ethylene formed. This is allowed to react with hydrochloric acid gas at low temperature in the presence of a catalyst to produce ethyl chloride.”*

The first public sale of leaded gasoline was at a single service station in Dayton, Ohio, on February 1, 1923 (Edgar 1939, 1).

*Competitive uncertainty*

*Potential entrants* How many firms will enter the market and what will their capabilities be? Should we expect pricing pressure?

There was not really a convenient way to circumvent the patents and successfully create leaded gas. Tetraethyllead was discovered by Thomas Midgley and his colleagues in the General Motors Research Laboratory after nearly six years of research. After discovering the gasoline additive and its benefits in regards to fuel efficiency, Midgley, Charles Kettering (his boss and vice president of General Motors research), and other research chemists at General Motors filed several patents to protect their discovery. (Kovarik 1994; National Academy of Sciences 1994, 341).

The patents were effective until they expired. The original holder of the patent on leaded gas, the Ethyl Corporation, had patents on the process for manufacturing leaded gas and contracted DuPont to help with manufacturing efforts. The Ethyl corporation also produced leaded gas, at least in the beginning (Edgar 1939). However, once the patents expired between 1924 to the 1950's, DuPont left to produce leaded gas and compete against Ethyl. (Gottlieb, p. 174).

Furthermore, when the TEL patents expired, Ethyl's parent companies, Standard Oil and General Motors, were ready to sell their stakes in Ethyl. Large chemical like Dow Chemicals and DuPont would have purchased Ethyl, but anti-trust laws prevented them from doing so. (Kepos 1994).

Ethyl Corporation held the patents for TEL production until they begun expiring (about 1924 to the 1950's). Then, other chemical companies like DuPont entered the industry and competing. (Gottlieb, p. 174-175)

Ethyl's patent positions eroded quickly and they lacked the capacity to produce leaded gasoline. So it appears that the corporation was able to extract some rents until the patents expired. However, this time was not used for experimentation, as the technology did not evolve much and was independent of changes to the automobile during the mid-20th century.

*Business model and value chain uncertainty*

*Monetization* How will the solution be monetized? Are there many different bets in the market? / The

*boundaries of the firm If the product is complex and built from many components, how will the market be vertically structured? Future market structure and power Can current players effectively restrict entry through intellectual property rights or other means? Will product differentiation matter and firms have pricing power, or not?*

*Which parts of the value chain will profit Which part of the value chain will capture the most rents?*

These questions are answered together given the straightforward business model. Once the technology was developed, it was licensed to DuPont and other chemical companies and produced. There was uncertainty as to whether rents would accrue more to the Ethyl Corporation or the chemical companies, but there appears that there was little uncertainty about the value chain itself and how it would work.

Members of the automotive, oil and chemicals industry were major stakeholders in the leaded gas industry. Because of this, the value chain for leaded gas drew from all the value chains of these three industries. Chemicals like salt, ethyl alcohol, and lead were inputs that came from the chemical industry. Hydrocarbons, often from propane, was another crucial input, which came from a different industry – oil. Lastly, automobile manufacturers, particularly General Motors, began producing engines that were more compatible with leaded gas in the 1920's. These lead-compatible engines were larger in size and generally less efficient and less powerful (Nriagu 1990, 15). These lead gas friendly automobiles contributed to the increased use of leaded gas.

#### *Regulatory uncertainty*

*Government actions Will government regulation slow down the market and determine winners and losers?*

*Will safety or other fairness considerations force the government to intervene?*

There is evidence that DuPont was not allowed to purchase the Ethyl corporation - though this did not matter much in terms of the demand for the product. Regulation of leaded gasoline only occurred in the 1970s. There was uncertainty at the start of production - as lead poisoning occurred to DuPont production workers - and production was suspended in the mid-1920s. This led to a regulatory battle between GM/Ford and Dupont and public health officials. While there were health concerns, it was also argued that leaded gasoline would lead to fuel savings (a concern in the mid-1920s). In the end, a favorable report was issued and leaded gasoline became widely adopted (Dimitri and Effland 2007).

#### *Demand uncertainty*

Market demand How quickly will demand develop? Will technological convergence accelerate or retard demand?

The central concern was over health (see above). Once that was resolved, usage increased because of performance advantages. It seemed like leaded gasoline slowly became available at gas stations throughout the United States. People began using leaded gasoline as soon as it was available to them locally, though this required some adaptation of early autos. The first public sale of leaded gasoline was at a single service station in Dayton, Ohio, on February 1, 1923. (Edgar, p. 1)

Leaded gas made regular, unleaded gas obsolete. By 1939, 75% of all gasoline used was leaded (Edgar, p. 144). This isn't surprising because leaded gas was more efficient than regular gas, and many consumers perceived leaded gas to be superior. Even though there were significant continuous improvements made to the engines and gas to make them work better together - the solution to the knocking problem proved important enough to lead to quick adoption increases.

Was there a Narrative?

*We break up this question into several elements that might be indicative of a narrative.*

Heath Factors Judgments:

Simple - Yes it is simple.

Unexpected - Not particularly. It is an improved version of an existing product

Credible - Yes, it was easy to understand and the information was credible.

Emotional - Not particularly.

Story - it did not hop onto an important narrative - there is no compelling story of a marginally improved input into a system.

*Did it actually pan out?*

Topline: There is no evidence of a compelling emergent narrative.

Questions to consider for analysis of Coordinating Event:

1. *Is there a collectively-experienced introduction of the technology, i.e. Was there some event that happened that focused the public's attention on this technology? Was there a public demonstration of value?*

Not really. It seemed like leaded gasoline slowly became available at gas stations throughout the United States. People began using leaded gasoline as soon as it was available to them locally. There was a debate in the mid-1920s about health, but that was resolved quickly and did not lead to a major counter-narrative.

2. *Is the coordinating event a single event or a series of demonstrations over time of the technology's value?*

The coordinating event (the gradual spread of leaded gasoline to gas stations national wide) was a series of demonstrations, as well as a series of public reports about the health concerns (or lack thereof).

3. *Does the technology have crossover appeal? Is there evidence that excitement about the technology was not solely limited to industry press, i.e. did the popular press also cover this technology?*

Yes, there was crossover appeal for leaded gas, especially since it was a consumer good. However, this technology did not seem to be highly promoted (besides the negative press it received).

4. *Did the technology create a paradigm shift in fundamental assumptions of how things should be done?*

There was not necessarily a shift in how things should be done. Anti-knock gasoline simply replaced regular gasoline. The way the gasoline was used (to fuel automobiles, planes, and other engines) remained the same.

5. *Does the technology have a “wow” factor?*

Yes. It made gasoline more fuel efficient, and it helped consumers save money on gas. So it had some of the elements of that made it sticky. However, it was not revolutionary.

6. *Is it simply a case of “you know it when you see it,” e.g. Justice Potter Stewart’s comments re pornography?*

No. The increasingly bad publicity and scientific studies about lead and leaded gas would have hindered others from entering and investing in this industry. These fears of leaded gas begun as early as 1924, when a manufacturing accident lead to “unwarranted fears about leaded gasoline (Edgar 1939, 1). The potential (and in hindsight, definite) health problems associated with anti-knock gasoline was unattractive to speculators.

The players in this industry were only large firms that could afford to take on such a risky endeavor.

*Questions to consider for analysis of False Certainty:*

1. *Is the business model to monetize this technology abundantly clear, obvious? Is it assumed that the business model is understood?*

Yes. The business model for anti-knock gasoline is identical to the business model for regular gasoline - with the added component of the Ethyl Corporations IP play..

2. *Is there evidence in the public markets of overconfidence?*

No there is not. When searching “(“anti knock gas\*” OR tetraethyllead OR “tetraethyl lead” OR “anti-knock gas\*” or “leaded gas\*”) AND (specula\* OR boom OR increase)” in the

Historical Newspaper Database, there are 849 results for 1910 to 2008. From 1910 to 1969, there are 314 results. Most of the articles in this smaller subset were not related to speculation. Instead, these articles mostly discussed changes in the price of leaded gas. The remaining articles were about health and safety scandals associated with the manufacture and use of leaded gas. After 1970, nearly all leaded gas articles were related to environment and health issues and regulation.

3. *Is there public discourse of “how this new technology will do X as [previous technology] did Y”? Is there evidence in the historical record of how people thought this technology would revolutionize an industry in a way another technology revolutionized another, i.e. are there analogies/ heuristics used to process/ describe the new technology? What is the common wisdom with regard to this technology? Please describe very specific examples.*

There were no specific analogies.

*Questions to consider for analysis of Investment Target:*

*Is the target for investment a public or private firm? / Is such an investment a pure or indirect play on the technology? Did the companies have a diversified portfolio of technologies (indirect) or did they only do this (direct)? Could someone on the sidelines invest in these companies? How?*

The initial research for tetraethyllead was conducted in General Motor’s research laboratory. Later, GM partnered with Standard Oil of New Jersey to form the Ethyl (Gasoline) Corporation, which manufactured leaded gasoline. Later, Ethyl Corporation contracted Dupont to help with manufacturing efforts. Later on, when some crucial patents expired, Dupont began producing leaded gasoline as a competitor to Ethyl. In the end, Dupont and Ethyl are the two main firms to target in order to invest in this technology.

Both direct and indirect investment was possible. Ethyl Corporation focused solely on chemical additives for fuels, so investing in Ethyl would be a pure play on leaded gas. However, Dupont, the other major player, was a chemical company with a huge portfolio of other chemicals. Thus, investing in Dupont would have been an indirect play on leaded gas.

The Ethyl corporation was private.

References

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