From Farm to Table to Board Room: The Impact of Industrial Agriculture on U.S. Corn Production

by

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Abstract

Over the last sixty years, farms in the U.S. have become more productive than ever, still the overall number of farms has steadily declined year over year. As the U.S. population continues to grow the demand for good quality safe food grows in tandem, yet this catalyst for expansion has overtly put the focus on increasing yield and productivity sometimes at the cost of other environmental and public health concerns. The evolution of the industrial agriculture complex has changed the way many crops are grown and how livestock is raised both domestically and globally. In this thesis I analyze the factors that led to a decrease in the number of farms and an increase in U.S. corn farm size by assessing the changes in variable and fixed costs over the last four decades to specifically consider whether the change in farm size may be attributable to a shift in the cost curve and accompanying equilibrium production quantity. In doing so I hope to show the impact economies of scale and highlight some of the potential downfalls of larger and less diverse farms in the process.

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Introduction

The Importance of Corn in American Agriculture

What was once an ancient grass found in modern day Mexico has come to be one of the most important crops in the world – corn. Over millennia civilizations in south-central Mexico selectively bred a tough wild grass called teosinte into the larger and palatable version of corn that we enjoy today (Katz, 2018). By the time the Europeans arrived in North America, the spread of corn, often referred to as maize, had made it a plentiful crop that would go on to support many early settlers during the colonial period. It may have taken millennia to transform an unruly grass into a staple crop, but the advancements in the last century alone have propelled this grain well above its former status as a mere source of food.

For many Americans corn is a standard side with dinner, an ingredient in a food products like high fructose corn syrup, or even a decoration on the family dinner table however, only 9% of corn used in the United States goes towards food and industrial applications (Iowa Corn Growers Association, 2019). In fact, the largest use for corn is as a source of feed for livestock domestically and abroad. In 2019, corn accounted for an impressive 96.2% of all feed grain production in the U.S., and equally noteworthy is the fact that roughly 10 to 20% of that was exported for use abroad (USDA Feedgrains Sector, 2020). Corn has become a vital component of the global industrialized agriculture industry as it is responsible for feeding cattle for slaughter, the dairy cows that provide milk, pigs, poultry and so on.

Aside from end uses as livestock feed, corn is also used in a variety of other applications ranging from biofuels like ethanol to new and innovative sustainable biodegradable plastics. About one third of the corn grown in the United States will be used in the creation of biofuels, namely ethanol. There are many industrial applications for ethanol, but most notably it is used as

a renewable alternative to traditional gasoline in automobiles, commercial trucks, and even trains. In the United States, corn is the biomass of choice in ethanol production as it accounts for 95% of the total starch used in the process (US Department of Energy Ethanol Fuel Basics, 2019). As an increasingly large portion of new vehicles are tuned to run on ethanol, it is expected to become ever more relevant as a renewable fuel choice for consumers and businesses alike given the growing appetite for sustainable energy alternatives.

Alongside with the traditional and emerging uses for corn, there are a handful of nascent industries that are also making use of corn components in an innovative fashion. The use of plastics and other petroleum derivatives has led to unprecedented levels of soil and water pollution. Efforts to reduce plastic use have focused largely on alternatives that can offer the same structural advantages of plastic while also being biodegradable as opposed to plastics made from oil derivatives. A promising candidate, polylactic acid (PLA), is a polymer that performs on par in most circumstances with petroleum counterparts even though it is produced from renewable corn starch.

The soaring demand for corn over the past thirty years for the aforementioned uses has prompted a steady growth in supply, yet the means by which farmers have kept up with the market appetite are not as clear cut. In recent years production has topped 15 billion bushels, up from approximately 10 billion bushels in the mid 1980's. This represents a 50% increase over just three decades time (USDA Feedgrains Sector, 2020). Such a large increase in production could be achieved with entries by a number of new farmers or an increase in the number of acres planted, yet in this case both assumptions would be incorrect. Instead, during the same thirty-year period, the number of farms decreased significantly while the number of acres planted remained roughly the same. In order to understand the nature of these changes, it is important to

consider the impact of technological advances, biochemical innovations, and the potential role of anticompetitive practices. In the remainder of this paper, I will examine the drivers of the rise of large farms by conducting analysis of the corn cost production curve. Additionally, I will identify a few top concerns that are associated with the growth of the industrial agriculture sector and large farms.

Consolidation in U.S. Agriculture: The Era of Large Farms

Background

Over the last thirty years, many domestic industries have seen periods of intense consolidation resulting in a small number of firms commanding ever larger shares of their respective markets. Drivers of such consolidation vary, but there are a number of growth engines that are similar irrespective of business type. A common factor that plays into consolidating industries is changing levels of economies of scale. For example, the U.S. telecom industry has driven growth and extended service through an outpaced number of mergers and acquisitions since the 1980's. Additionally, changing input costs can shift the cost curve for an industry making higher quantities the most efficient output leading firms to grow or thus selecting for larger firms that can supply the larger levels of output.

The colonies in the Americas and the eventual budding nation that was born out of them relied on agriculture to fuel growth and expansion that eventually bore the one of the greatest world powers in all of history. The founders of the United States of America recognized and promoted excellence in agriculture as a vital prerequisite to success in all facets of life and government. Thomas Jefferson went as far as to remark that, "Agriculture is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness". While the

claim of good morals and achieving happiness remain subjective, it is no secret that the patchwork of farmers growing crops like corn and tobacco made up the backbone of the economy then and now, even as the economy continues to shift focus to manufacturing and, most recently, towards more service jobs. Middle America has always been anchored by a farming community, and even with consolidation, it remains one of the most fragmented and family operated industries in the country.

As of the latest USDA Agricultural survey taken in 2017, there were over 2 million unique farms in the United States growing thousands of crops, raising a vast array of livestock, all part of the growing global industrialized agriculture economy. These farms are still most often owned and operated by families in the United States. In fact, according to the USDA over 96% of farms were family owned and operated as of the 2017 survey. As the size and diversity of farms continue to shift, family ownership is one thing that has remained fairly constant over time. In the 19th and 20th centuries a boom in population fueled an increasing number of farms along with a westward expansion. During that time, it was not uncommon for a family farm to be split among siblings or for the younger children to move westward to establish farms of their own. While family farm ownership remains dominant, the dynamic of inheritance and expansion has reversed in a sense as farms are currently being rolled up and sold instead of being passed down to the next generation.

In the 21st century, corporations have begun to establish a strong foothold in the agriculture industry with large farms that utilize an array of expensive farm equipment and automated harvesting technologies. According to the USDA, as of 2017, an impressive 96% of U.S. farms were family owned. However, as the number of farms has continued to decline because average size has grown along with the share of ownership by non-family entities. In the

same year, 2018, farms that had sales of USD $5 million were comprised of 78% family operations (USDA Examining Consolidation in U.S. Agriculture, 2018). As the share of sales shifts towards larger farms which are disproportionately owned by corporations as opposed to families, it is relevant to note the corresponding shift in power from lobbying measures to price setting capabilities in the larger market. Furthermore, and of prime significance, is the pressure being put on the production cost and how the shift of that cost curve could be playing a role in changing the optimal quantity produced at any given farm.

Changes in the cost curve has come from many different directions over the last thirty years, ranging from technological changes to demographic shifts in the way farmland is owned and operated. The aforementioned change in ownership among large farms has made increasingly larger amounts of capital available – capital that appears necessary to buy into the advanced technology that has spurred the intense increase in corn yield per acre. Technology that helps plant, harvest, and even monitor crops has become quintessential to retaining a competitive edge in a commodity market like corn. Before the corn even has the chance to sprout, the seeds themselves have been engineered to produce the largest and most viable crop. The multitude of advancements in these technologies may explain, to a great degree, the shift in the cost curve for corn production and the accompanying new equilibrium quantity produced at any given farm.

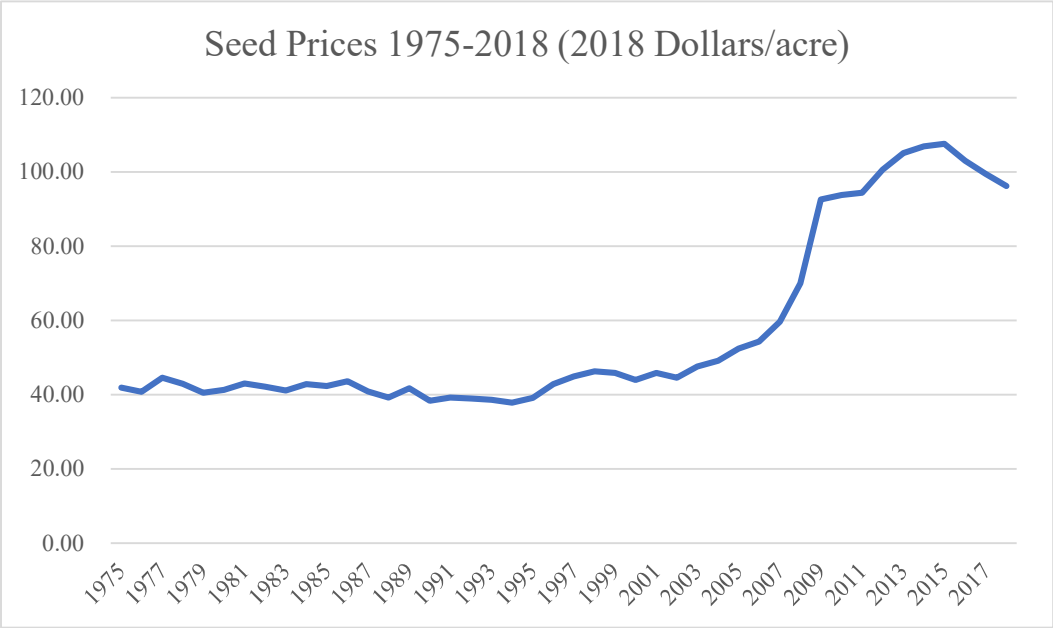
Examining the Corn Production Cost Curve

Input Price Analysis

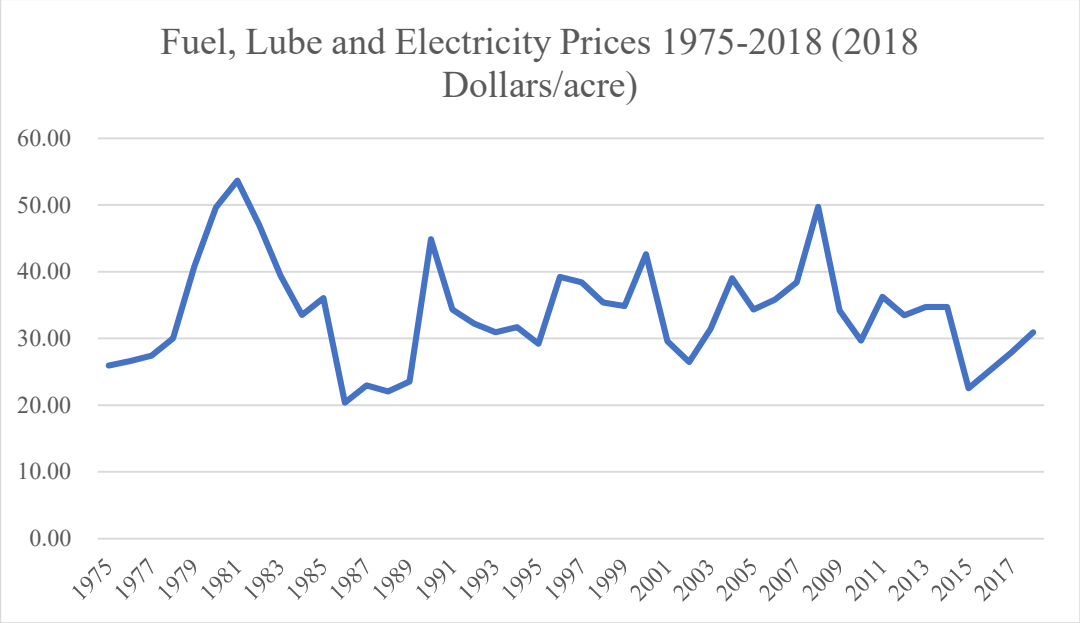
As is the case for all manufactured goods, corn production costs can be separated into two buckets for analysis, fixed and variable costs. Since 1975, the USDA has conducted a survey amongst corn farmers to assess the costs and returns per planted acre, excluding government

payments. The data from these surveys offers great insight into the breakdown of costs for farms and shows how the cost structure has evolved over time. Reporting metrics changed slightly over time, and in 1996 the inclusion of average reported enterprise size meant that a further analysis of average cost could be conducted utilizing the new average quantity (enterprise size) metric.

The variable side of the cost equation for corn proves to be very interesting as certain inputs rose in price dramatically over the period while other variable costs remained fairly stable or saw only slight increases or decreases over time. The main input whose price rose dramatically are seeds, particularly at the turn of the millennium when seed prices went from approximately forty dollars per acre to over one hundred by 2015 (see graph below). This trend goes hand in hand with reports from farmers related to increased seed prices and intellectual property cases involving re-using seeds for more than one season. As margins shrink for farmers and the focus on yield remains a top priority, having the best seeds will conceivably allow seed producers to continue demanding top dollar.



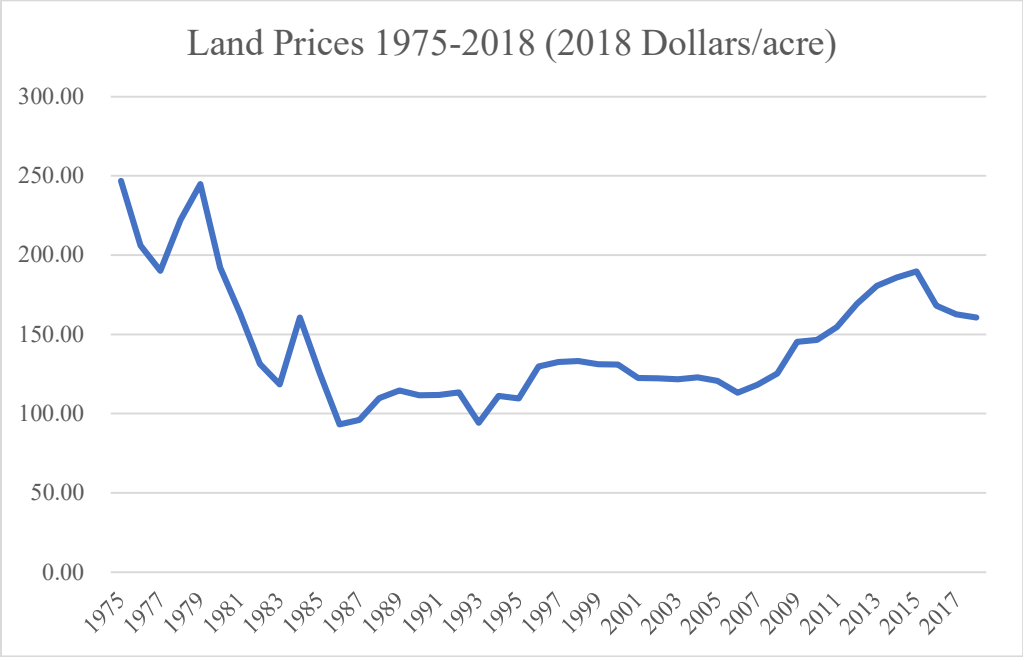
Another variable input worth considering is the category of "Fuel, Lube and Electricity" which encompasses much of the energy input a farm consumes. As farms have grown larger and become increasingly automated, it is vital to fuel the combines for harvesting and keep the power going to automated irrigation systems and the like. Unlike seeds however, the per acre cost of this variable input has remained relatively stable throughout the period only experiencing spikes during periods such as during the oil crisis in the late 1970's, and again during the financial crisis and great recession of 2008 (see graph below). This illustrates that while the overall energy consumption for an average farm has not changed significantly, there is still the ever-present risk of external market shock for this input which is third in terms of costliness behind seeds and fertilizer.



While the variable cost side of the equation remained constant or increased over the last few decades, the fixed cost side did not adhere to the same trends. Corn production, like many other goods, involves fixed inputs such as machinery and land that remain the same regardless of the quantity produced. In this category there are two major line items in the USDA survey data;

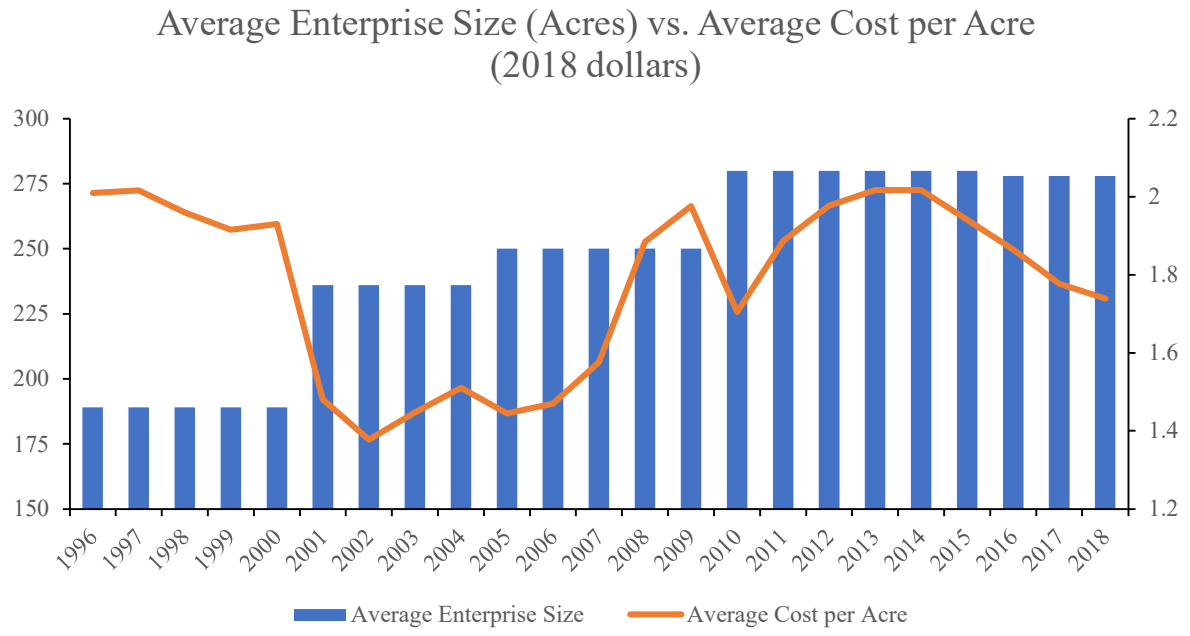
General Farm Overhead and Land. The former illustrates in part the cost of doing business for farms while the latter represents to many the most important part of any farm -- the land on which one farms. These data points also aid in the calculation of average cost as when they are combined can be used to find total fixed cost of production.

As mentioned above, during the period from 1975 to 2018, variable costs saw an overall increase, yet during this same time fixed costs saw a reduction that had the net impact of reducing cost across the board. In any given year, land usage tends to be the largest cost per acre for any farm, and throughout the last two decades of the twentieth century land saw a large decline in price as efficiencies rose and less land was needed to yield the same amount of output. In 20 short years, farm land prices fell from approximately two hundred and fifty dollars per acre in 1980 to less than one hundred and fifty dollars per acre in 2000 (see graph below).



The large drop in the value of land during this time stemming from both a drop in land prices and a reduction in general farm overhead costs had the effect of offsetting the opposite rise

in variable input prices. Overall, the average cost of land declines from $2.01 dollars per acre in 1996 to $1.73 dollars per acre in 2018, a decrease of 14% in a little over twenty years. The decline in average cost coincides with the rise of average enterprise size going from one hundred and eighty-nine acres in 1996 to two hundred and seventy-eight acres in 2018, an impressive 47% increase. This change (see graph below) typifies an industry that is going through a period wherein increasing economies of scale make the new equilibrium quantity of acres farmed higher than it once was. The increased amount of output results in a lower average cost as the expensive fixed capital equipment costs are spread out, lowering the per unit fixed cost expense, which makes large farms more efficient over the long run. As technology makes production ever more efficient and the cost of fixed inputs continues to decline the average size of a corn farm will likely increase into the foreseeable future to match newer (and larger) equilibrium minimum cost quantities.



The Downsides of Industrialized Agriculture

Monoculture Concerns

Across the sweeping fields of America's heartland is a story painted by picture alone in the seemingly endless rows of crops that go on mile after mile. The perfectly pedicured and planned fields of corn, soybeans, and other grains and oilseeds mostly have one thing in common – the ubiquitous practice of arranging themselves in a way to maximize yield and increase harvest efficiency. In modern industrial agriculture systems, this has by and far resulted in the practice of cultivation referred to as a monoculture, meaning simply only one crop being grown in a certain area. While the rolling fields of corn rows have come to symbolize American farming, the practice of growing crops in unnatural arrangements has had consequences for the land and the food supply chain.

Much of the cause for concern that comes with the cultivation of monocultures has to do with the lack of diversity in the crop and the way in which land is organized to grow said crop. In natural settings plants grow in diverse biomes according to the region, soil type, and sun exposure among other variables. It is common to see a multitude of plants grow in unison with one another while bare soil is a rare sight. The modern industrial farm favors the practice of cleared fields and rows of crops strategically placed to maximize yield and make the job of harvesting increasingly mechanical. These practices have exposed serious flaws with the system for decades – one case being the near extinction and continued threat of a favorite fruit, the banana.

In the mid-20th century the common banana, then a variety known as the Gros Michel, came under attack by an invisible enemy that threatened to take bananas off of grocery shelves for good. A fungus that caused an ailment known as Panama Disease rapidly spread through

banana farms which lacked the diversity of crop and soil integrity to properly fight off the fungus effectively. Farmers were quick to switch to the now common Cavendish variety that was more resistant to the fungus, yet the farms did not properly prepare for the possibility of a resurgence of the fungus attacking the new variety.

Currently a new strain of the Panama Disease has emerged and is threatening the global production of bananas. The way this fungus poses a threat to the crop provides key insights into the threats that all monocultures face. The latest research on the spread of this fungus shows that bare soil increases disease incidence while intercropping, the practice of planting more than one crop in an area, lowers the overall risk (Bosman, 2016). The current situation also exemplifies a possible future for many crops as scientists have yet to identify a banana hybrid resistant to the fungus. Ultimately, a solution that utilizes the best of seed technology with an updated approach to farming techniques that are more sustainable, such as intercropping, could be the answer the agriculture industry settles on.

Environmental Impact

In its effort to maximize output for a growing world population the agricultural sector of the economy has not considered fully the environmental consequences. To run such a system requires the use of vast swaths of land, plenty of fossil fuel, and at the heart of it all, water. The negative externalities from this practice are varied. Leo Horrigan, from the Center for a Liveable Future at Johns Hopkins University put it "[Industrial agriculture] contributes to numerous forms of environmental degradation, including air and water pollution, soil depletion, diminishing biodiversity, and fish die-offs" (Horrigan, 2002). The very industry that fuels population growth is threatening the populations that it supports.

A common cause for concern that is closely related to corn farming is the use of fertilizers and the impact they have on the quality of soil where they are spread. Between 1950 and 1998, the global use of fertilizer increased by more than 10-fold (Horrigan, 2002). Over time, the use of more and more fertilizer increases the acidity of soil until the point where crops struggle to grow. Locally, increased fertilizer use can result in nitrification of waterways and ponds. On a larger scale, the amount of nitrogen that runs off into the Mississippi River from the heartland of America has created an entire dead zone in the Gulf of Mexico.

Conclusion

The simple corn farm of the nineteenth century has become a technological and economic powerhouse in the twenty first century. While these farms are still majority owned by families, the number of large corporate farms has increased significantly. An average farm utilizes the latest in seed technology paired with automated watering and harvesting methods to reduce the amount of work and simultaneously maximize yields. The advent of technology that made this possible is also responsible for transforming the cost curve and pushing prices down and quantities per farm, and in total, much higher. This transformation has gradually, but surely, made the equilibrium quantity a farm must produce higher and higher which explains in part the increase in larger farms throughout the last thirty years.

Industrialized agriculture has come to dominate the global production of food supply from livestock to grain and every other category under the umbrella. With a growing world population, it has never been more important to identify methods that will allow more crops to be grown on the planet's fixed amount of arable land. This goal of output maximization has come to overshadow some other very important goals such as sustainability. The food supply chain must

adapt to the changing environment and safeguard the future by implementing more responsible growing and fertilizing methods. Farms may inevitably become larger and more consolidated over time, but that does not mean they cannot do so in a way that benefits all stakeholders, including future generations, and, thus, the environment.

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