An Analysis on the Replacement of Animal-Powered Farming by the Tractor From 1910 to 1950

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

According to the most recent UN estimates, the global population has quadrupled over the last century. In 1915, there were 1.8 billion people on the planet. Today, there are 7.3 billion people, and we may reach 9.7 billion people by 2050. As the world's population increases at an exponential rate, food demand is expected to increase by 59% to 98% by 2050 (Schierhorn, 2019). On the other hand, supply is dampened due to climate change. There is enough scientific consensus to agree that global rising temperatures, water scarcity and extreme weather have decreased crop yields. As market shocks shape how we grow food, traditional agricultural methods must evolve to ensure the continuity of human nature. From macroeconomic theory we know that significant increases in productivity lead to improved living conditions and stronger economies. As the farming industry continues to employ technology to increase productivity, we can improve and strengthen our society.

At the start of the twentieth century, the US population continued to increase and the demand for food began to pick up. The introduction of the tractor to society represented a technological solution to help propel society forward. From its conception in 1892 to the modern day, the tractor has arguably been the most influential technology to shape the farming industry. The farm tractor significantly altered the structure of rural America, and freed up millions of workers to be absorbed into the rapidly growing manufacturing and service sectors of the country. In 1890, the tractor brought a new concept into agricultural America. The tractor streamlined tedious processes to save farmers precious time and money spent on unnecessary manual labor. Its invention is a prime example of the use of technology in the farming industry in order to increase productivity and maximize food production.

It is evident that the impact of technology on agriculture is vast. It is, however, a more challenging task to be able to relate these changes to how they have shaped society. By analyzing the impact of the tractor and its importance to the first adopters of this technology we can better understand its importance for agriculture and foster more investment for farming technologies. In my paper I will look to analyze how the replacement of animal-powered farming by the tractor felt for the people experiencing it and what it meant for society at the time.

Background

The mechanization of the agriculture industry through the invention of the tractor permanently changed the physical landscape of the United States. The replacement of animal-powered farming by the tractor boosted productivity and accelerated rural to urban migration. In the 1900s, 10.9 million agricultural workers produced the food for 76 million people. In 1950, 7.5 million agricultural workers produced food for 151 million people. As horses and mules disappeared from farms, the diesel tractor began to take center stage in food production. As a result, the average farm size tripled, mainly driven by economies of scale (Steckel & White, 2012). From census data it is also possible to observe a rapid loss in farm population occurring during World War II because of the demand for manpower in industry and in military services.

Existing literature shows that in general, tractors were still the exception in American agriculture in 1920. On the national level, only 3.6 percent of farms had tractors. A few states such as North Dakota and South Dakota boasted over 15 percent of farms with tractors, but they were unusual (Ellenberg, 2000). This was largely explained by clashes between draft animal advocates with tractor manufacturers over which type of power would best suit American agriculture moving forward. The mediation of this debate was carried out by the United States

Department of Agriculture (USDA); however, secondary accounts show that these attempts proved futile as the wheels had been set in motion years before with the invention of the car and the nation's transition to a service economy. The tractor was set to replace donkeys and mules.

In Illinois, the study of farm organization and management has been underway since 1912. In 1918 surveys carried out in cooperation with one hundred farmers operating tractors showed that the horse used to make up a large proportion of operating expenses and that tractors were improving at a very fast pace (Handschin, Andrews, & Rauchenstein, 1921).

It is also worth noting that at the time the tractor was being developed, other scientific advancements were occurring that also increased productivity for the average American farm. The Census Bureau reported that in 1920, only 10% of farms in the US had electricity whilst by 1950 this number was close to 80% - with more than half of the increase in the number of farms with electricity coming after the end of World War II. The adoption of electricity provided stationary power for farm production uses, such as for pumping water, operating milking machines, as well as completing many of the house work. Improvements like these significantly reduced the necessary time to complete a variety of tasks, which increased general productivity. Whilst the introduction of electricity was contingent on expensive infrastructure, the tractor’s adoption was remarkably easier and faster. The tractor proved to be the essential technological piece for farmers as its benefits were immediately apparent, and its use required less technical knowledge. By having the tractors work the lands, the number of necessary people to work on farms decreased and the ability to work more land increased. Many technological improvements were occurring on farms throughout the country; however, the tractor proved to be the crucial piece to significantly change farming. Ultimately, the farm tractor significantly altered the

structure of rural America and freed up millions of workers to be absorbed into the rapidly growing manufacturing and service sectors of the country.

STS Theory

Technological determinism is a theory that assumes that technological advancements determine the social structure and culture values in a society. It's a theory that encourages society to pursue technological developments for the sake of innovation. More recently, an approach called the social construction of technology (SCOT), suggests that technology doesn't determine human action but that instead human action determines technology (Bijker & Pinch, 1987). In this new way of thinking, society pursues technological development as a result of social structure and culture values. An example put forward by Pinch and Bijker (1987) is the development of the design of the bicycle. They argue that the development of the bicycle from the early-twentieth century to today has been a complex one, with various designs being tested and rejected by society. They go further to say that even the best design might not have been the best one. This is because each model had its own advantages and disadvantages for each different relevant social group (sports enthusiasts, men and women who ride bicycles, bicycle makers, etc). They believe that each new model is aimed at solving problems that these social groups might have. These can include safety, how easy it is to build or repair it, speed, what terrain they're supposed to traverse, and so on. In addition, designs carried social meaning that can inhibit their development or use. Bijker also refers to the bicycle's first design as the point of stabilization. This is when the most relevant social groups agreed upon one design that solved problems for all of them. After this, incremental changes in new designs continued to be made. In this fashion, Bijker shows how the design of the bicycle was socially constructed in a way to

succeed rather than through the objective sense presented by technological determinism. In this paper, I similarly look to use SCOT theory to understand how society allowed for the development and improvement of the tractor whilst it replaced animal-powered farming. I will complement my work by employing the theory of technological momentum, developed by Thomas Hughes as a response to SCOT and technological determinism.

Technological momentum suggests we look at socio-technical systems through a new lens encompassing both SCOT and technological determinism. Hughes attempts to study how society and technology both exert influence on each other. People direct the development of new technologies, but as these grow, then the sociotechnical systems can gain "momentum". By this he means that the sociotechnical systems have financial, capital, infrastructure, and ideological reasons to keep them going. These reasons are wrapped up with the technology, creating a sociotechnical system. Once these larger systems are in place it becomes harder to abandon them, than keeping them going and innovating them. The sociotechnical systems gain this momentum and, investments of money, effort and resources make changes to those resources hard (Hughes, 1994). I intend to apply Hughes' theory on technological momentum to understand how the tractor replaced animal powered farming from 1910 to 1950 in the US. I will take it a step further and attempt to understand how this change felt like to the people living it and why it was so significant.

Methods

My research focuses on analyzing the mutual shaping of society and the tractor from 1910 to 1950. I will focus on the impact the tractor had for the life of people living on farms at the time. This question will be analyzed using an STS framework in order to better understand

the motivation for the development of the tractor and how it not only impacted the lives of farmers but also derived from their necessities.

In order to conduct this analysis, I will draw on “American Life Histories: Manuscripts from the Federal Writers' Project, 1936 to 1940”, from the U.S. Library of Congress, as a resource for first-person accounts of life at the time. This collection of life histories consists of approximately 2,900 documents, compiled and transcribed by more than 300 writers from 24 states, working on the Folklore Project of the Federal Writers’ Project, a New Deal jobs program that was part of the U.S. Works Progress (later Work Projects) Administration (WPA) from 1936 to 1940. Typically, 2,000-15,000 words in length, the documents vary in form from narratives to dialogues to reports to case histories. They describe the lives of Americans who lived at the turn of the century and often describe the informant’s physical appearance, family, education, income, occupation, political views, religion and more. From these accounts, I expect to set the scene for what living on a farm was like before the mass adoption of the tractor. By reading people’s personal experiences about life at the time, I will be able to pick up recurring themes that will help strengthen the argument that the invention of the tractor was both socially driven and shaped.

I will complement this work by looking at census data that will help me understand the demographic and agricultural changes in the United States landscape occurring at the time. I expect to see a rural to urban population migration largely explained by the productivity increase the tractor brought to farms. I also expect the data to show an increased adoption rate for tractors and technology in farms driven by an increase in food demand. I also predict an industrialization of the agricultural industry with farm sizes increasing and family farms going out of business.

The current literature surrounding this research topic mainly deals with specific case studies for individual states regarding the adoption of the tractor by farmers such as Handschin, Andrews and Rauchenstein (1921), and their exploration of the adoption of tractors by the state of Illinois. There have been several other studies done that attempt to analyze the history of the adoption rate through a quantitative standpoint such as Steckel and White (2012), Manuelli and Seshadri (2014) and Olmstead, and Rhode (2000). My work will fill the gap in understanding the motivations behind the development of the farm tractor by analyzing the census data in the sociotechnical context that was the life of farmers at the turn of the century.

Major Themes

By scanning the first-person descriptions of life in the early 1900s in the American Life Histories collection from the U.S Congress Library database and then categorizing certain passages by relevant themes, it is possible to identify recurring themes that are descriptive of life on a farm during that period. We can only identify these key themes by looking at a variety of manuscripts from all over the country. It's important to note that these manuscripts are only valid descriptions for some people and that there were millions of people, each with unique stories and experiences living at the time. I hope that my limited sample size together with a general understanding by the reader of American history at the time, is sufficient to help visualize what life must have looked like throughout rural America without falling into a generalization trap. I selected the interviews by performing a keyword search for the word's "tractor", "agriculture" and "farming". This method helped me refine my search and pick the most relevant transcripts. I then read those that mostly linked with agriculture and categorized them based on recurring themes that I identified throughout the process. The large spread of different interviewees

together with a clear variation in geographical location should strengthen the conclusions from my analysis. When looking at the data I identified mobility, display of technology, capital, family and poverty as the key five themes that helped describe some of the struggles of life in those days. These key themes appeared in many of the interviews I analyzed and were examples of the lives of Americans spread out over the U.S.

Mobility, or the lack of thereof, was a recurring theme that appeared over multiple passages during data collection. The passage below is an interview by Francis Donovan to Arthur Botsford, about living in New England at the start of the 20th century. The interview was conducted in 1938 and it describes how even during the summer holidays, people living in rural America didn't take vacation trips but instead found an occupation near their home. Many of these people would try and find jobs in farms that needed seasonal help.

> *"[..] by summer time, folks used to go berrying. You know they used to do a lot of cannin' the women did. Others would hire out to farmers, pitch hay, or do other work like that. There wasn't many goin' to the seashore, or to the mountains like there is today" (Donovan, 1938, p.2).*

Similarly, from the same interview we find a passage that describes how farmers would tend to avoid large trips and mostly stay working the land. This lack of mobility was largely explained by the fact that farmers had most of what they needed to live at home. Another important theme we can observe from this passage is that of display of technology. It talks about how farmers didn't come into town often and that when they did it was largely for big events,

such as the circus. In some of these occasions they would proudly exhibit their farming equipment such as their wagons, thus putting their technology on display.

> *"Big day of the year was circus day. We'd all go down on the morning train, and spend the day there. Shops was shut down tight. If they didn't nobody would have worked anyway. All the farmers from the surrounding towns, they drove down with their teams. You'd see rigs from all over. Some from the back roads you'd swear never got down to the city but that once all year round" (Donovan, 1938, p.1).*

From an interview conducted by Pool and Saunders with Mose Sutton, a tenant farmer from North Carolina, we are able to understand how technology for many of the most secluded areas was really a rarity. His words show how older generations really didn't pay much attention to new inventions as they believed this to be aspirations for the younger members of the family.

> *"Ev'y time a ottermobile goes by Roseos he jes quit anything he happen to be doin' en jes watch it till it's plum o' sight. Mose has never owned an automobile and says he is too old to aspire to ownership of one now. But Roseos, that oldest grandson of his, is 'jes plum sot on 'em,' he says" (Pool & Saunders, 1938, p.10).*

In the same interview, Sutton introduces the themes of poverty and capital through two complementary passages. In the first passage, seen below, we are able to picture the degrading living conditions Mose Sutton has to cope with due to poverty as well as the lack of capital

investment for his farming equipment. This really paints the picture of the harsh life some of these farmers had.

> *"A rickety farm wagon stood in the yard. It had cost $12 at a foreclosure sale several years ago. Two old plows and a broken down drill completed his visible farm equipment, not to mention the two forlorn looking mules that looked their abject shame of ancestry and repair posterity. [...] There was something about Mose's appearance that reminded me of the two mules I had observed in the yard - something that suggested too much hard work in the fields and too little to eat at times" (Pool & Saunders, 1938, p.1).*

The second quote is shown below to cement the idea that for many Americans farming was not a profitable occupation but rather a necessary one to survive. Sutton was never given the capital to expand his farming operations and due to his agreement with the landlord, he was never able to make enough money to spend in a discretionary fashion.

> *"'What is your average annual income, Mose?' I asked. [...] 'Nothin', or almos' nothin',' he replied. 'If I have enough left over, after payin' for my go-ano and such, to buy flour an' meal and rice through de winter, den I calls myself lucky. I ain't made no money farming in ten or fifteen years'. 'De landlord, he gets a fourth of de peas (soy beans) and de cotton and a third of de corn and sweet potatoes, and I get de rest'" (Pool & Saunders, 1938, p.2).*

It is also important to note that Mose Sutton is a tenant farmer whose poverty derives from his ancestral background of being born into an enslaved family. In many cases throughout the U.S, farmers were still recovering from slavery and without the appropriate investments and technology this process took many years.

> *"And not in all his years of his life has Mose aspired to ownership of a farm. He was born of slave parents who stayed on the plantation of their master after they were freed, and ended their days in the selfsame quarters they occupied in slavery. His pappy taught him that white folks were the owners and bosses of the earth and that the best way to get along was to stick by his white folks" (Pool & Saunders, 1938, p.12).*

An interview carried out by Kanipe and Deal shows how a farmer in the same state of North Carolina, decided to spend his capital on technology.

> *"My folks have always lived in town and it seems the farm was a sort of experiment. We worked like the dickens on that farm; raised cotton, wheat, corn, vegetables, hogs and chickens. Dad had five or six cows and there was always gallons of milk, cream and butter. Mother made more cheese than we could use and gave a lot of it to the neighbors. We had plenty to eat, but it seems that we were unable to turn our products into money. When Dad bought the place it looked a sight, but when he sold it four years later it was in the best condition. [...] Dad owned his own tractor and truck, and our car was the best in the community; but when it come to extra money for clothes and the extra things we'd been used too, there was none" (Kanipe & Deal, 1939, p.1-2).*

Crawford, Deal, and Travis also conducted an interview with Allen Teavis, a farmer with nineteen children, whose words exemplify why family is such a prominent theme. Teavis describes a numerous family that helped him work the farm.

> *"I have nineteen children, born to us in twenty-six years. The babies come so fast there was no time to get one doctor bill paid and rest up before the next arrived. [...] I had a tough time raising them. There was so many of them we sure could turn off work. You put about twelve in an acre field, they can hoe it out in an hour" (*Crawford, Deal & Travis, 1929, p.2).

Discussion

The five key identifiable themes: mobility, display of technology, capital, family and poverty, are important to explain how society helped shape the invention of the tractor. The propagation of the car as a new form of transport at the start of the twentieth century, provided the tractor with the necessary technological momentum to gain adoption as a revolutionary piece of farming equipment. From the first person accounts it is possible to discern with confidence that at the start of the 1900s, the typical farmer performed chores by hand, plowed with a walking or animal-powered plow, forked hay, milked by hand and rarely went to town unless there was a special occasion or to obtain necessities not produced in the farm. The power needed for farm work was either supplied by horses or humans. The farm acted as a self-sufficient ecosystem, producing most, if not all, the necessary outputs one needs to survive. In the span of 50 years, from 1900 to 1950, farming in the United States had been revolutionized by the

widespread use of machinery and improvements in agriculture methods. Taking center stage in this revolution was the tractor and the many improvements it brought to farms. By combining the data provided by the census bureau and the above extracts, I will explain how the embedment of the tractor into modern day society was inevitably shaped by society.

Mobility is an important theme because it demonstrates how people living in rural areas didn't travel and did not feel the need to travel before the invention of cars. Consequently, without using cars to travel it was tough for farmers to understand what the tractor could do for them as they had never experienced the power of the diesel engine. At the beginning of the century, work animals provided practically all the power for farm operations and by the 1950s practically all of the transportation of farm products to market was done with motor power and tractors provided four-fifths of all the power for operating field machinery. This change from animal-powered farming to the tractor occurred at an exponential rate as younger farmers began to replace their elders (U.S. Census of Agriculture, 1952). This new generation realized the potential productivity gains from the adoption of this new technology and seeking higher returns, onboarded the risk from investing and pioneering the use of the tractor. Their futuristic aspirations shaped farmer's perspective on the potential of this new technology for agriculture and thus rapidly resulted in an increased adoption of the tractor. Additionally, as shown by the older generations such as Arthur Botsford in the interview conducted by Francis Donovan, the proud display of technology was an important theme as wagons and farm machinery were, in many cases, all farmers had to be proud of. Interestingly this passage in combination with Moses' account of his grandson's reaction, suggests that people at the time did not want to get rid of the wagons they were so proud of and thus, it was the responsibility of the younger generations to adopt the use of the tractor.

Capital was also an important theme as the path to profitability for smaller farms was a tough one. The size of the farm was proportional not only to the available land to work but also the efficiency of the equipment. This made it harder for farmers to make abnormal profits. The introduction of the tractor was the first step to help convert farms into profitable businesses, yet the Kanipe and Deal interview illustrates that in particular cases a tractor alone wasn't enough get farmers to make money. The tractor increased productivity on the farm and consequently, between 1899 and 1949 there was a net increase of nearly 55 million acres of cropland harvested. Most of the growth in harvested cropland came from the Great Plains, where wheat, cotton and later, cereal were major crops. In the eastern half of the United States the acreage of harvested cropland actually decreased mostly due to the expansion of cities and urban areas (U.S. Census of Agriculture, 1952). From 1850 to 1950 the number of farms in the United States tripled. The peak number of farms was in 1935, however, we then witnessed this number shrinking rapidly to levels close to those of 1900. In addition, in 1900 nearly all of the 5,737,872 were full-time farms fully employed in agriculture, however, of the 5,382,000 farms in 1950, 639,239 were part-time farms employed in some agriculture and 1,029,392 were residential farms employed in no agriculture (U.S. Census of Agriculture, 1952). The ratio of workers (including both family and hired labor) per farm was remarkably stable over the 1910-60 period, hovering between 2.1 in 1910 and 1.7 during World War II. Based on the 1960 ratio of 1.8 workers per farm, the labor savings estimated above suggests that there would have been 967 thousand more farms in 1960 in the absence of the tractor. The average farm size, assuming a constant land base, would have been 239 acres. This implies that 37 percent of the growth in farm size since 1910 was due to the tractor and other technological developments (Olmstead and Rhodes, 2000). This data suggests that through the introduction of the tractor, agriculture at the start of the twentieth century

became a profitable industry, driving more people to the farming industry. From the data we can also discern that even though there were more acres of cropland harvested, there were also fewer farms. This hints at the idea that farms had become bigger. This could be due to tractors having the ability to work larger areas at a reduced cost. This productivity in agriculture has resulted in cheaper and cheaper food. The efficiencies brought by the tractor, as well as other innovations and equipment, made food more available than ever before. According to the Bureau of Labor Statistics, the percentage of our annual income spent on food has continually plummeted. In 1900 when horses ruled our farmlands, Americans spent 43% of their income on food. By 1950, it had dropped to 30% (Masumoto, 2013).

The theme of family shows how large families used to work the land together, but as younger generations went off to war and productivity on the farm fell, a special need for the replacement of labor arose. The tractor then became a necessary investment to replace the less productive horse and mule. The replacement of draft animals led to their drastic decline, which can be seen in the reduction of farmland devoted to raising feed. From 1920 to 1950, There was a decrease in over 70 million acres of cropland, that used to raise feed for animals (U.S. Census of Agriculture, 1952). This land in turn has been diverted to the production of food or feed for meat animals. The change from horses and mules to the tractor made an acreage of cropland greater than the total increase in cropland during the half century for the production, directly or indirectly, of meat, milk, eggs, and other food. The tractor increased productivity on the farm allowing for many family members that used to stay and work the farm to migrate to rural areas and take on non-farming jobs. In spite of this, total farm production increased, and it is estimated that with a tractor in 1950 the average farmer was able to produce twice the amount of output his

father did 50 years before with a team of horses. In addition, less of the farmer's time was needed to maintain the tractor than to raise feed and take care of the horses and mules.

Full credit to the rise in farming can't be solely attributed to the tractor. Besides the increased adoption in food importation, American farmers had experienced good times during World War I. Demand for their crops were high, and competition from European farmers was low due to the war (U.S. Census of Agriculture, 1952). The acreage of irrigated land also increased by 18 million acres from 1900 to 1950, improving crop yields and area of workable land (U.S. Census of Agriculture, 1952). Improvements in fertilizers, such as the Haber-Bosch process for capturing atmospheric Nitrogen led to drops in fertilizer prices and consequently the tonnage of fertilizer consumed between the early 1900s and 1950 increased by 6-fold (Bellis, 2019). This increased adoption in fertilizers was mirrored by the adoption of herbicides and pesticides, which also helped improve crop yields. Additionally, whilst in 1900 practically no farms had electricity by 1950, more than three-fourths of farms had electric service from central station-sources (U.S. Census of Agriculture, 1952). Electricity allowed farmers to more efficiently pump water, operate machinery and work longer hours when paired with the light bulb. As pointed, full credit to the productivity improvement in farming can't be solely attributed to the tractor. Even though the tractor clearly played a central role in revolutionizing farming, multiple forces worked in combination to drive down food prices and improve crop yields.

The social construction of the tractor can therefore be explained somewhat by the five key identifiable themes of mobility, display of technology, capital, family and poverty. As the profitability of farming improved, more technologically adept farmers began adopting the tractor and thus shaping its design. Farmers were willing to invest more on tractors and equipment to achieve significant gains in productivity, which consequentially led to design improvements.

These same farmers aimed to buy the best tractors they could display. A bigger and better tractor was something to be proud of, similar to the wagons before them. This drove tractor manufacturers to build bigger and better-looking machines. The tractor converted farming from a family affair to a for-profit business activity. Industrial America grew at precisely the same moment in our nation's history, absorbing this labor force. Commerce benefitted from a new set of skilled hands, launching the rise of the urban middle class. The tractor freed millions from farm labor and the isolated rural life, and thus illustrating the mutual shaping between technology and society. The exploration of these themes through the first-person accounts together with the data provided by the Census Bureau suggest that the tractor as a sociotechnical system had financial, capital, infrastructure, and ideological reasons to keep it going. This technological momentum backed the evolution of the tractor and reinforced it as sociotechnical system that would prevail to today's age.

Conclusion

It is undeniable that the tractor has been an important technology in changing both the farming industry in America as well as the physical and economic landscape of the country. The farm tractor has made a major impact on the social and economic fabric of the United States by increasing the productivity of agricultural labor through mechanization that freed up millions of farm operators, unpaid family workers, and farm hands. Horses and mules gradually vanished from the nation's farms as they got replaced by the tractor. At the beginning of the century there were almost 22 million horses and mules on farms, by 1950, this number was less than 8 million (U.S. Census of Agriculture, 1952). As horses and mules drooled, tractors began to rule.

The tractor shows how important technology can be to agriculture; however, it is a more challenging task to be able to relate these changes to how they have shaped society. By embedding the first-person narratives of life at the turn of the twentieth century with census data from 1900 to 1950, one can understand that society was not only shaped by the invention of the tractor but that in turn the tractor shaped society. This paper shows how necessary the invention of the tractor was to boost productivity levels in the farming industry at a time that food demand increased, enabling workers to leave their farming jobs to join an industrial society and national war efforts. The American people experienced this increased adoption at an exponential rate, propelling improvements in farming technologies and decreases in food prices.

I believe that implementing technology in agriculture is not only a necessity but an important measure to cope with an expanding and hungrier world. While the mutual shaping between the tractor and society proved at the turn of the twentieth century to be crucial for the development of farming, current efforts into developing new technologies such as hydroponics - growing crops in vertically stacked layers, could indicate a new, equally revolutionizing, improvement in agriculture. The next steps in this area involve identifying current promising technologies that could prove to be equally as revolutionary to the agricultural space as the tractor proved to be in the first half of the twentieth century.

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