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Analysis of Henry Ford's contribution to production and management

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ABSTRACT

Henry Ford is widely known as the car constructor, the founder of the Ford Motor Company, the pioneer of mass production and the inventor of the moving assembly line, which many consider as the world's greatest contribution to manufacturing. In 1908, Ford started production of the Ford Model T, which has become one of the most successful automobile in automotive history. But his contribution far surpasses these excellent accomplishments. What are not well known are Ford's contributions to the just-in-time production, product platforming, mass customization, vertical integration, designs for maintainability, ergonomic considerations, employee management and other features of the manufacture. The Ford's production system has become the characteristic American mode of production widespread all over the world.

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1 Introduction

Henry Ford's vision was to build a motor car for the great multitude, constructed of the best materials, by the best men to be hired, after the simplest designs that modern engineering can devise, so low in price that no man making a good salary will be unable to own one and enjoy with his family the blessing hours of pleasure in God's great open spaces [1]. The first Ford's Model T was assembled on September 27, 1908 at Ford's Piquette Avenue plant in Detroit. The automobile at the beginning of the twentieth century was very expensive and attainable only for rich and privileged people. In that time, the automobile was more like a personal jet airplane of our time – very high-priced and unreachable for ordinary workman and farmer [2].

Before the beginning of a serial production of the Model T, Ford, together with his collaborators, worked three years on its design, experimentation and research. Experimental cars were driven in all conditions varying from snow, slush covered roads to country roads. It was completely a new car with a new chassis and a new engine. The Model T had a front-mounted 2.9-litre inline four-cylinder engine, producing 20 hp (15 kW), for a top speed of 64–72 km/h. The engine was capable of running on gasoline, kerosene or ethanol with the fuel consumption of 11-18 litres per 100 km. The engine was a water cooled four-cylinder cast in one block with removable top, so that cylinders, pistons, valves and other interior parts were easy available. The transverse leaf spring suspension system was used for front and rear axles. The Model T was a rear-wheel-drive vehicle with two speed transmission [3]. At the beginning of the manufacture, the Model T was produced in five body styles at different prices: Touring at US$ 850 (current equivalent cost US$ 54,445), Runabout (Roadster) at US$ 950 (US$ 60,851), Coupe at US$ 950, Town car at US$ 1,000 (US$ 64,054) and Landaulet at US$ 950 (US$ 60,851) [4]. If we wish to compare the prices of the Model T with the today's prices, we can compare the gold prices at the beginning of the ninetieth century (for one ounce US$ 20.67) with the today's gold price (for one ounce US$ 1,324.00), since, in terms of purchasing power, the gold's value stood impressively constant during a long period of time [5].

The Model T was designed to be a simple, useful, robust, reliable and inexpensive car. The Model T was a strong but a relatively light car; it did weight only 544.31 kg. It could have been at the same time a personal car, tractor and portable engine. It could pass over a rocky, muddy farm road, cross a shallow stream, climb a steep hill. It could be parked on the side with a rear wheel removed and a pulley fastened to the hub to make a conveyor belt drive a water pump, electrical generator, band saw, thresher, baler, silo blower, conveyor for filling silos, and many other applications [6].

The production of the Model T started on September 27, 1908, and ended by May 1927. In that period, more than 15,007,033 units were built. The Ford car was called the people's car 20 years before this term was used in Germany. In 1909, the Ford Motor Company produced 10,666 Model T's, and the Runabout model was sold at US$ 850 (US$ 54,445), in the time when the cars were double or three times more expensive. By the year 1925, the Model T production rose to 1,911,705, and the prices of the similar but improved Runabout version decreased significantly to US$ 260 (US$ 16,654) [11].

By the year 1918, half of all the cars in the U.S.A. were the Model T cars. The Ford Motor Company was the largest automotive manufacturer in the world. At the same time, the Ford automobiles were assembled in thirty-six towns within the U.S.A. and in nineteen foreign countries as well.

In this paper we will emphasize the most important characteristics which have had an influence on such skyrocketing accomplishments of Henry Ford. Furthermore, many well-known achievements of Ford and his associates have been overwhelmed by new ones. Some have been used only partially, while, today, some have been completely forgotten.

2 Features of the Ford Model T

Three years before the serial production of the Model T, Henry Ford with his collaborators worked on his research, design, and experimentation. Then, experimental cars were tested under all possible conditions and each part was thoroughly examined. The "Model T" had practically no features which were not accommodated in some of the previous Ford's models. Ford designed eight models in all, before the "Model T." They were: Model A, B, C, F, N, R, S, and K. The Model T was a universal car which was manufactured for people and had the following characteristics: the highest material quality of car parts; simplicity in operation, maintenance and repair; power in sufficient quantity; absolute reliability; lightness; easy driving control; light weight; pretty design and low price [11]. The Model T engine had the extremely basic design and construction simultaneously, was very sophisticated in its operation and performance. The greatest innovations of the Ford Model T which led to such a great success were: vanadium steel, flywheel magneto (alternator and dynamo), separate cylinder head and block, planetary transmission,

Tourning 1908 [10]

Runabout 1908 [11]

Tourning 1927 [12]

Runabout 1927 [13]

Figure 1 Two Versions of the Touring Model T and Two Versions of the Runabout Model T
Source: [7], [8], [9], [10]

fully enclosed powertrain, three-point suspension, left-hand drive, etc.

2.1 Vanadium Steel

In 1905, at an American motor race, a French car smashed. Henry Ford picked up a small valve strip stem, which was light and strong. As he did not know which type of steel was that and no one of the present experts did know that material, Ford asked his assistant to examine the material. They discovered that it was the French steel alloyed with vanadium. There was no one steel maker in America who produced and could not produce vanadium steel. The problem was that vanadium has a higher melting point (1910°C) than iron (1538°C) for 400°C and the ordinary furnace, in that time, could not work beyond 1500°C. Ford found a small steel company in Canton, Ohio and offered them a guarantee for any losses which could incur during the experimental production of vanadium steel. In the second attempt they succeeded in producing the corresponding vanadium steel. Until then, all car manufacturers in America used only four types of plain steels with tensile strength between 410 and 480 MPa. But, vanadium steel, which also contained chromium and manganese, achieved a tensile strength up to 1.170 MPa. Further researches, especially with heat treatment, resulted in an even greater tensile strength of vanadium steel, which enabled an even greater reduction of the weight of the car. For the first time in history, intensive scientific researches of every part of the car were carried out showing that, despite the high strength of vanadium steel, it could be machined more easily than plain steel. For each part, according to what its needs were, the strength, hardness, or toughness of twenty different materials of the best quality were determined. Around ten of these were some sort of vanadium steel. Especially where the strength and light weight of the parts were sought, the vanadium steel was used. In two-year researches of vanadium steel, Ford spent more than US$ 200,000 (US$ 14 million) [3].

2.2 Flywheel Magneto

It was common in that time, that cars, like the previous Ford Models A, C, F, R, S and N, depended solely on storage batteries for electric current to generate the energy for the ignition system. The major drawback was that the batteries should be frequently recharged or changed. If this was not done on time, after about 150 to 300 km of driving, the batteries were empty and the car stopped. Henry Ford decided that his Model T ought to be capable to generate its own electricity for the ignition system. He recognized that the solution was a dynamo or magneto, which would constantly generate the electrical power for ignition. Henry Ford's original idea was to mount a magneto system on a flywheel. This flywheel magneto was in fact an alternator or dynamo, which generated sufficient current to supply the stock ignition coils of the car. The storage batteries were not needed. The Model T ignition system was unusual but utterly simple, reliable and maintenance free [12].

2.3 Separate Cylinder Head and Block

Henry Ford´s idea was to construct a detachable cylinder head and the engine block with cylinders cast as an integral part. Modern automotive engines are designed in the same way. Previously to the Model T, engines commonly had their cylinder heads and engine blocks cast in one heavy piece of iron. Removable cylinders were fastened to the crankcase. These assembly operations were complicated and required a lot of time [3].

2.4 Planetary Transmission

The Model T had a spur planetary transmission with no internal gears, which was a very similar system to an automatic transmission. This transmission was very quiet, lightweight, close-packed, long-lasting and economical to manufacture [3].

Figure 2 Driving Characteristics of the Centennial Ford Model T [13]

2.5 Fully Enclosed Powertrain

Dissimilar to the majority of other cars of that time, the Model T was characterized by one-piece pressed steel plate covering the underside of its engine, flywheel, transmission and drive shafts. This cover considerably protected the powertrain and kept the car cleaner than many of its contemporaries [3].

2.6 Three-point Suspension

The Model T was designed with a suspension system in which the chassis with the engine and transmission were mounted on the front and rear solid beam axles with transversely leaf springs in a triangular configuration. So constructed, the Model T was able to drive without great problems on the worst rural roads, to cross big acclivities and downhills, effortlessly climbed steep stairs and railroad tracks. Figure 2 shows the remarkable driving characteristics of the centennial Ford Model T [13].

2.7 Left-Hand Drive

The Model T was constructed with the left-side driver (LHD) seating. Until then, the steering column in American cars was placed on the right side. Henri Ford argued that due to greater traffic safety in the right hand traffic (RHT) America, the steering column should be placed on the left side of the vehicle. Namely, with the left hand drive configuration the driver has a better overview and easily can avoid danger. In addition, the passenger does not have to go around the car to enter the sidewalk and it makes a comfortable ingress of the lady in the car. Soon, all other car manufacturers in America and the world followed Ford's configuration, which became the standard layout for right hand traffic countries [6].

3 Model T as a Platform and Mass Customization

The Model T's platform comprised the chassis, engine, suspensions, transmissions, wheels, gas tank, steering system, lights etc. This platform was constantly improved during the construction of the Model T and was the base for all eleven body styles, which were assembled. Numerous Model T platforms were also sold as a separate product to specialized companies which modified hundreds of unique vehicles in order to satisfy the customers' needs [14]. In Figure 3, various specific vehicles which were based on the common Model T platform can be seen.

In order to improve the features and appearance of the Model T, numerous specialized manufacturers manufactured more than 5000 different gadgets and accessories [14]. These different products were controlled by the Ford Motor Company, but the assemblage was committed to owners of the Model T. The most popular accessories were: rearview mirror, automatic oiler, auxiliary transmission, hot spot generator, exhaust whistle, hoods, aluminium pistons and connection rods, gasoline injector, heater, shock absorbers, etc.

Mass customization was defined as a strategy for fulfilling individual customer's desires with maintaining mass production efficiency [14]. Duray et al.'s claim that mass customization must include the purchaser in the design procedure [18]. Mass production of the Model T and its platform with mass customization generated thousands of unique vehicles during the lifecycle of the Model T. The Ford Motor Company, by producing a base product and by modifying each product through specialized factories, fully met the conditions of mass customization, which was defined hundred years later by Jiao et al.'s [14] and Duray et al.'s [18]. Henry Ford, with the production strategy of outsourcing customization, generated a new industry branch

Fire truck [15]

Snow mobile [16]

Racer [17]

Woody wagon [14]

Trick w/chain hoist [14]

Tractor [14]

Figure 3 Various Specific Vehicles which were based on the Common platform [14], [15], [16], [17]

of car accessories, which today exceeds a value measured in billions of US dollars [14].

4 Model T Factories

The first 14,000 Model Ts were manufactured at the Piquette Avenue Plant, and relied on the masonry construction. The Model T car in 1908 had an immediate success and the Ford factory in 1909 was unable to keep up with immense demands. Ford was opened in 1910 - The Highland Park Plant - which was considered as the largest factory in the world at this point of time. Within its 480,000 square metres, the plant had, in addition to the factory area, administrative offices, foundry, power plant and all needed premises. A well known industrial architect, Albert Kahn, designed this plant using reinforced concrete constructions with huge windows and excellent electrical lighting, which drastically improved the working conditions. Ford knew very well that to achieve a high capacity and productivity, as well as to humane production, it was absolutely essential to have a clean, well-lighted and well-ventilated factory. Huge open floors made the location of machinery economically very efficient and the option for further expansion was also added. Despite this possibility, the Ford outgrew the production capacity of this plant, which at one point reached 1,000 cars per day. Therefore, in 1920, Henry Ford moved the production of most of the Fords parts into an even larger production complex, the River Rouge [8]. The Rouge had own docks, 160 km of interior railroad tracks, own electricity plant, integrated steel mill, innovative glass plant and 93 buildings with nearly 1,500,000 square metres of floor space. Kahn also designed factory buildings with windows placed in the ceiling, thus providing plentiful natural light. At that time, the Rouge was regarded as a prime example of humane factory with a vertical integration production. Throughout the U.S.A. Ford established thirty five village factories, which were all assembly plants, but in twenty-two of them car parts were also manufactured. In England, from 1920 to 1925, the Aeroford automobile was manufactured [20]. It was the Model T with a different hood and grille, which gave a completely different design to the car. This production policy was the first of this type in the automotive industry and was later called badge engineering. Badge engineering is the practice of using a different manufacturer's name to an already existing product, the variant of which was then merchandised as a distinct product.

5 Scientific Management

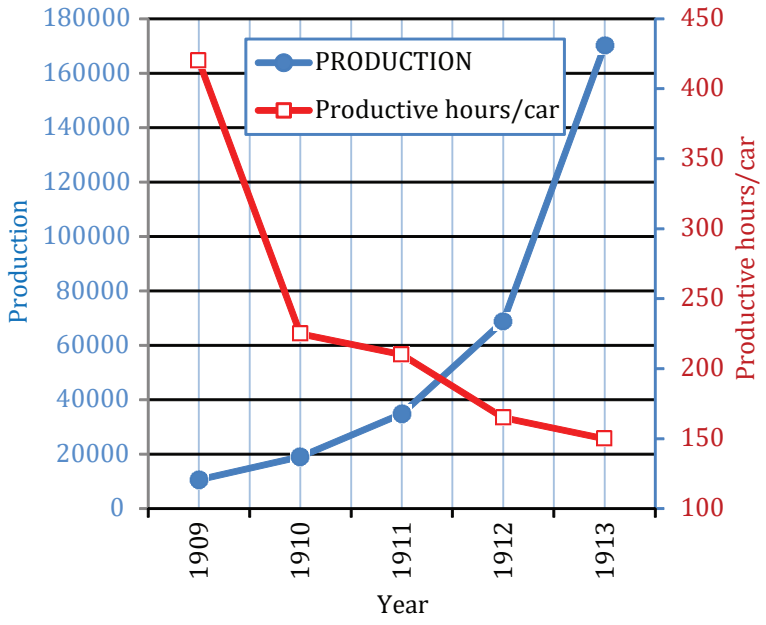
The factory of the Ford Motor Company was organized as a job shop, in which similar equipments were grouped together in the factory process layout. The larger parts of the car remained stationary, while the smaller parts, as needed, were brought at fixed assembly stations. Hand tools were used for the assembly work. Each car was assembled in over 12 hours by groups of skilled workers, which were working together. Early in the Model T's production, Henry Ford hired Frederic Taylor to examine his workmen and decide the most efficient and time saving procedures for increasing the productivity [21]. Taylor's scientific management principles can be summarized as follows:

1. Replace working by "rule of thumb," or simple habit and common sense, and instead use the scientific method to study work and determine the most efficient way to perform specific tasks.
2. Rather than simply assign workers to just any job, match workers to their jobs based on capability and motivation, and train them to work at a maximum efficiency.
3. Monitor the workers' performance. If the worker fails to do his tasks, instead of brutally discharging him or lowering his wages, provide instructions and supervision to ensure that he is performing the working tasks in the most efficient ways
4. Allocate the work between managers and workers so that the managers spend their time planning and training, allowing the workers to perform their tasks efficiently.
5. Detailed written instructions should be prepared in advance in the planning department in order that workers can carry out each piece of work in the best possible way.
6. A form of motivation for the employees should be proposed so that they can make suggestions if they feel an improvement could be made regarding either the method or the implements used to undertake a task.

The Ford team analyzed the Taylor's examinations and begun to implement scientific management principles into every production procedure through the creative and innovative search for solutions. They examined each operation and evaluated how to reorganize it by redesigning the part in order to carry it out in a better and cheaper way [21].

Ford applied the scientific management strategy in its mass production plants by dividing and subdividing operations into clear specialized phases of labours. This task specialization allowed unskilled workers, with a very small number of exercises, to perform their single repetitive tasks efficiently in order to inhibit delays in the production process. By applying scientific techniques, like varying the speed, feed and shapes of cutting tools, Ford found the best way to do any metal cutting task. To achieve this goal the key production factor was the interchangeability of all the parts so that they can be most easily performed at high velocity and attached to each other.

The old Mushet tool materials were not able to machine at high speeds and could not cut previously-hardened steel parts. Therefore, car parts had first to be machined and then quenched with old tools. Quenching causes uneven dimensions and tolerances of the parts due to the generation of martensite crystals in steel, which is a very hard form of steel crystalline structure. For these reasons very



YEAR	PRICE	CURRENT PRICE (Gold)	AVERAGE NUMBER OF EMPLOYEES
1909	$ 825	$ 52,844	2,190
1910	$ 900	$ 57,648	3,672
1911	$ 680	$ 43,556	4,100
1912	$ 590	$ 37,791	7,042
1913	$ 525	$ 33,628	16,000

Figure 4 Productive Hours per Car and Number of Produced Cars in the First Five Years
Source: Authors

skilled craftsmen were needed and production speed was very low. In the Ford's Motor Company new Taylor-White high speed steel (HSS) tool started to be used, which allowed a very fast machining of previously-hardened steel parts. Higher feed rates and deeper cuts, without changes of cutting tools, were possible, which enabled a higher production of parts with greater accuracy and tolerances. HSS tool enabled the perfect part interchangeability, which eliminated the need for customization and fitting.

Before starting with the production of the Model T, the Ford Motor Company invested in new machinery and tools US$ 150,000 (US$ 9,608,100) [3]. The machinery was scientifically arranged and placed very close together. For each machine and worker, the exact amount of place was measured. If a worker and his machinery occupied more room than was required, it was considered as an economic loss. If the working area was too tight, it was also a loss. The Ford Motor Company installed more machinery on floor space then any other manufactory in the world [8].

Ford was striving for manufacturing with a minimum of waste, both of materials and of human efforts. For example: previously the cylinder casting travelled 1,220 metres in order to be finished. After the implementation of the scientific management principles, it travelled slightly over 91 metres. The second example: the old method of making a certain gear comprised four operations and 12 per cent of the steel went into scrap. A very simple new method for making this gear was devised in which the scrap was only one per cent [8].

Special machines that could do only one operation considerably decreased the set-up time. The unskilled workers with few minutes' training could set the workpiece in simple jig and fixture of the machine, push a button or pull a lever to perform the required task and then unload the finished part. As installing times were reduced from minutes and, in some cases, from hours to seconds, machines could manufacture significantly larger number of parts within the same time. And even more important, in Ford's factories machines were used that could manufacture several identical parts at once. At Highland Park two special milling machines were installed, one for milling blocks and the other for milling heads, which could cut fifteen blocks and thirteen heads at the same time [21].

Ford together with his engineers required the mechanization of the production processes in order to eliminate labour by machinery. If the machine was able to perform an automatic operation, the operation was performed automatically. Only about ten per cent of Ford's machine tools were special machines, while the other were normal machines modified to a specific work. Not a single operation was ever considered as being done in the best or cheapest way. During the production years of the Model T hardly a week had passed without some improvements being made somewhere in the process, on the machines or tools [11].For example: painting the rear axle assembly formerly caused certain problems. The whole sequence of difficult operations was performed by two men. A special machine was designed and built for this operation in the Ford factory. With this machine, only one man took care of the entire process, which was carried out in just thirteen seconds. Another example was the manufacture of the radiator that had ninety five tubes, which were fitted and soldered by hand. This was a difficult operation that required time, skill and patience. A special machine was designed that made twelve hundred radiator frames in eight hours. Automatic soldering of tubes was carried out

through a furnace by a conveyor. There was no tinsmith job and therefore no skill was required [11].

In the first four years, with the application of the Scientific Management Strategy and the mechanization of the production, the number of the produced cars was significantly increased. In Figure 4, the reduction of the productive hours per car from 420 hours in 1909 to 150 hours in 1913 could be seen. At the same time, the exponential growth rate of the number of produced cars from 10,666 in 1909 to 170,211 cars in 1913 could also be seen.

Discussions hold on the Taylor and Ford influence on the manufacturing productivity [19] were presented in literature. Taylor improved efficiency in the existing production technologies by, for example, designing ideal tools, such as different shovels. Ford transformed the means of production by the mechanization and simplification of labour processes. Ford's influence was far much more significant. This could be observed by comparing the Taylor system that was applied at the Packard Motor factory with the Ford factory in 1914. In just four days Ford's workers produced more automobiles than Packard in an entire year. Ford's employees surpassed those Taylor's organized by three thousand percent [21].

6 Moving Assembly Line

In the first five years, the assembling of the Model T simply started at a stand on the floor where a car had been put together and workmen brought to it the parts and tools as they were needed. The worker spent more of his time walking about for materials and tools than he did in processing. Often, congestions and stops were also created, because more efficient workers were faster than the slower ones. Ford engineers observed these drawbacks with moving the workers from assembly stand to assembly stand. The accelerated expansion of production made it necessary to invent a system of production that would avoid these problems. Ford engineers came up with the idea by investigating the meat packaging factory in Chicago. In these meat packers cows and hogs were slaughtered, dressed, and packed with the use of machine operated overhead trolleys. They transported hanging carcasses through a line of stationary workers, who were butchered different pieces of the animal. Only 35 minutes for the slaughter and cutting of a bullock was needed. The same job for a skillful slaughterer and his assistant on an American farm would take 8 to 10 hours. In this packing plant, 1,500 to 2,500 steers were killed a day, from 6,000 to 8,000 pigs and the same number of sheep as well [22].

Ford first tried with the experimental assembly of the relatively simple flywheel magneto set. With lots of attempts, mistakes and corrections, the first moving assembly line was installed on April 1, 1913. Previously, the flywheel magneto was assembled by one workman in 20 minutes. In order to adapt this operation to the moving assembly line, it was divided into twenty-nine sub-operations. The tools and the worker were placed in the sequence of the sub-operations so that each component moved on the transport bond at the least possible distance. Such an organized assembly line cut the montage time to 13 minutes and ten seconds. Further experimenting with the speed of transport bond had cut the time down to five minutes. The speed of the conveyor was examined very carefully. The first was set to a high speed of sixty inches per minute. Then it was set to a slow speed of eighteen inches per minute. Finally, the appropriate speed of forty-five inches per minute was determined. It was important that a workman must not be speed up. He should have had enough time, but not a single excessive second.

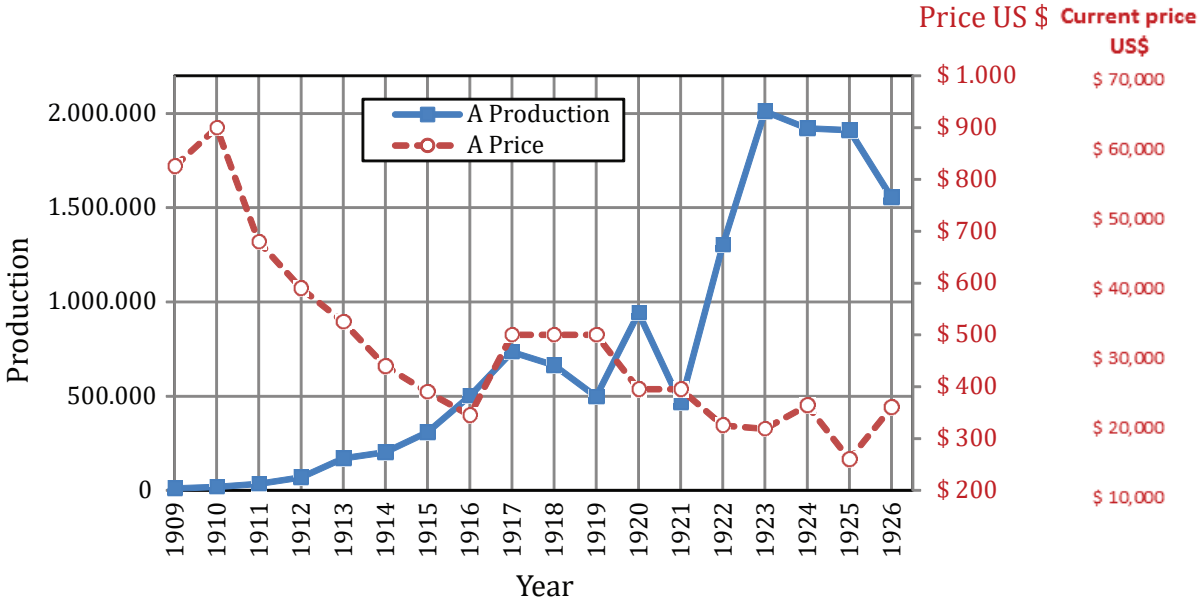


Figure 5 Numbers of Produced Cars per Year and Price of Cars
Source: Authors

This assembly line method proved to be very effective and began to be implemented overall in the Ford factory. Essentially, the same ideas were applied to the assembling of the motor, chassis, body etc. To assemble one motor in October, 1913, nine hours and fifty-four minutes were required. Six months later, by the moving assembly method with eighty-five sub-operations, it required five hours and fifty-six minutes. With a stationary chassis assembly, an average time was twelve hours and twenty-eight minutes. Numerous experimentations, especially the policy of "man-high" work (The high of transport bond that was adjusted to the high of workers on the assembly line) and a further subdivision of the montage in forty-five sub-operations, reduced the labour time to one hour and thirty-three minutes [11].

The strategy of moving the assembly line that was introduced at Ford's Highland Park made the production of the Model T eight times faster. The enormous effects of the moving assembly line were seen immediately and they are still seen today. Every manufactured product, such as a television, telephone, refrigerator, washing machine etc. that the people use today, are available in large quantities at a low price and of a good quality that the Ford's invention made possible. With the help of mass production and especially the moving assembly line, America was industrially and politically placed at the top of the world.

7 Ford's Contribution to Just-in-time (JIT) Production System

Just-in-time (JIT) production, also known as the Toyota Production system, attempts to reduce costs and improve production processes by carefully planning raw materials, supplied parts and own finished products with the principle "only what is needed, when it is needed, and in the amount needed." According to this production philosophy waste, inconsistencies, and unreasonable requirements are eliminated, which results in an improved productivity [23]. It is generally accepted that Toyota's industrial engineer Taichi Ohno has developed the JIT system and build the Toyota's impressive growth into a world prominent manufacturing company. But, what is not well known is Ford's contribution to the JIT system. Toyota's leaders visited Ford's factories in the thirties and the fifties of the last century in order to study their production system. Ohno repeatedly pointed out that he learned it all from Ford's book "Today and Tomorrow" [24]. If we analyze all factors which comprise the JIT production, we can conclude that Ford applied them almost sixty years before the Toyota Motor Company. Kiichiro Toyoda, who founded Toyota Motor Co., visited the Rouge Works in 1929. In early 1950, Eiji Toyoda, the president of the Toyota Company visited the Ford Rouge complex in Dearborn, Michigan. He said: "It may have been the most valuable plant tour of all time..." It showed a great similarity between the Ford's productions in the early 20th century with the today's productions of the Japanese Toyota. The production of the Model T in Highland Park had a very favorable ratio of indirect to direct labour hours of 1 to 1. Toyota, which is now one of the best organizing firms in the world, has today the same ratio of 1 to 1. To make a comparison: today, the modern American production is nearly at a ratio of 8 to 1 while the Japanese production is at the ratio of 4 to 1 [21].

In December 1920, the Ford Motor company did have great financial problems. Between January 1 and April 18, 1921, Ford had to pay for different obligations US$ 58,000,000 (US$ 3,714,958,000). He had only US$ 20 million in the bank and would have to get the additional US$ 38 million.

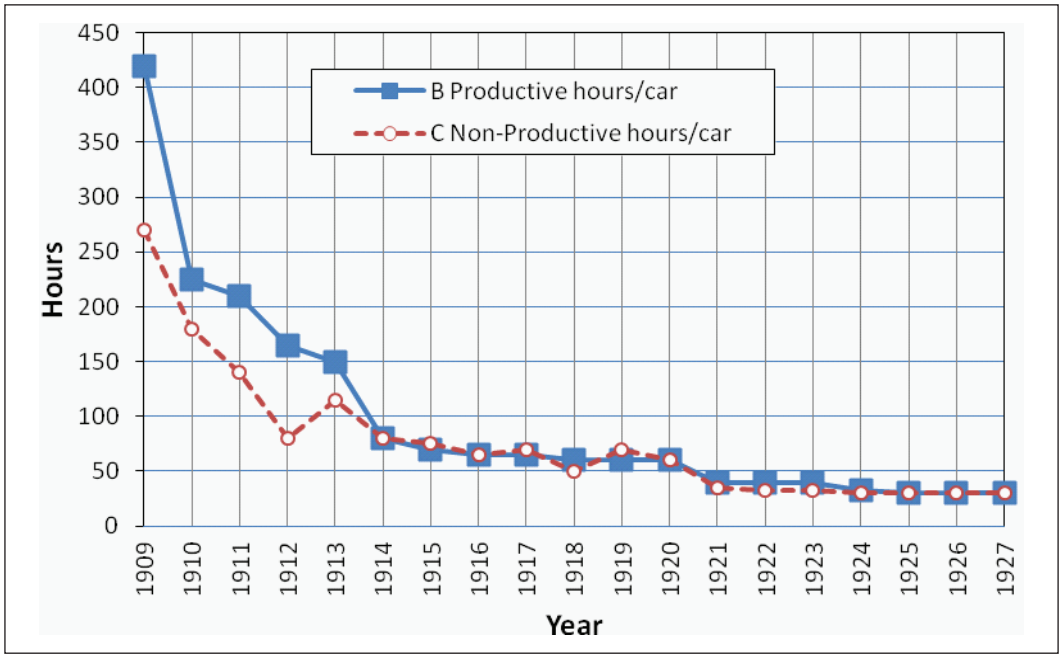


Figure 6 Productive Hours per Car and Number of Produced Cars from 1909 to 1927 [21]

Table 1 Obligations and Savings from December 1919 to April 1920 [11]

Obligations US$ millions			**Savings US$ millions**		
Bank debt due to stock interest	33	(2,112.00)	Surplus stocks	24,7	(1,580.80)
			Speeding up transit	28,0	(1,792.00)
Income taxes due to the Government	18	(1,152.00)	Collected from agents	3,0	(192.00)
			Sale of by-products	3,7	(236.80)
Usual bonus in 1919 to the workmen	7	(448.00)	Sale of Liberty Bonds	7,9	(505.60)
Total	**58**	**(3,712.00)**		**67,3**	**(4,307.2)**

Instead of borrowing money from banks, he decided to reorganize the company in order to reduce costs and increase revenue. Any costs that did not contribute to the production were eliminated, all surplus stocks and by products sold, freight transports accelerated and other measures undertaken. Before the restructuring, the Ford employed fifteen men per car per day. Afterwards, nine men were employed per car per day. The office staff was cut in half the number and they were offered a better job in production. It was the rule that everything and everybody must produce or have to go out. Previously, there was one foreman on five workers and afterwards, one foreman on twenty workers. The overhead expenses were reduced from US$ 146 (US$ 9,351) per car to US$ 93 (US$ 5,956) per car. In that time, Ford produced 4,000 cars per day, thus realizing enormous savings in overhead expenses. The elimination of waste was important, but the most important factor was the speeding up of transport by buying the Detroit, Toledo, & Ironton railroad (see Table 1). All these measures resulted in a total profit of US$ 67,300,000. On April 1, Ford eliminated all obligations and earned an extra of US$ 9,300,000 (US$ 595 million) [11].

8 Ford's Vertical Integration

In the first years of the production of the Model T at the Ford's Piquette Avenue assembling plant, almost all parts were purchased from external suppliers and were very expensive. On average, two thirds of the total component price fell to earnings and inefficient production of external suppliers. When Ford moved production to the Highland Park Ford, most of the Model T's components were manufactured in-house. Between 1909 and 1916, the price of raw materials and manufactured components bought elsewhere dropped by half from US$ 590 (US$ 37,760) to US$ 262.29 (S$ 16,786.56) per car. Furthermore, the remaining suppliers were forced to lower the prices or risk losing their contracts with the Ford. The Piquette plant had only eighteen departments, but the Highland Park had five hundred departments. That illustrated clearly how far the Ford Company did come in the manufacture of parts. Ford claimed that his vertical integrated strategy was the single most important factor for his success. Ford was famously quoted as saying "if you want it done right, do it yourself" [25].

By the 1920s, Ford had purchased iron-ore mines in Michigan and Minnesota, coal mines in Kentucky, acres of timberland, a rubber plantation in Brazil, a fleet of ships, the Detroit, Toledo, and Ironton Railroad and more. These achievements in the vertical integration assured the Ford's company that they would have raw materials and parts when they were needed, guaranteeing a continuously production and higher profit [11]. Ford claimed that when, at 8 o'clock, just enough ore for the day would arrive to the River Rouge facility, after exactly 28 hours, this ore would emerge as finished automobiles. The ore was brought from the Ford-owned mines, transported by the Ford-owned rail and transformed into steel with heat supplied by coal from the Ford Kentucky mines.

Due to serious transportation problems with the Detroit, Toledo & Ironton Railroad, Henry Ford purchased it in 1920. In that time everybody was dissatisfied with this railroad. The railway fleet was in a very bad condition and a large part of it could not be used at all. The railway line looked like a bunch of old rusty iron, which could not be used in large part at all. All the buildings were in poor condition. In the maintenance departments too many employees worked and they were poorly equipped with machinery. There was a large executive and administrative department with, as usual, a huge unnecessary legal department. Only the monthly expenses of the legal department exceeded US$ 18,000 (US$1,152,000). Ford invested US$ 15 million (US$ 960 million) in the railroad reconstruction and begun to apply industrial principles. It is worth to emphasize that Ford's policy was that not one cent had been borrowed and everything was built out of profits from the Model T. The most important improvements were general cleaning up of the ways, buildings and premises, placing of new stone or slag ballast, new creosoted ties, new rails and other tracks, ditching, bank widening, bridge and culvert improvements, double-tracking of several miles of line near Detroit, rebuilding of locomotives, wagons, machinery and buildings, the removal of obsolete buildings, purchase of new locomotives, wagons, machinery, etc. Following Ford's policy, all titles and offices, except those prescribed by law, were eliminated. The number of employees was reduced from 2700 to 1,650 by eliminating all unnecessary workers and all unnecessary administration. The minimum payroll of the employee was raised to US$ 6 (US$ 384) for an eight- hour working day.

All these above mentioned measures resulted in a triple higher efficiency of all employees and made the DT&I railway profitable. Before that, the DT&I railway took 8 to 9 days to get the freight from Detroit to Philadelphia or New York. After the reorganization of the DT&I railroad, it took three and a half days [11].

9 Ford's Relationship with His Employees

Ford claimed: „Every business that employs more than one man is a kind of partnership. It is a reciprocal relation; the boss is the partner of his worker, the worker is the partner of his boss." On January 5, 1914, Henry Ford announced that he would raise the minimum salaries to US$ 5 (US$ 320) a day for 8 hours of work and would give to the employees of the company US$ 10,000,000 (US$ 640 million) of the profits of the 1914 business. The news caused that more than 10,000 people came next morning at the Highland Park plant to look for jobs. The previous minimum wage was US$ 2.34 (US$ 150) for nine hours of work. Today, the average pay for an assembly line worker in the American automotive industry is US$ 130.88 per day [26]. The main reason was a desire to ensure a stable work force. As the work was monotonous, the turnover rate was close to 400% in 1913. Some workers simply walked away from the production line so that the line was blocked and the production of cars stopped. The training time of the labour forces was also expensive. Ford wanted to run the factory continuously for 24 hours in three shifts of eight hours each, instead of only eighteen hours a day. At the time fifteen thousand employees were at work in the Detroit factories. By the introduction of the eight-hour shift, four thousand more workers were employed. In the article published on the front page of The New York Times on January 5, 1914, Henry Ford stated that "movement toward the bettering of society must be universal" and his company can make a start and create an example for other employers. After introducing these innovative measures, Ford picked up a lot of criticisms and sceptics from its "expert" contemporaries. However, time showed that the rate of labour turnover fell from 400% in 1913 to 16% in 1915, that the number of cars produced increased from 170,211 in 1913 to 501,462 in 1916 and that profits doubled to US$ 60 (US$ 3,840) million from 1914 to 1916. At the same time the price of the Model T decreased. For example, the price of the Runabout in 1913 was US$ 525 (US$ 33,600), but in 1916 it was US$ 345 (US$ 22,080) [11].

The minimum salaries of US$ 5 (US$ 320) a day for 8 hours of work was applied to female workers in 1916. In 1919, Ford increased again his minimum wage, this time to US$ 6 (US$ 384) a day [11]. This wage enhancement resulted also in a lot larger production numbers. In 1926, the Ford Motor Company pioneered in the implementation of a five-day and 40-hour working week for workers. Soon after followed the Ford's lead companies all over the U.S.A. and the world, and the Monday-to-Friday working week became a standard practice.

In the Ford's factories, the culture of an individual responsibility was created. The worker should have known what was going on within his competence and was completely responsible for his work. The supervisor was responsible for the workers under him. The foreman was responsible for his personnel. The department head was responsible for the department. The managing director was responsible for the whole factory. There were no titles and no limits of authority. Each worker could talk to each of the superiors and go directly to the factory manager. If one of the superiors was unjust to the worker, it was quickly revealed and he was soon removed from that position. No one superior in the Ford Company had the power to discharge a worker. If the worker did not do a good work, he got an opportunity to try to make good in other departments. The worker could be released only when he repeatedly, in other workplaces, showed dishonesty and inability. Ford paid special attention to handicapped people. He employed handicapped workers from the community wherever possible. An analysis of the employed at his factory showed that there were 4 totally blind men, 207 blind in one eye, 253 with one eye nearly blind, 37 deaf and dumb, 60 epileptics, 4 with both legs or feet missing, 234 with one foot or leg missing, 123 had crippled or amputated arms, forearms, or hands and one had both hands off [11].

Ford's vision, obsession, design and construction skills, and his patents gave him a significant advantage over his rivals in automotive production. But, perhaps the best of his qualities was to recognize the best men for particular jobs, which under his leadership created such a tremendous success. They invented thousands of improvements, which resulted in more efficient, cheaper and massive production of the Model T. The Ford team constantly upgraded each component and each step of the production in order to make it better and cheaper. The most noticeable innovation was the moving assembly line, but it was only one of many.

10 Discussion

Henry Ford was the first of the five children born to Irish immigrants in 1863. He reached to be ranked seventh on the list of the richest men in the history of mankind, while in popular polls in that time, he was ranked as the third greatest man: just below Napoleon and Jesus Christ (27). From a young age he was a thinker and showed interest in mechanical engineering technology. In his biography, he stressed that in those early days the greatest event was a meeting with the Nichols & Shepard Co. road steam engine. From that time, his great interest has been in making a machine that would travel the roads. The second great event was when he got a watch. With thirteen years he could quickly disassemble and reassemble a watch. In that time, he wanted to make something in quantities. He thought that he could build a suitable watch for around thirty cents (US$ 19). But he concluded that people would not buy it in sufficient quantities to make the idea profitable (biography). He believed, in that time, in the new inter-

nal combustion engine. Despite all the "wise" people who conclusively claimed that this engine could not compete with steam engine.

Carmaker Henry Ford introduced a series of technical innovations to the automobile construction: vanadium steel, flywheel magneto, separate cylinder head and block, planetary transmission, fully enclosed powertrain, three-point suspension, platform based construction, etc. He introduced a series of production management innovations to the automobile manufacture, which we call today: moving assembly line, Just in time and lean production, vertical integration, dual relationship with its suppliers and end consumers, knock-down kit concept (throughout the U.S.A. 35 assembling factories were established and in 22 of them parts are also manufactured), establishment of production and assembly factories in different foreign countries (he had successful dealerships on six continents in 1928), establishment of small production facilities (the Village Industries), etc. Fifty years after the Ford's time, Robert M. Solow, the 1987 Nobel laureate in economics, proved that a new technology – widely described as the implementation of new knowledge to the production process – is chiefly responsible for expanding the national economy over a long period, even more than increases in labour or capital [28]. During Henry Ford's life time, America was entirely changed to the better. Much of these transformations came about as a result of his technical and production innovation, which enabled him to realize his vision of producing a cheap, high quality car for the masses.

Ford had a special employer/employee relation. He considered that each employee was a partner in his company. In 1914, he paid more than double the minimum salary in the automotive industry, which was increased from US$ 2.32 to US$ 5 per day, while at the same time the working time was reduced from 9 to 8 hours; in 1919 he increased his minimum salary to US$ 6 per day, and in 1926 he was the first who introduced the five-day working week. Very soon, all other employers in America and the world had to follow his relationship with the workers. He also decided to give to the employees the share of the profits of the company business - in 1914, US$ 10 (US$ 640) million bonus and even in hard time, in 1919, US$ 7 ($448) million. Women, blind, and physically disabled people, especially veterans have had employment opportunities that they would not have had elsewhere. His concern for workers' wellbeing went beyond their salaries. He founded the social department, schools, hospitals, etc. In the early history of the Ford Motor Company the Social Department was established, which promoted social values to their, mostly immigrant, workers. Non–native speakers of English could receive free English lessons. They were directed towards the American way of life, family values, thrift, temperance, diligence, loyalty, etc. Workers diet, dress, mannerism, living conditions, sleeping arrangements, cleanliness, living space for children, abstention from alcohol, smoking, card, betting and domestic squabbling were closely monitored by the Social Department. People were so proud that they were the Fords employees that they would wear the Ford badge to pub and church [29].

Ford have had a special relation to purchaser, he claimed that every Ford's customer should be provided with the best service. The Ford's aim was to provide customers with a low price and an impressive quality of the Model T. The price reduction was in the first place. Ford argued that the reduction in price, with the same or better quality of products, will considerably increase the possible number of purchasers. That means less profit per each car, but more employment and all the total profit would be larger. For example, Ford figured out that they had 500,000 buyers of cars on the US$ 440 (US$ 28,180) basis, but on the US$ 360 (US$ 23,040) basis they will increase the sales to possibly 800,000 cars per year. It is worth to note, that during one year the Ford's profit was so much larger than they expected, so that they voluntarily returned fifty dollars to each purchaser of a car [11]. Business experts told to Ford that a good and clever business is one that must force people to buy frequently and that a business that creates products that last for a long time is a bad business. The Ford's principle of business was completely the contrary. He wanted to construct such a car that will last forever. He wanted the man who bought one of his products to no longer need to buy another one. Ford also demanded that, in spite of the fact that his car models frequently changed and improved from year to year, all spare parts could be replaced not only with other cars of the same model, but with all other cars they have produced as well.

Henry Ford was personally involved with a trade school and a hospital. He proved that such institutions, which were commonly regarded as benevolent, could be made self-sustaining. The school was incorporated in 1916 as a private school for boys between the ages of twelve and eighteen, which have to take a hard test to get in. Each boy was awarded an annual cash scholarship of US$ 400 (US$ 25,600) at his entrance. This could be gradually increased to US$ 600 (US$ 38,400) if his results were good. Classes were organized in blocks of weeks - one week in the class and two weeks of practice in the factory. These boys trained to be workers and earned from 19 cents (US$ 12.46) to 35 cents (US$ 22.40) per hour. Students who completed this school received a good general and technical education and gained the skills of good workers [11].

In November 1919, the first private patient was admitted to the Ford Hospital, which was established in a similar way as the Ford's school. Ford invested in a hospital about US$ 9 (US$ 576) million. This hospital was organized to be self-supporting with a purpose to give a maximum of service at a minimum of cost and without any kind of charity. Each floor was complete in itself. Like in a Ford's factory, the hospital was designed in such a way that any unnecessary motion was eliminated. The rooms, which were in groups of twenty-four, were all identical in size, fittings, and furnishings. All rooms were private and each one had a bath. There was no protection for anyone and every patient was equal to every other patient. In that

time diagnosis was not very much developed. Therefore, a routine for a correct diagnosis was organized. The incoming patient was first examined by the senior physician and then was routed for examination through three, four or, if necessary, a greater number of doctors. Finally, absolutely complete and absolutely independent diagnoses were analyzed by the head of the hospital. The fee for the patients for the room, care and treatment was US$ 4.50 (US$ 288) per day and for a complex operation the price was US$ 125 (US$ 8,000). The hospital had a management, similar to the Ford's factories one, which provided a complete service at prices so low that they were affordable to everyone. Ford built an enormous public interest to ensure every newspaper carried stories and advertisements about the Model T. Henry Ford was often on the cover of the most famous newspapers and magazines not only for his business moves but also for his famous trials and other stories. He used it all for advertising and marketing purposes of his products [30].

One of the remarkable characteristic of Henry Ford was that he shared knowledge to others car producers. For years, the world's executive leaders from Toyota, Fiat, Citroen, Renault, Volkswagen etc., visited and freely studied the Ford's famous factory. Apart from the fact that many companies were greatly disadvantageous, if not crippled; by knowledge loss there are many beneficial reasons to share expert knowledge. Cherbel [31] summarized these reasons as: helps company grow, helps company stay motivated, getting top talent access, recognition, generating new ideas, future leaders' discovery, limiting the skill gap, team cementing and silo breaking, sense of purpose, operational efficiency, etc.

Henry Ford was the most important person in the last century, who influenced the creation and emergence of a whole new economic class - the American middle class and the American way of living. We can today show our appreciation for what he has done and we have to admit the affect that Henry Ford has had on our society and on each of our personal lives. Many of the ideas developed by Henry Ford and his employees are valuable to be reconsidered for their practical use today.

11 Conclusion

Henry Ford was the first of the five children born to Irish immigrants. From a young age he showed interest in mechanical engineering technology. He reached to be ranked seventh on the list of the richest men in the history of mankind, while in popular polls, in that time, he was ranked as the third greatest man: just below Napoleon and Jesus Christ.

The carmaker Henry Ford introduced series of technical and production management innovations to the automobile manufacture. This new technology was chiefly responsible for expanding national economy and caused that the U.S.A. was placed at the top of the world nations.

Taylor improved efficiency in the already existing production. Ford transformed the means of production by mechanization and simplification of the labour processes. The Ford's influence was far much more significant. The Ford's employees surpassed those that Taylor organized by three thousand per cent.The strategy of moving the assembly line that was introduced at the Ford's factory made the manufacture of the Model T eight times faster.

The production of the Model T had a very favorable ratio of indirect to direct labour hours at the ratio of 1 to 1. Toyota which is now one of the best organizing firms in the word has today the same ratio of 1 to 1. Today, the modern American production is nearly at the ratio of 8 to 1 and the Japanese one is at the ratio of 4 to 1.

Ford claimed that his vertical integration strategy was the single most important factor for his success. Ford was famously quoted as saying "If you want it done right, do it yourself."

Ford had a special employer / employee relation. He considered that each employee was a partner in his company. He paid more than double the minimum salary in the automotive industry and decided also to give to the employees the share of the yearly profits of the company business.

Ford had a special relation with purchasers. He required that every Ford's customer should be provided with the best service. The Ford's aim was to provide customers with a low price and impressive quality of his vehicles.

Ford proved that with a proper business organization, transportation can be three times more efficient, and schools and hospitals can be self-standing.

Henry Ford was the most important person in the last century, who influenced the creation and emergence of a whole new American middle class. Many of the ideas developed by Henry Ford and his employees are valuable to be reconsidered for their practical use even today.

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