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THE MODEL T

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ABSTRACT

We ask (1) why the United States adopted the car more quickly than other countries before 1929, and (2) why in the United States the car changed from a luxury to a mass market good between 1909 and 1919. We argue that the answer is in part the success of the Model T in the United States and its relative lack of success abroad. Mass production of the Model T began in 1913; by 1917, more than 40 percent of cars on the road were Model Ts. Cross-state and cross-county evidence suggest that the Model T opened up a new market for cars among farmers and in poorer areas of the country. Tariffs and difficulties producing outside Detroit made the U.S. success of the Model T difficult to replicate abroad, even in Canada.

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"I will 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 of hours of pleasure in God's great open spaces." -Henry Ford, likely said some time between 1903 and 1906.[1]

1 Introduction

Between 1910 and 1930, the United States rapidly adopted the passenger car. In 1910, there were fewer than 50 passenger cars per 10,000 people in the United States; by 1930, there were more than more than 1,800.[2] We highlight two facts about the U.S. adoption of the car. First, as illustrated in figure 1, the United States adopted the car more rapidly than other countries.[3] Second, the gap between car adoption in the United States and abroad reflected a transformation of the U.S. car market in the decade between 1909 and 1919. In 1909, the car was a luxury, mostly owned by the rich for leisure and / or to signal social status. In 1919, the car was a mass-market good, owned by many in the middle class and used for practical purposes.

We argue that the rapid adoption of the car in the United States, and in particular the car's transformation from a luxury to a mass-market good between 1909 and 1919 were in large part (though certainly not entirely) a result of the success of Ford's Model T in the United States and its relative lack of success abroad. The Model T was introduced in 1908, began to be mass produced in 1913, and ceased production in 1927. To understand the effect of the Model T on U.S. car adoption, we study aggregate time series, cross-state, and cross-county data on motor vehicle registrations. All point to the conclusion that Model T sales were not simply substitutes

[1]The Henry Ford museum says: "The precise year in which Ford issued the "multitude" statement is not known. Earliest source 6/6/13 Ford Times. Probably said 1903-1906, when expressed same views to associates." See Burlingame (1955) p. 62, and The Henry Ford.

[2]See note to figure 1 for sources.

[3]The figure compares motor vehicle ownership across countries. Ideally, we would compare car ownership rather than motor vehicle ownership. But the classification of motor vehicles into cars versus trucks was inconsistent across countries. U.S. data from the Federal Highway Administration (table MV-201) divides motor vehicles among the categories of cars, trucks, and after 1925, buses. Palgrave Macmillan, ed. (2013a), however, divides numbers for "motor vehicles in use" between "private cars" and "commercial vehicles." The comparison of motor vehicle rather than car numbers likely understates the conclusion that the United States had a large lead in car ownership. Between 1913 and 1929, cars made up 87-95 percent of total U.S. motor vehicle registrations. Abroad, where private car ownership was less, buses and trucks likely made up a larger share of motor vehicles.

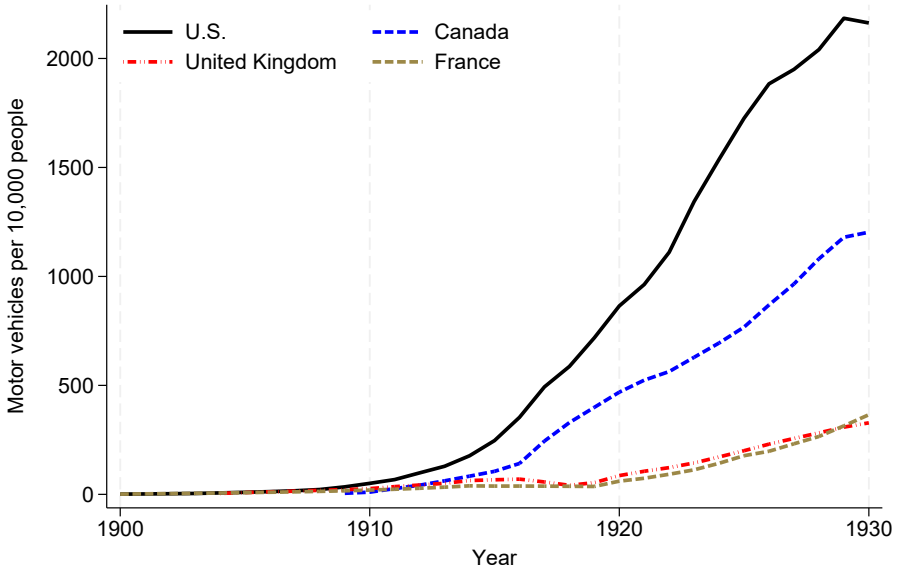


Figure 1 – Sources: U.S. motor vehicle registrations are from the Federal Highway Administration, Highway Statistics, table MV-201; U.S. and France population is from Bolt et al. (2020). UK and France vehicles are from Palgrave Macmillan, ed. (2013a). Palgrave Macmillan, ed. (2013a) provides no data on commercial vehicles in France before 1920; in order not to underestimate the total number of vehicles in France, we estimate the number of commercial vehicles pre-1920 by assuming that the ratio of commercial vehicles to private cars was the same in each year before 1920 as it was in 1920. UK population is from Palgrave Macmillan, ed. (2013b). Vehicle and population data for Canada are described in appendix A.

for sales of other cars: the Model T expanded the market. Much as the iPhone transformed the smartphone from a niche device to an everyday item, the Model T popularized the car.[4] But unlike the iPhone, the diffusion of the Model T outside the United States was limited. It was limited not because foreign consumers disliked the Model T; rather, success abroad was limited because the Model T cost roughly 20 to 130 percent more outside the United States.

Of course, the importance of the Model T for U.S. car adoption is well-known. Not only have many scholars (though few economists) written about the Model T, its popularity made it a cultural icon. Our work is in part inspired by the recent argument for the importance of the Model T made by Gordon (2016). Gordon (2016) writes (p. 165): "[B]y far the most important reason for the rapid diffusion of automobile ownership through 1929 was the rapid decline in prices, an achievement largely brought about by Ford's Model T and unmatched in any other nation." Relative to Gordon (2016) and prior observers of the auto industry, our contributions are: (1) the quantitative documentation of the U.S. car adoption lead pre-1930; (2) our use of state and newly-collected county data to document the change in the car from a

[4]We are not the first to see an analogy between the Model T and the iPhone. See, e.g., Stratechery.

luxury to a mass market good between 1909 and 1919; and (3) our use of state and county data to document the Model T's appeal to a new segment of the market; (4) our use of newspaper advertisements to show that in 1914 and 1922 the Model T cost 20-130 percent more outside the United States.

We begin in the next section by examining cross-country data on the adoption of the motor vehicle relative to the adoption of the telephone and the radio. There were two unusual features of the motor vehicle's diffusion in the United States. First, while the United States led the world in telephone and radio adoption, the U.S. lead in motor vehicle adoption was much larger. In 1929, for instance, Germany had 30 percent of the U.S. level of telephones per capita, but only 4 percent of the U.S. level of motor vehicles per capita.[5] Second, the gap between motor vehicle adoption in the United States and abroad generally stayed the same or grew from 1913-29 whereas the gap between U.S. and foreign telephone adoption shrank. We focus particularly on the comparison to Canada, given Canada's many similarities to the United States. Canadian provinces generally had only about half the cars per capita of adjacent U.S. states; e.g., in 1919 Manitoba had fewer than half as many cars per capita as North Dakota.

The unusually large U.S. motor vehicle (primarily car) ownership lead reflected a transformation of the U.S. car market between 1909 and 1919. In section 3, we look at the association between income, population density, and literacy with car ownership. In 1909, the cross-state elasticity of car registrations per capita with respect to income is well above one and there is little correlation between population density or literacy and car ownership. By 1919, the income elasticity of car ownership had dropped to well below one, and there is a strong negative relationship between car ownership and population density and a positive relationship between car ownership and literacy. These results are consistent with narrative evidence suggesting a change in the car from a luxury good purchased by the rich, often in urban areas, to a mass market good purchased in large numbers, in particular, but far from exclusively, by farmers. County data in California for 1907 and 1921 corroborate this finding. In 1907, the largest number of motor vehicles per capita in California were in and near San Francisco and Los Angeles. In 1921, the car remained popular in and around Los Angeles, but most of the California counties with the largest number of vehicles per capita were in the rural central valley.

In section 4, we begin our argument that the model T helps to explain the U.S. car adoption

[5]For sources, see the note to table 1.

lead and the transformation of the U.S. car market between 1909 and 1919. We describe the history of the Model T's production and pricing. The Model T was revolutionary not only because of the mass production methods used to produce it, but also because of Ford's unusual decision to design a cheap, basic car to appeal to a mass market. The raw number of Model Ts on the road strongly suggest that it contributed to the large number of cars in the United States; by 1922, 47 percent of all cars in the United States were Model Ts (*Automotive Industries*, 9/6/1923, p. 481).

We turn to cross-sectional data in section 5 to better understand who bought Model Ts. We expect that the Model T added to total car sales by appealing to a distinct set of consumers. We test this implication with cross-state and cross-county data. Cross-state data show that the first few years of Model T sales (1909-13) coincided with the beginning of a large gap in the speed of car adoption between urban and rural states, with rural states starting to adopt cars more rapidly when the Model T was introduced. County data on Model T ownership fits with these results. They show that the Model T made up a larger share of cars in rural areas of the country, consistent with the Model T opening up a market for cars among farmers.

In section 6, we turn to the barriers faced by Ford to selling large numbers of Model Ts abroad. Difficulties were varied, including tariffs and expensive local production. These difficulties reduced sales of the Model T in part by increasing the Model T's price. To document the difference between the Model T's price in the United States and abroad, we collect car prices from newspaper advertisements in 18 countries in 1914 and 13 countries in 1922. These advertisements show that the Model T cost roughly 20 to 130 percent more outside the United States.

1.1 Previous literature There has been surprisingly little work by economists on the adoption of the car. We have already mentioned Gordon (2016) who reviews the history of pre-1940 car adoption in the U.S (chapter 5). He emphasizes the importance of the Model T in lowering prices and in appealing to farmers, and he also discusses the dramatic effect on daily life of the car. The results in our paper support the arguments in Gordon (2016), but we go beyond his work by using cross-sectional data to document the U.S. lead in car adoption and the role of the Model T in maintaining the U.S. lead.

Cheng, Crucini, Oh, and Yilmazkuday (2019) are, like us, interested in understanding variation in the speed of car adoption across countries. They explore the effect of trade barriers and income differences, concluding that higher prices for cars abroad explain the majority of the U.S. car adoption lead before the Second World War. While their emphasis on car price differences between the United States and abroad mirrors ours, they do not discuss the Model T. Also closely related to our work are a pair of papers on the pre-World War Two auto industry, Raff (1991) and Raff and Trajtenberg (1996). Raff (1991) provides useful background on Ford's unique competitive position, arguing that it was not until 1926 or 1927 that Chevrolet was able to roughly match Ford's unit costs. Raff and Trajtenberg (1996) document a large decline in the quality-adjusted price of cars before the Second World War. While they note the significance of the Model T's uniquely high quality to price ratio, the Model T is not their focus.

Outside economics, historians have done descriptive work on the causes and consequences of car adoption, often focusing on specific regions. Brilliant (1989) focuses on the history of the car in southern California in the 1920s, for instance, while Davies (1987) looks at the history of the car in Ontario, Canada. While interested in similar questions, we differ from this prior work in history with our focus on quantitative measurement. More similar to our work than is that by historians, the sociologists Fischer and Carroll (1988) use cross-state data to quantitatively compare the diffusion of the telephone and the car in the United States before World War II.

Our work is also related to the large literature in economics on technological progress. A long-standing literature in economic history looks at the sources of U.S. technological leadership, specifically in mass production. Nelson and Wright (1992) and Hounshell (1985) use the auto industry and Ford in particular as an example of this leadership. We add to this history by showing the consequences of U.S. mass production for car prices and car adoption. More abstractly, much work on the adoption of new goods focuses on so-called internal drivers of adoption, such as social learning. Young (2009), for instance, looks at how social dynamics determine the speed of adoption of an unchanging technology. Our work, by contrast, shows how a so-called external development, in this case a cheaper car, changed the adoption process. We expect that the dynamic in which a technology starts to diffuse, and then external developments accelerate the adoption process, may be common. As already noted, the iPhone is contemporary example.

Within the economic history literature on technology adoption, our work can be compared to that on the diffusion of the tractor. The comparison to the tractor shows both the importance and the difficulty of studying the car. Understanding the diffusion of the tractor on U.S. farms has been a classic concern of economic history,[6] and work on the tractor has been motivated by its large role in U.S. economic history. Olmstead and Rhode (2001) note that the tractor "[w]as one of the great labor saving innovations of the twentieth century," replacing the labor of 1.7 million workers (table 7, p. 692). Yet, the car likely changed the economy more. Certainly this is implied by farmers' spending. Farmers spent more than twice as much on cars (excluding trucks) between 1910 and 1939 as they did on tractors. In all but two years between 1910 and 1939, farmers' spending on cars exceeded farmers' spending on tractors (U.S. Department of Agriculture, 1940, Table 1, p. 3). And farmers were only a minority of car purchasers, so total spending on cars far exceeded that on tractors.[7] The tractor transformed agriculture, but it had little direct effect on the rest of the economy. By contrast, it is difficult to find a sector of the U.S. economy unaffected by the car. Production of the car transformed manufacturing; the use of the car transformed the housing market and the retail sector; and cars transformed rural life.[8]

Despite the car's greater importance, there is a good reason why economic historians have written extensively on the tractor and almost nothing on the car. The more limited use of the tractor makes it easier to study. The tractor had one use: to produce farm products. Thus its adoption can be studied as the solution to a producer's cost minimization problem. The result is a set of well-posed questions, such as whether the cost characteristics of the tractor versus the horse made the tractor more suited for large farms (Olmstead and Rhode, 2001). By contrast, cars were purchased by both businesses and consumers, for an almost limitless number of uses, including the transportation of goods (e.g. from a store to a residence), commuting, and recreation. Thus the determinants of consumers' car purchase decisions are largely unobservable. This general difficulty in understanding car adoption makes the Model T useful to study, since the Model T was a largely exogenous shock to the type of car available to consumers.

[6] See, e.g., Griliches (1960), Olmstead and Rhode (2001), Manuelli and Seshadri (2014), and Gross (2018).
[7] In 1924, for instance, roughly one third of cars were owned by farmers (McKee, 1924).
[8] The content and some of the wording of this paragraph draw from Eli, Hausman, and Rhode (2022).

2 The United States adopted the car unusually quickly

Our interest in the Model T is motivated by our wish to explain the rapid U.S. adoption of the car. To see whether U.S. car adoption was unusual, we compare the adoption of the motor vehicle to the adoption of the telephone and the radio in the United States and abroad.[9] Such a comparison is necessarily inexact; while motor vehicles generally had to be registered, registration was less often required for telephones and radios. Still, the comparisons below paint a consistent picture of anomalously rapid U.S. adoption of motor vehicles. U.S. motor vehicle adoption was anomalous in the sense that the gap between motor vehicle adoption in the United States and abroad was much larger than that for the telephone and radio, and in the sense that the gap between U.S. and foreign vehicle ownership levels generally held steady or grew between 1913 and 1929 at the same time as the gap in telephone ownership shrank.[10]

Table 1 shows per capita motor vehicle, telephone, and radio ownership in twelve countries in 1913 and 1929. The twelve countries include the nine countries for which Palgrave Macmillan, ed. (2013a) reports motor vehicle and telephone ownership in 1913 and 1929, and radio ownership in 1929. (We cannot look at radios in 1913, since there were few radios in use before the early 1920s.) We have not located data on motor vehicle ownership in New Zealand and Australia in 1913, but we include them in table 1 since they had the most motor vehicles per capita in 1929 after the United States and Canada. Despite its lack of radio data, we also include France given its importance as a center of the very early auto industry. Per capita ownership in table 1 is expressed as a share of the U.S. level. The 39 percent for motor vehicles in Australia in row one, for instance, means that per capita ownership of motor vehicles in Australia in 1929 was 39 percent of the U.S. level.

We conclude from table 1 first that in both 1913 and 1929 the United States had a large lead in motor vehicle ownership. Australia, Canada, and New Zealand were closest to the United States, but they still had only about half the number of motor vehicles per capita. Europe was much further behind, with less than 15 percent of the U.S. level of per capita vehicle ownership. The exception is the UK, which had more than a third the U.S. level of motor vehicles per capita in 1913. Second, in 1929 the United States had a larger lead in motor vehicle ownership than

[9] As in figure 1, ideally we would compare car ownership rather than motor vehicle ownership. See footnote 3.

[10] Here and throughout this section "ownership" means the numbers of motor vehicles, telephones or radios in use. For U.S. motor vehicle data, it means the number of registered motor vehicles.

Table 1 – Share of U.S. per capita number in use (%)

	Motor vehicles		Telephones		Radios
	1913	1929	1913	1929	1929
Australia		39	23	47	43
Canada	48	54	60	82	34
Denmark	7	13	39	60	86
France	19	14	8	15	
Germany	8	4	22	30	52
Italy	4	3	2	6	4
Japan	0	1	4	6	15
Netherlands	5	6	13	22	43
New Zealand		54	33	67	43
Norway	2	7	37	42	33
Switzerland	11	8	26	41	25
UK	36	14	17	25	71

Notes: Radio data are for 1930 in Australia, Japan, the Netherlands, and New Zealand. Motor vehicle and telephone data are for 1914 rather than 1913 in Denmark and Italy. Sources: Number of motor vehicles, telephones and radios from Palgrave Macmillan, ed. (2013a) and population from Bolt et al. (2020). Exceptions: U.S. motor vehicle registrations are from the Federal Highway Administration, Highway Statistics, table MV-201. Motor vehicles per capita in Canada are as described in appendix A. In 1913 we do not have have commercial car data for France; we estimate the number of commercial vehicles in 1913 by assuming that the ratio of commercial vehicles to private cars was the same in 1913 as it was in 1920, the first year for which Palgrave Macmillan, ed. (2013a) provides data on the number of commercial vehicles in France. Radios in Canada are from Dominion Bureau of Statistics (1930), p. 692. Telephones in New Zealand in 1913 are from *The New Zealand Official Year-Book, 1913*. Telephones in Australia in 1913 are from Commonwealth Bureau of Census and Statistics (n.d.), table no. 62, p. 45.

it did in telephone or radio ownership. Each of the twelve countries in the table had a level of telephone ownership closer to the U.S. level than their level of vehicle ownership. Denmark, for instance, had 60 percent of the U.S. number of telephones per capita in 1929, but only 13 percent the U.S. number of motor vehicles per capita. Likewise, of the eleven countries in the table with radio ownership data, for nine radio ownership in 1929 was closer to the U.S. level than was motor vehicle ownership. The large lead in U.S. motor vehicle ownership did not simply reflect a general U.S. technological lead. There was something unusual about the United States and the car.

Table 1 also allows us to look at the change in motor vehicle and telephone ownership between 1913 and 1929, years when we would expect to see the impact of the Model T on vehicle ownership. In most countries there was convergence toward the U.S. level of telephone ownership. In the UK, for instance, the per capita number of telephones in use rose from 17 percent of the U.S. level in 1913 to 25 percent in 1929. Motor vehicle ownership followed a different path; most of the countries in the table saw little, if any, convergence to U.S. levels. In the UK, motor vehicle ownership per capita fell from 36 percent of the U.S. ownership level in 1913 to 14 percent in 1929. We take the lack of convergence in motor vehicle ownership as suggestive evidence of a Model T effect: during the years of Model T mass production, telephone ownership was converging to U.S. levels while motor vehicle ownership was not.

An obvious concern is the influence of World War I. It is inconvenient that mass production of the Model T starts in 1913, a year before World War I begins; there are many ways in which World War I might have slowed the adoption of the car in Europe. Indeed, Gordon (2016) attributes the rapid adoption of the car in the United States relative to Europe in part to the impact of World War I (p. 162). To some extent this concern is addressed by the comparison of motor vehicles to telephones and radios. Some ways in which World War I would have slowed motor vehicle adoption would also have been ways in which the war would have slowed telephone and radio adoption. Lower incomes, for example, ought to have slowed the adoption of all three of these new goods. The concern is also mitigated by the consistency of the results in table 1 across countries with varying degrees of involvement in the war. Switzerland was neutral, yet its pattern of ownership looks similar to that of other European countries.

2.1 Canada World War I is only one of many factors that complicates the comparison of motor vehicle adoption in the United States and Europe. A cleaner comparison is between the United States and Canada. Canada's geographic proximity and similarities along many dimensions to the United States make it a natural comparison and make its slower adoption of the car a mystery. Canada was part of World War I from the war's beginning, in 1914. But unlike in Europe, in Canada involvement in the war did not have obvious effects on consumer's car purchases. The number of private cars in use fell in the UK and France during World War I (Palgrave Macmillan, ed., 2013a), but between 1914 and 1918 passenger car registrations in Canada rose by a factor of three. In fact, the percentage increase in passenger car registrations was larger in Canada during these four years than it was in the United States (315 percent versus 234 percent).[11]

We have already seen (e.g., figure 1 and table 1) that Canada had many fewer motor vehicles per capita than the United States before 1930. Figure 2 illustrates the fact again, by comparing cars per capita in Canada to all U.S. states. Canada had fewer cars per capita than most U.S. states before 1930. In 1909, for instance, the first year for which we have data, there were 5 cars per 10,000 people in Canada while there were 33 per 10,000 people in the United States.[12] The relative difference between the two countries shrank between 1909 and 1912 but then remained roughly constant. From 1912-1929, Canada consistently had roughly half the car registrations per capita of the United States.

Lower per capita income is an obvious candidate to explain fewer cars in Canada, since from 1909-29, U.S. GDP per capita was on average about 50 percent higher than Canadian GDP per capita (Bolt et al., 2020). But at best lower income can explain only part of Canada's slower car adoption. In 1909 and 1929, Canada's real per capita income was higher than that in 10 U.S. States. Yet in 1909 Canada had fewer cars per capita than every state except Oklahoma, and in 1929, Canada had fewer cars per capita than every state except Alabama. Income alone cannot explain Canada's slower adoption of the car. Aikman (1926) comes to the same conclusion in

[11] U.S. passenger registrations are from the Federal Highway Administration, Highway Statistics, table MV-201; the source for passenger cars in Canada is as described in appendix A.

[12] Throughout this section, we use data on motor vehicle registrations from the Federal Highway Administration, table MV-201. See appendix A for details on the Canadian data. Unlike in the cross-country comparison above, in the comparison to Canada, we compare passenger car rather than motor vehicle ownership. We do this since the division in the Canadian data between passenger car and truck registrations appears comparable to that in the United States.

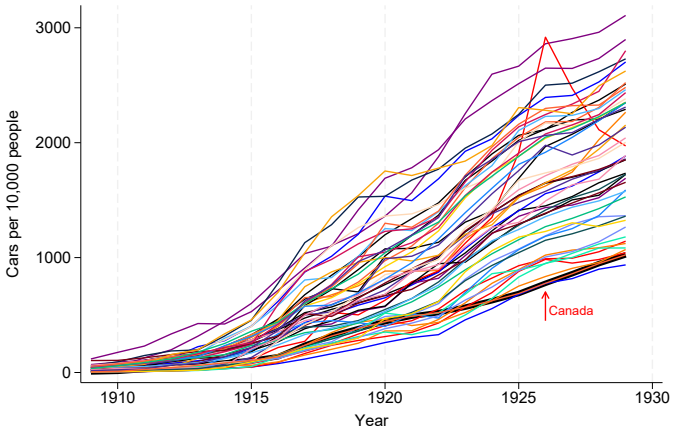


Figure 2 – Note: The thick black line is Canada; the other 48 lines show the number of cars registered per 10,000 people in each U.S. state. Sources: Canada car registrations - see appendix A. U.S. car registrations are from Federal Highway Administration, Highway Statistics, Table MV-201; population data by state and provinces are interpolated between Census years by assuming that population in year t is equal to $pop_c(1+g)^{t-c}$, where c is the closest census before year t, and g is the average annual growth rate of the population between year c and c+10.

Table 2 – Cars per 10,000 people: Canadian provinces and U.S. border states

	1909	1919	1929
Canada	5	382	1024
United States	*33*	*632*	*1883*
British Columbia	15	453	1189
Washington	*43*	*1006*	*2436*
Alberta	10	633	1226
Saskatchewan	4	818	1236
Montana	*19*	*958*	*2153*
Manitoba	17	524	1004
North Dakota	*54*	*1261*	*2383*
Ontario	4	449	1423
Minnesota	*49*	*1011*	*2461*
Michigan	*50*	*787*	*2523*
New York	*26*	*430*	*1528*
Quebec	3	129	507
Vermont	*40*	*692*	*2348*
New Hampshire	*63*	*629*	*2042*
New Brunswick	5	206	692
Nova Scotia	1	194	655
Maine	*37*	*620*	*1859*

Sources: See note to figure 2.

his thesis on the Canadian automobile industry, arguing (p. 44):

> Figures for 1925 show that in Canada there is one automobile for every thirteen persons. Similar statistics in the United States indicate that on the average, one person in every six is a car owner. This difference is, in part, accounted for by the larger per capita wealth and consequently larger incomes of Americans. This is not, however, the whole answer. The main factor is the increased price, resulting in a corresponding restriction of ownership.

Population density is also an unlikely explanation for United States-Canada differences. Canada as a whole has very low population density. The large area of northern Canada, of course, does not rule out the possibility that much of the Canadian population could have been living in relatively dense areas. To see whether a small number of cars in dense areas of Canada can explain low per-capita ownership in the country as a whole, table 2 compares Canadian provinces with neighboring U.S. states. If slow adoption of vehicles in high population density areas (e.g. Toronto and Montreal) explained slow vehicle adoption in Canada as a whole, then we would expect to see large differences vis-a-vis the United States in Ontario and Quebec and smaller differences in more rural provinces. Instead, in all but one case,[13] we see lower car ownership rates on the Canadian side of the border. In most cases, per capita car ownership was more than double on the U.S. side of the border; in 1919, for instance, British Columbia had 453 cars per 10,000 people while Washington state had 1,006; and Manitoba had 524 cars per 10,000 people while North Dakota had 1,261.

2.2 Cross-country conclusions While hardly proof of the influence of the Model T, the cross-country data rules out some other possible explanations for the large U.S. lead in car and motor vehicle ownership. First, the large lead in U.S. motor vehicle ownership did not simply reflect that the United States adopted more of all new goods: the U.S. lead in telephone and radio ownership was much smaller than that in motor vehicle ownership. Second, the cross-country data show that the influence of per capita income on motor vehicle ownership was limited. Even poor U.S. states had more cars than richer European countries. Switzerland in 1929, for example, was richer than Alabama, but it had fewer than 20 percent as many

[13] In 1919, New York state had slightly fewer cars per capita than Ontario.

passenger cars per capita.[14] Finally, we see that the influence of population density on adoption was limited. The United States had a denser population than Canada, Australia, New Zealand, and Norway yet it had far more cars. Manitoba and Saskatchewan were no denser than North Dakota and Montana but had only about half the cars per capita.

3 1909-1919: From luxury to mass-market good

Behind the U.S. car ownership lead in 1929 was the remarkably rapid adoption of the car in the prior two decades. More cars were bought in the decade after 1920 than in the decade before (Eli et al., 2022), but the decade before 1920 is of more relevance for understanding the advent of the car as a mass-market good. In 1909, the first full-year the Model T was available,[15] the car was a rare, luxury good. There were 305,950 cars in the United States, roughly one car for every 300 Americans. In quantity and purpose, cars were similar to yachts today.[16] Like yachts today, a car in 1909 could be used for recreation, and it could signal social status. But like a yacht, it had limited practical use.

The expense of a car explains its limited popularity. The mean price of a car in 1908 was roughly $3000, about $87,000 in 2021 dollars.[17] By comparison, per capita income in 1908 was $317,[18] and annual earnings of a wage earner in manufacturing were $518 (Margo, 2006). Thus a manufacturing worker would have had to work for almost six years while consuming nothing in order to afford the average car. And the few cheap cars that were available tended to be of low quality and limited usefulness. The Brush runabout, for instance, cost $500, but had a wooden axle and solid rubber tires (Flink, 1988, p. 35). The lack of cheap, good cars meant

[14] In 1929, Switzerland's GDP per capita (in 2011 dollars) was $9,920 (Bolt et al., 2020); in Alabama, GDP per capita was $5,929 (for source, see note to table 3). Switzerland had 142 passenger cars per 10,000 people, and Alabama had 936. (The source for the number of passenger cars in Switzerland on 1/1/1930 is U.S. Department of Commerce (1930); we use 1/1/1930 data for cars in Switzerland, since the 1929 figure for cars in Alabama is as of 12/31/1929. The Swiss population in 1930 is from Bolt et al. (2020). For the source for cars per capita in Alabama, see the note to figure 2).

[15] Model T deliveries started on 1 October 1908 (Nevins, 1954, p. 388).

[16] In 2020, there were 587,917 recreational boats in the United States more than 26 feet long, one for every 564 people. So cars in 1909 were a bit less than twice as common as yachts are today. (The number of mechanically propelled recreational boats more than 26 feet long is from U.S. Coast Gaurd (2021), table 37, p. 70; the U.S. population is from the 2020 Census.)

[17] Raff and Trajtenberg (1996) table 2.7, p. 87 report that the average price of car in 1993 dollars in 1908 was $46,640. Converted to 1908 dollars using the CPI series in Lindert and Sutch (2006), this is $2981. Converted to 2021 dollars using FRED series CPIAUCNS this is $87,486. This is the simple average price of the cars in the Raff and Trajtenberg (1996) dataset. A quantity weighted figure would be somewhat lower, but not enough to change the basic conclusion that cars were expensive.

[18] This is nominal 1908 U.S. GNP from Romer (1989), table 2, p. 22 divided by the 1908 U.S. population from Bolt et al. (2020).

the almost complete absence of cars in poorer areas of the United States. At the end of 1909, there were a total of 790 cars in Arkansas, one of every 2,000 residents.

Anecdotes from the time confirm that the car was a luxury good with a limited market. Nevins (1954), pp. 396-397 writes that before the Model T: "For years most farmers had shown a stubborn dislike for automobiles, which scared horses, killed poultry, and sometimes (as Woodrow Wilson noted in a speech made when he first entered politics) flaunted idleness and conspicuous consumption in the faces of hardworking, hard-pinched men." Berger (1980), pp. 30-31 writes: "For the better part of two decades [1893 to 1913], rural America had passively observed the growth of the automobile industry ... [M]ost farmers continued to believe that the automobile was a plaything of the rich and that motoring was a sport. They could see little utilitarian value for the automobile in their own lives." Wik (1972) (p. 17) reports that in 1909 farmers near Sacramento California dug ditches across country roads to stop cars.

Cross-state and cross-county data confirm that cars were a luxury good. Figure 3 shows the number of cars per capita in U.S. states in 1909.[19] The three states with the most cars per capita were California, Rhode Island, and Massachusetts. In every year from 1900 to 1913, California led all other states in the number of cars per capita. California was both wealthy and blessed with climate and topography well-suited to the use of the car, especially for leisure purposes.

Figure 4 shows per capita car registrations in 1919. In 1919, it remained the case that there were a large number of cars per capita in California and a small number in the south. In the rest of the country, however, the geographic pattern of car ownership was transformed. By 1919, the northeast had (relatively) few, rather than many cars. From Kansas north, the Great Plains had many more cars. The three states with the most cars per capita in 1919 were South Dakota, Nebraska, and Iowa.

[19]Data on passenger car registrations by state beginning in 1900 come from the Federal Highway Administration, Highway Statistics, table MV-201. The data documentation include this caveat: "Motor-vehicle and motorcycle registration records of the early years are incomplete and, in some cases, contradictory. The figures in these tables are based on many sources, and necessarily include adjustments and estimates." While unfortunate, potential measurement error is unsurprising, since many states did not require cars to be registered until after 1910. The last state to require registration, Minnesota, did so in 1921 (Highway Statistics, table MV-230). A complication with this and all other registration data involves the day within the year that the data refer too. While the data description is not entirely clear, private communication with the Federal Highway Administration suggests that these figures are as of 31 December. Thus we match car registrations in year t to Census population in year $t+1$. For this reason we focus below on car registration in the years 1909, 1919, and 1929 (i.e. registrations as of 12/31/1909, 12/31/1919 and 12/31/1929), since in these years we have exact Census population figures.

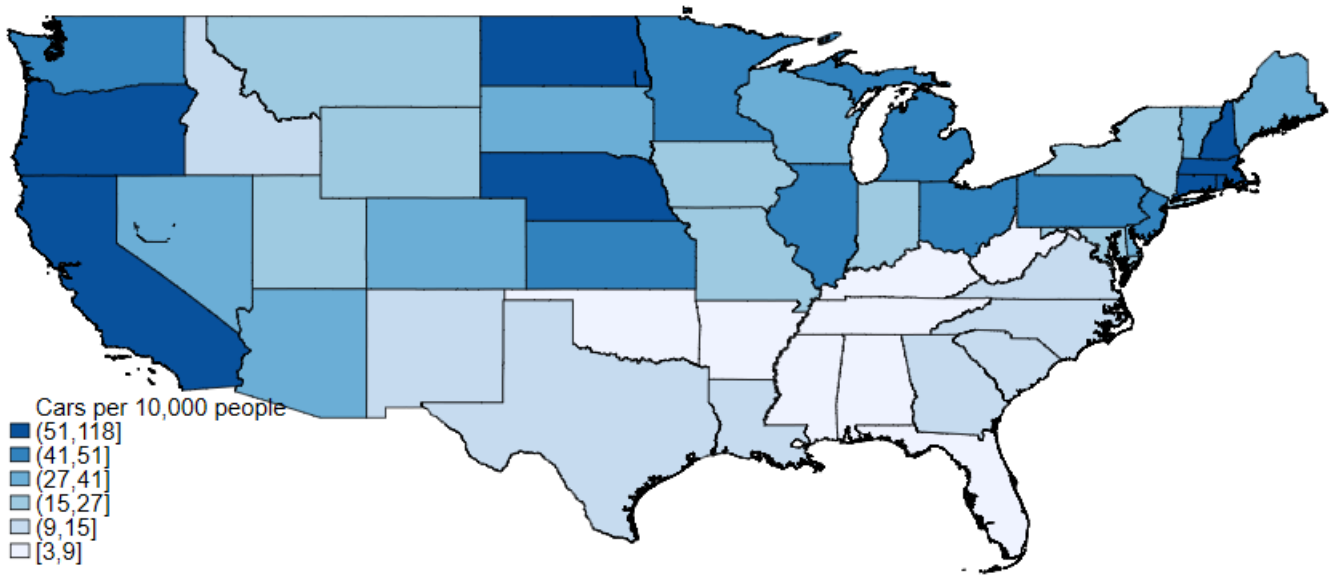


Figure 3 – 1909 Sources: See footnote 19.

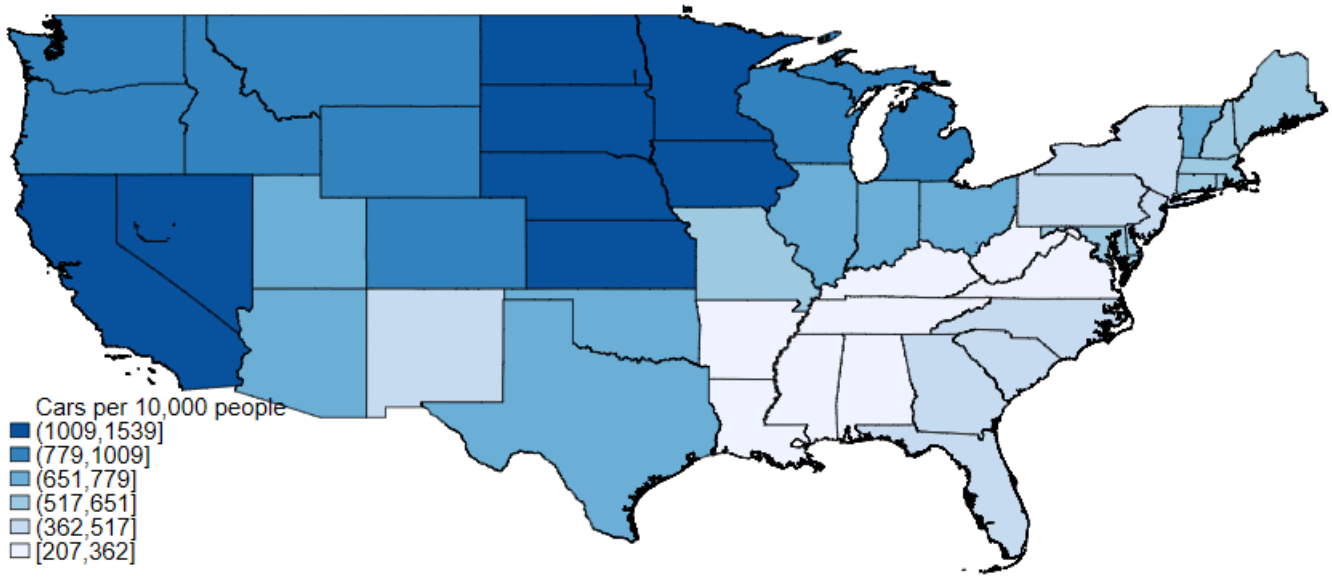
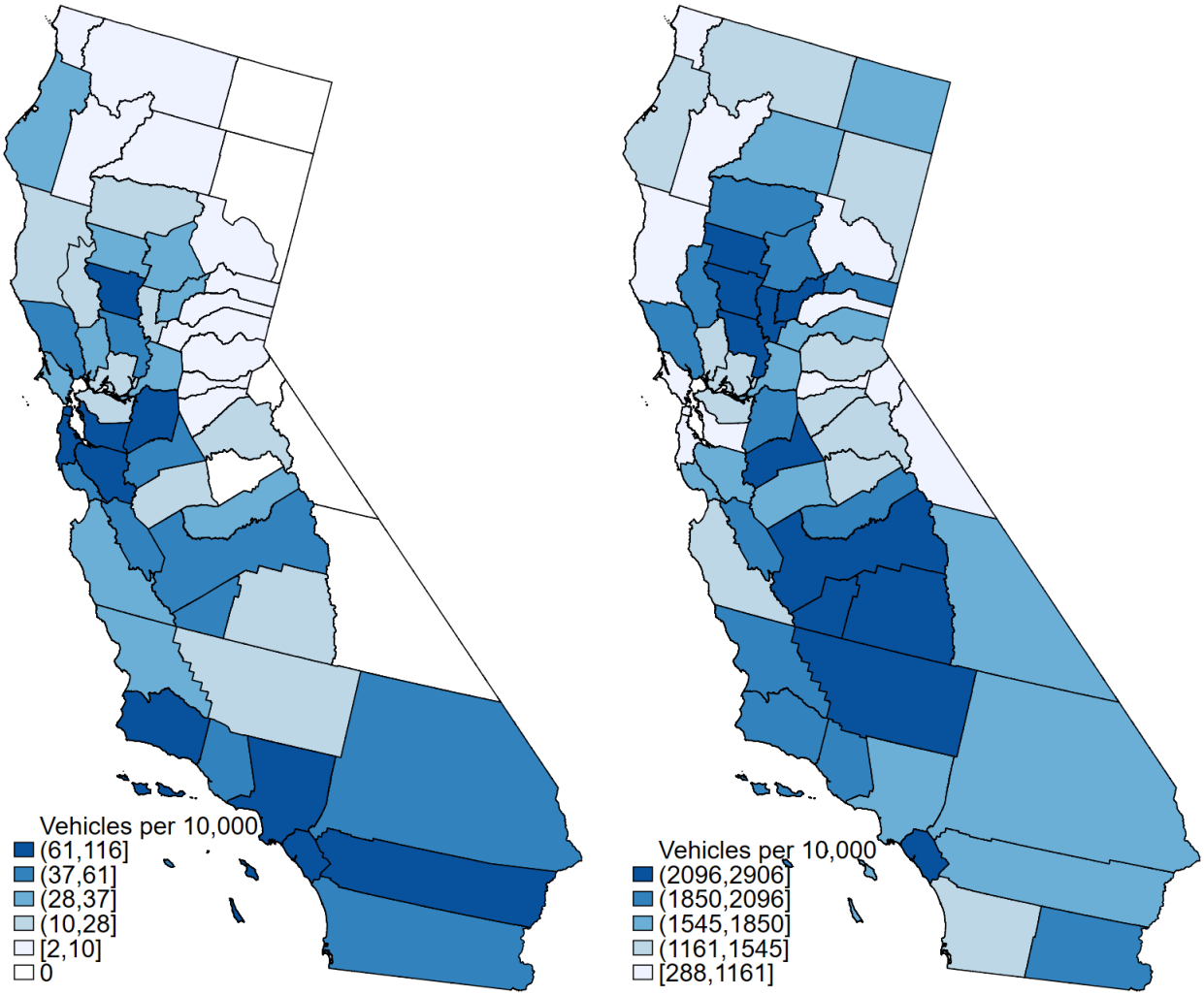


Figure 4 – 1919 Sources: See footnote 19.

County data from California match the national patterns. The data show that pre-Model T vehicle ownership, in 1907, was clustered where the rich lived, in or near urban areas. Figure 5(a) shows that in 1907, the most vehicles per capita were in and near San Francisco and Los Angeles. In 1921 (figure 5(b)), by contrast, most of the counties in California with the largest number of vehicles per capita were in the rural central valley.



(a) 1907 (b) 1921

Figure 5 – Sources: 1907- Motor vehicle registrations are from California Secretary of State, Motor Vehicle Department (1907). These figures are as of 1 September 1907, so we match to interpolated population figures for counties as of mid-year 1907. Interpolation between Census population figures is as described in the note to figure 2. 1921- Motor vehicle registrations are from Tuttle (1921). (It is unclear whether these data are as of 1/1/1921 or another day in 1921.)

To more systematically understand changes in car ownership between 1909 and 1919, we use cross-state regressions. Table 3 shows the OLS estimates of the relationship between log cars per capita and log population per square mile, log real income per capita, and literacy in

Table 3 – Cross-state regressions

	1900	1909	1919	1929
Right hand side variables:				
Log pop. per sq. mile	0.052	0.13**	−0.14***	−0.088***
	(0.046)	(0.051)	(0.023)	(0.017)
Log real income per cap.	1.70***	1.61***	0.28	0.32**
	(0.25)	(0.31)	(0.17)	(0.13)
Share literate	−0.16	1.42	5.68***	4.51***
	(0.94)	(1.46)	(1.02)	(0.74)
R^2	0.68	0.64	0.72	0.74
Observations	48	48	48	48

Notes: The dependent variable is the natural log of the number of cars per 10,000 people. Robust standard errors in parenthesis. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Sources: Car registrations are from Federal Highway Administration, Highway Statistics, Table MV-201. These data are likely as of 12/31 so we match registrations in year t to population in year $t+1$. Population data and land area are from the Census as reported in Haines and ICPSR (2010). Nominal state per capita income data for 1909 are nominal per capita income in 1900 multiplied by $(1+g)^9$ where g is average annual growth in per capita state income between 1900 and the 1919-1921 average. State per capita income in 1900 and 1919-21 are taken from Easterlin (1957), table Y-1, p. 753. Nominal state per capita income for 1929 are from the BEA, table SAINC1. These figures are converted to 2011 dollars by multiplying each per-capita income figure by $\frac{Y_{mad,t}}{Y_{nom,t}}$, where $Y_{mad,t}$ is the Maddison estimate of GDP per capita in the U.S. in 1900, 1909, 1919, or 1929 in 2011 dollars (Bolt et al., 2020), and Y_{nom} is nominal U.S. GDP per capita as described above. Literacy is from the Census as reported in Haines and ICPSR (2010).

1900, 1909, 1919, and 1929. The coefficients tell a story consistent with the maps above. In 1900 and 1909, the car is a luxury owned by the rich, often in urban areas. There is a very strong relationship between income and car ownership, with the elasticity of car ownership with respect to income well above one. There is little relationship between literacy and car ownership, as one would expect given that cars in 1900 and 1909 were almost exclusively owned by the rich, who were literate in all states. Reflecting the fact that rich tended to live in urban areas, there is if anything a positive relationship between population density and car ownership.

As we saw in the state and California county maps, there was a large change between 1909 and 1919 in the geographic distribution of car ownership. By 1919 (and similarly in 1929), there is a negative relationship between population density and car ownership; more rural states had more cars per capita. And while the relationship between income and car ownership in 1919 and 1929 remains positive, the elasticity is well under 1. The large coefficient on literacy beginning in 1919 reflects the small number of cars in the south, where literacy was lowest. Literacy may proxy for income equality, which likely was positively associated with car ownership.

To summarize, the maps and cross-state regressions show that the car was a luxury good

before 1909. Ownership was strongly associated with income, with the most cars owned in or near urban areas where the rich lived. By 1919, however, the car had become a mass-market good. Ownership was less associated with income in a state, with the highest levels of per-capita car ownership in the Great Plains and in rural areas.

4 The Model T

We presented two facts about car diffusion in the United States. First, car diffusion was unusually rapid compared to that in other countries. Second, from 1909-1919 the car changed from a luxury to a mass market good. In the rest of the paper, we argue that the Model T is likely a partial explanation for both facts. That the car became a mass-market good as the Model T began to be produced in large numbers is already suggestive of a Model T effect. In this section, we briefly summarize the history of the Model T, a history suggesting that the Model T contributed to rapid U.S. car adoption in the nineteen teens.

The Model T was revolutionary in two ways: its design and its method of production (Raff and Trajtenberg, 1996). The new design was present from the Model T's introduction in fall 1908. Mass production was put in place fully in 1913. Prior to the Model T, cars were designed to appeal to existing customers, and they were produced in relatively small numbers without mass production methods. As already mentioned, the cheap cars that did exist tended to make compromises that limited their appeal. Henry Ford was unique in his combination of a desire and an ability to design a car that would be both cheap to produce and yet still meet the needs of many consumers. As Brinkley (2003) (p. 103) puts it, when Henry Ford worked with company engineers:

> [W]hat he had to sell was his outrageous vision of a car that would be all things to all people—except rich people. The car he wanted to build would be daily transportation for city dwellers, a new kind of workhorse for farmers, and the key to freedom for anyone anywhere left behind by the Automobile Age.

The Model T design was novel in several respects, making the car both cheap to produce and attractive to consumers. Of particular importance to Henry Ford, the Model T was light, at roughly 1200 pounds (Brinkley, 2003, pp. 100-103). Its lightness was made possible by the use of vanadium steel (Brinkley, 2003, pp. 101-102). Lightness had many advantages; it meant less

wear on tires, and it meant that a small engine could provide adequate power. Other features of the Model T's design included high ground clearance, which made the car well suited for unpaved roads, a transmission that was easy to operate, and the placement of the steering while on the left. The latter was a first for an American car.

Contributing to low costs, the Model T was sold with a minimum of unnecessary features. An electric starter was unavailable before 1919,[20] and was optional until 1926 (McCalley, 1994). From 1914-25, the Model T was famously sold only in black.[21] As Raff and Trajtenberg (1996) put it, "the Model T was a smaller, simpler, less powerful, and less luxurious car than virtually any other car of its time" (p. 91). The simple design meant that the Model T was (relatively) reliable and cheap to maintain (Brinkley, 2003, p. 121). Farmers could service the model T themselves, often drawing on existing familiarity with gasoline-powered farm equipment (Nevins, 1954, p. 493).

Though sold with few features, the Model T could be easily modified. As (White, 2003) (p. 13) recalled:

> When you bought a Ford, you figured you had a start—a vibrant, spirited framework to which could be screwed an almost limitless assortment of decorative and functional hardware. . . . A Ford was born naked as a baby, and a flourishing industry grew up out of correcting its rare deficiencies and combating its fascinating diseases.

Not only did consumers make small modifications and additions to the car, Model Ts were modified to serve business purposes. Business uses of the Model T ranged from tractors pulling plows (Wik, 1972), to fire engines and mail trucks (Brinkley, 2003, p. 128). One might draw an analogy between the market for aftermarket changes to the Model T and the app-store for the iPhone. Just as apps make the iPhone more useful for consumers and businesses, modifying the Model T allowed it to serve many different purposes. Like the iphone, though to a much smaller extent, the Model T also steadily improved over time. In 1915, for instance, Ford began to use electric rather than gas headlights (McCalley, 1994, p. 197).

The Model T's design made it popular, but it was the combination of its design with mass production that made the Model T affordable to the middle class. Elements of mass

[20] By 1913, many other cars were available with electric starters (Nevins, 1954, p. 482).
[21] See Ford Corporate History.

production, such as part standardization, were in use before the Model T. But the move in 1910 of production to Ford's new Highland Park plant led to a rapid series of improvements culminating in 1913 with the novel use of a moving assembly line (Nevins, 1954, chap. XVIII). The assembly line saved many labor hours. In summer 1913, for instance, before an assembly line was installed, it took 12.5 hours of labor to construct a Model T chassis. In December 1913, after the installation of a system in which the chassis moved continuously (an assembly line), labor time per chassis had fallen almost 80 percent, to 2 hours and 38 minutes (Nevins, 1954, p. 473). As a result of improvements like these, in 1914 Ford made 260,722 cars with 13,000 employees; all other U.S. car companies combined made 286,770 cars with 66,350 employees (Nevins, 1954, p. 488).

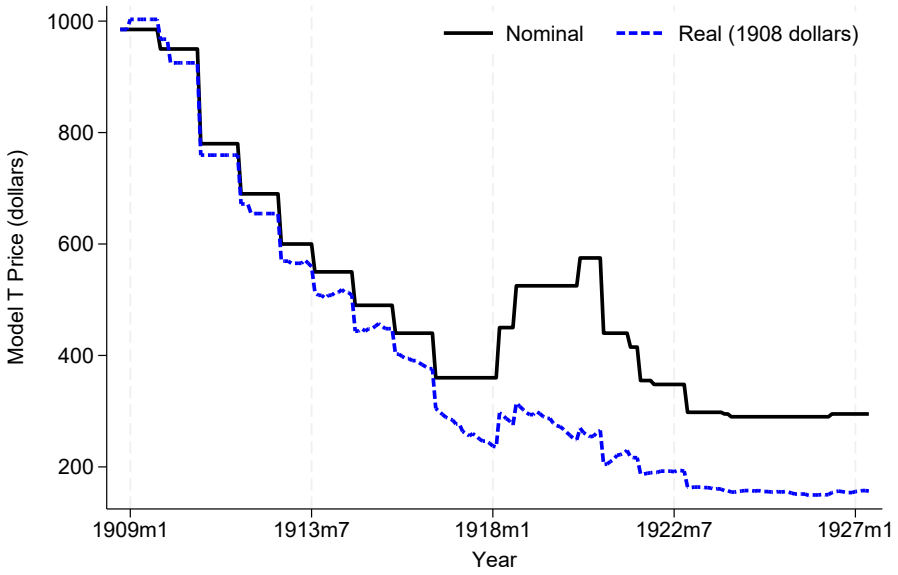


Figure 6 – Notes: Monthly price for the Touring model. Prices exclude starter and demountable wheels. Since these were standard equipment in 1926 and 1927, the prices shown here are $85 less than the posted prices in these years. Sources: Model T price - Brinkley (2003), p. 111 for 1909-1910; thereafter McCalley (1994). CPI - Lindert and Sutch (2006) for 1908-1912 (annual data), thereafter the monthly, non-seasonally adjusted BLS series from FRED series CPIAUCNS.

Productivity improvements allowed Ford to continuously lower the Model T's price after its introduction. Figure 6 shows the nominal and real (CPI-deflated) price of the Model T. The Model T's nominal and real price fell by roughly half between 1909-15; the real price then halved again between 1915-21. The result was a price-quality ratio unmatched by other cars. Figure 7 is a scatter plot of car price and one indicator of quality - engine displacement per pound - for 250 car models in 1916. Engine displacement is strongly correlated with engine

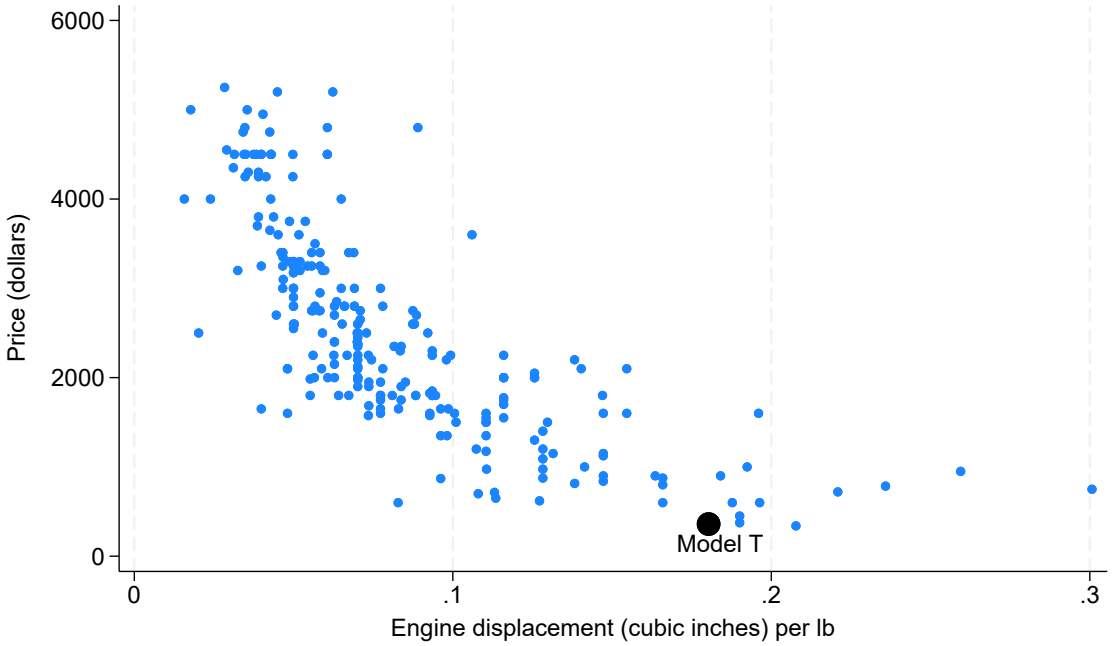


Figure 7 – Notes: This shows the 1916 chassis price and engine displacement divided by the chassis weight for the Model T plus the 249 cars with these data available from Raff and Trajtenberg (2011). Data on the Model T price and weight is from McCalley (1994), p. 195. Data on the Model T's engine displacement is from Raff and Trajtenberg (2011); we look at their 1915 and 1917 data and infer that the Model T engine in 1916 was the same as that in 1915 and 1917.

power, and so cars with more engine displacement per pound were faster and more capable. One can see that the Model T was almost unique in the amount of engine displacement per pound that one got for the price. Ford himself was proud of this quality indicator, writing in 1922:[22]

> With the Ford there are only 7.95 pounds to be carried for each cubic inch of piston displacement. This is one of the reasons why Ford cars are "always going," wherever and whenever you see them—through sand and mud, through slush, snow, and water, up hills, across fields and roadless plains.

As the fact that price and engine displacement are not positively correlated implies, engine displacement is only one dimension of quality. Figure 7 does not reflect the many other attributes (e.g. reliability, ground clearance, availability of aftermarket modifications) which made the Model T more attractive than other cars.

[22] Ford and Crowther (1922) qtd. in Chandler (1964), p. 36. Ford's co-author Samuel Crowther likely actually wrote these words.

As the price of the Model T fell, quantities sold rose. Figure 8 shows annual production of the Model T, a good proxy for sales. Production rose from 10,660 in the first year of production (October 1st 1908 - September 30, 1909) to 170,211 in 1913 and more than 900,000 in 1920. In the 1923, the peak year of Model T production, Ford produced more than 2 million Model Ts. Model Ts quickly captured a near monopoly on low-price car sales. Around 1913, Model Ts made up 96 percent of all cars sold for less than $600 (Nevins, 1954). The share of the stock of passenger cars that were Fords (almost entirely Model Ts) was already 29 percent in 1914 and rose to 42 percent in 1917.[23] By 1926, half of all cars on the road were Fords. Of course, while these time series show the large success of the Model T, it cannot prove whether the large numbers of Model Ts sold added to the total number of cars in the United States or simply substituted for the sales of other cars.

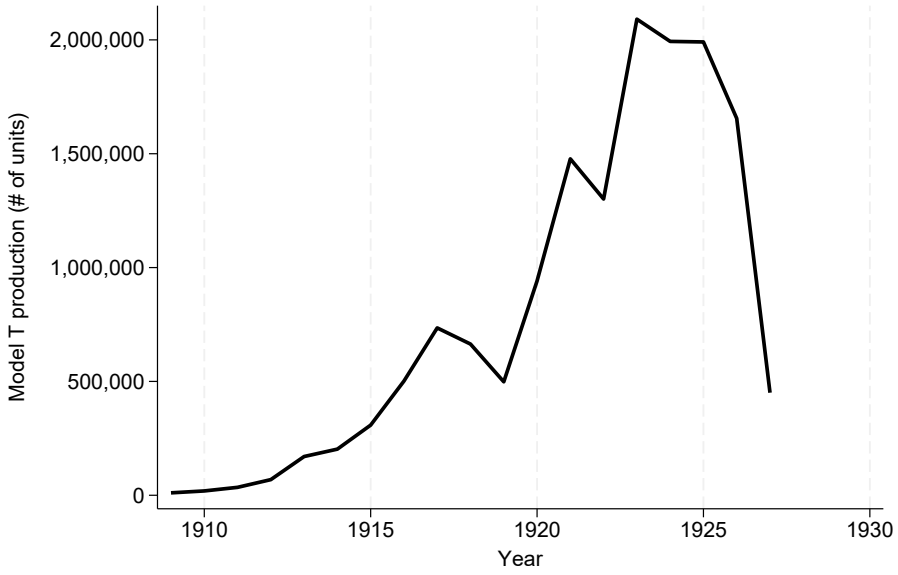


Figure 8 – Notes: Production of all Model T types, including trucks. Some production was exported, though as discussed further in section 6 numbers exported were small. For 1909-1912, production is for the fiscal year beginning October 1st; in 1914, production is the 10-month period from 10/1/1913-7/31/1914; from 1915-1920, production is for the fiscal year beginning August 1st; in 1921, production is for the 17 month period from 8/1/1920-12/31/1921; from 1922-27, production is for the calendar year. Source: McCalley (1994).

The history points to the Model T expanding the market by appealing to consumers who could not or did not previously buy cars, in particular farmers. As the policy of producing the Model T only in black suggests, the Model T's design was utilitarian, not stylish. Narrative evidence suggests that while many cars were bought to signal social status or for leisure pur-

[23] *Automotive Industries*, 9/6/1923.

poses, Model Ts were often bought for more utilitarian reasons. In their 1914 investigation of the automobile industry Parlin and Youker (1914) report (p. 620):

> Nearly one-half of all cars sold in 1913 were Fords. All classes of people — farmers, residents of minor cities and of major cities who cannot afford to buy a $1,000 car — turn to the Ford, and many owners of higher-priced cars have also been buying Fords for business purposes.

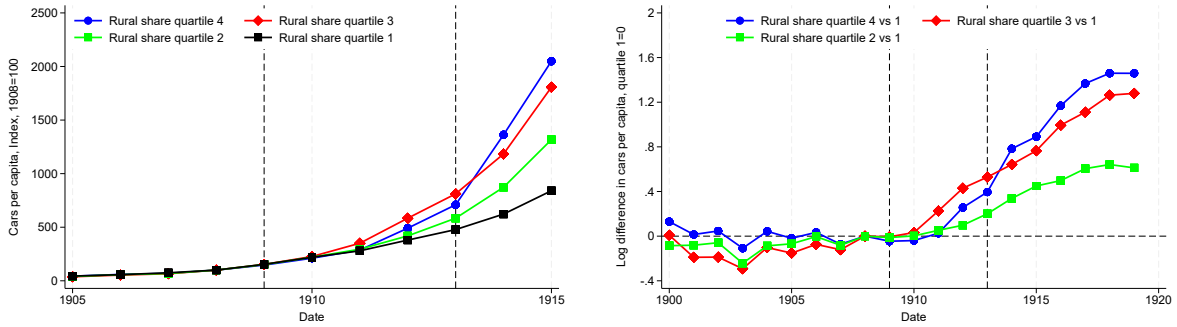
They go on to state that: "People will more readily buy Fords where the kind of car they drive has little or no effect on their social standing in the community" (p. 622). We next turn to quantitative evidence on the hypothesis that the Model T opened up a new mass-market for cars.

5 Cross-sectional evidence that the Model T expanded the market

The hypothesis that the Model T expanded the market rather than cannibalizing the sales of other manufacturers is itself untestable. But an implication is that Model T owners were different from non-Model T owners. Consider the iPhone analogy: one reason to be confident that the iPhone caused an increase in smart phone ownership is that people who bought iPhones were largely new smartphone owners, not the same people who had previously bought smart phones (i.e. the Blackberry).

The historical narrative suggests that the Model T particularly appealed to farmers. And we saw in section 3 that population density became negatively correlated with car ownership during the first decade of Model T production, between 1909 and 1919. To further examine what happened to car ownership in farm versus non farm states when the Model T was introduced, we divides states into four quartiles based on their rural population share. Figure 9(a) shows the path of car registrations per capita in these four groups of states. It shows that after the Model T was introduced, car registrations per capita grew more rapidly in more rural areas of the country. We can see this pattern more clearly in figure 9(b) which shows the log (i.e. percent) difference between car registrations per capita in states with rural shares in quartiles 2 through 4 relative to the states with the smallest share of the population in rural areas (quartile 1). The figure shows that prior to the introduction of the Model T, car registrations per capita grew similarly in all states, regardless of the rural population share. After the introduction of

the Model T, car registrations per capita began to grow more quickly in states with a larger share of the population in rural areas. And this relationship is monotonic: between 1908 and 1915, the number of cars per capita in the least rural states (quartile 1) grew 840 percent, in quartile 2 1,320 percent, in quartile 3 1,800 percent, and in quartile 4 2,050 percent.



(a) Level (b) Log difference

Figure 9 – Notes: Figure 9(a) shows the path of car registrations per capita in four sets of states grouped by the rural share of the population in 1910. Quartile 1 has the smallest share of the population living in rural areas. Figure 9(b) shows the natural log difference in car registrations per capita in quartiles 2-4 relative to quartile 1. The first vertical line indicates 1909, when Model T was introduced; the second vertical line indicates 1913, when the Model T began to be mass produced. Sources: Car registrations per capita - see the note to figure 2. Rural share of the population in the 1910 Census as reported in Haines and ICPSR (2010).

Figure 9 is consistent with the hypothesis that the Model T opened up a new market for cars among the rural population. To more formally test this hypothesis, we use county-level data on the share of cars in a county that were Model Ts. Figure 10 shows the share of cars in a county that were Model Ts in 1922, the first year for which we have such data. The large variation itself suggests that the Model T's appeal varied across the country. The standard deviation of the share of cars in a county that were Model Ts was 13 percent. The share ranged from more than 90 percent in 17 counties to less than 30 percent in 30 counties. The only county with both more than 1,000 total car registrations and a Model T share of less than 20 percent was Manhattan. That Manhattan is an outlier with a low Model T share is consistent with the Model T appealing relatively less to the rich, to those concerned with social status, and to urban populations.

To better understand the patterns in this map, we estimate regressions across counties j of the form

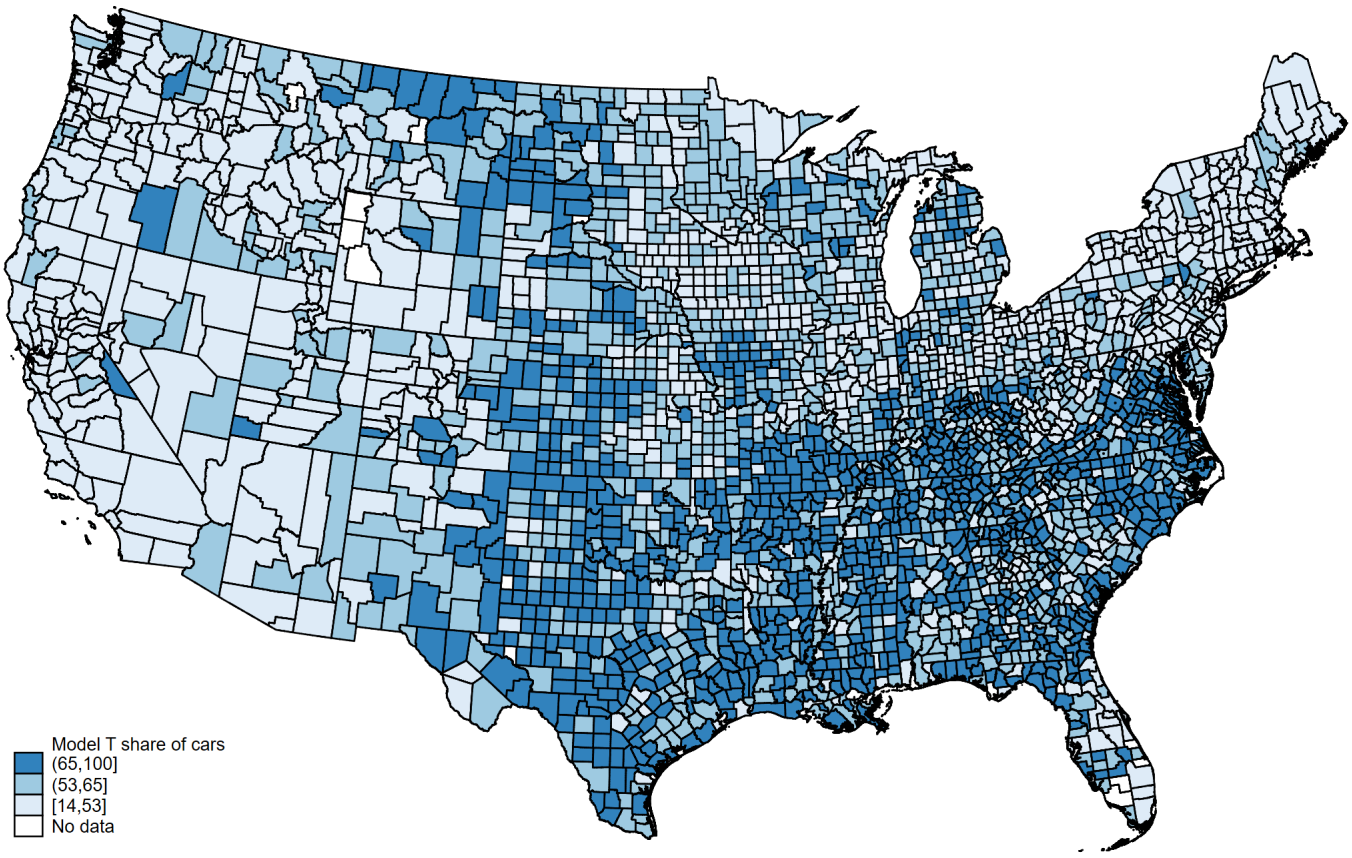


Figure 10 – Note: The map shows the share of cars in a county that were Fords (nearly entirely Model Ts) on January 1st, 1923. Source: Tuttle (1923).

$$\text{Model T}_j = \beta_0 + \beta_1 \text{Rural share}_j + \beta_2 \text{Income tax return p.c.}_j + \beta_3 \text{Share literate}_j + \gamma' FE_j + \varepsilon_j. \quad (1)$$

Model T_j is either the share of cars in a county that are Model Ts or the number of Model Ts per capita in a county. Income tax return p.c. is the per capita number of income tax returns filed in a county in 1922. Since only the rich had to pay income tax, this variable is a proxy for income in a county. FE_j are state fixed effects. State fixed effects are useful control variables and are themselves of interest. Column 1 of table 4 shows results with Model T share as the dependent variable and with no state fixed effects. Column 2 adds state fixed effects. With and without fixed effects, there is a large coefficient on the rural share of the population. The coefficient of roughly 0.15 means that for every 10 percentage point increase in the share of a county's population that was rural, the share of cars that were Model Ts increased by 1.5 percentage points. So a one-standard-deviation increase in the rural share of the population (25 percentage points) was associated with a 3.5 percentage point increase in the Model T share. The coefficient is precisely estimated. With state fixed effects, the 95 percent confidence interval is [0.13, 0.21].

We obtain a similar result in columns (3) and (4), in which the dependent variable is Model Ts per capita. With and without state fixed effects, the coefficient on rural share is roughly 3; this means that a one standard deviation increase in the rural share of the population was associated with 75 more Model Ts per 10,000 people. In columns (5) and (6), we see that there was no relationship between rural share of the population and the per-capita ownership of cars that were not Model Ts. It was not that rural areas bought more of every type of car; the model T was unusual in its rural appeal.

The next row of the table looks at the association between Model T ownership and tax returns per capita (measured as tax returns per 100 people). As noted above, per capita tax returns are an indicator of the share of residents in a county who were well off. The estimates in table 4 show a negative relationship between tax returns per capita and the *share* of Model Ts in a county (columns 1 and 2), and a (statistically weak) positive relationship with the number of Model Ts in a county (columns 3 and 4). The relationship with the number of non-Model T cars in a county is much larger (columns 5 and 6). Conditional on rural share, literacy and state

Table 4 – Cross-county regressions

	(1)	(2)	(3)	(4)	(5)	(6)
	Share Model T		Model Ts p.c.		Non-Model Ts p.c.	
Right hand side variables:						
Rural share of population (%)	0.14***	0.17***	3.11***	3.08***	0.44	−0.51
	(0.024)	(0.019)	(0.84)	(0.77)	(0.78)	(0.45)
Tax returns per 100	−1.71***	−1.04***	12.7*	13.0*	43.2***	29.4***
	(0.21)	(0.16)	(6.95)	(6.65)	(9.46)	(4.38)
Literate share of population (%)	−0.14**	0.084	27.0***	13.7***	19.2***	8.39***
	(0.067)	(0.066)	(4.38)	(2.32)	(3.27)	(2.08)
State fixed effects	No	Yes	No	Yes	No	Yes
R^2	0.48	0.61	0.33	0.62	0.47	0.71
Observations	3,012	3,012	3,012	3,012	3,012	3,012

Notes: The dependent variables are as of January 1st 1923. Counties with fewer than 20 total cars are excluded. Share Model T is the share of cars in a county (in percent) that were Fords; these would have been nearly entirely Model Ts. Model Ts p.c. is the number of Fords per 10,000 people. Non-Model Ts p.c. is the number of non-Ford cars per 10,000 people. Standard errors clustered by state in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Sources: Model T and other car registrations - Tuttle (1923); rural population share and literacy - 1920 Census as reported in Haines and ICPSR (2010); tax returns - IRS statistics of income.

fixed effects, a one standard deviation increase in income tax returns per capita was associated with 53 more Model Ts and 119 more non-Model T cars per 10,000 people. These results fit with a story in which richer counties had more cars overall but had a smaller share of cars that were Model Ts. The regression results closely match the narrative in Parlin and Youker (1914) who observe (p. 622):

> Those sections will absorb larger numbers of Fords, which contain the largest number of people who can pay $550 for car, but cannot afford a car of a more expensive grade; that is, which contain the largest number of people who are not well-to-do, but who are earning more than a bare living. These are found among the farmers and in minor cities and villages.

The final row of the table shows the association between car ownership and the literate share of the population. With state fixed effects (column 2), there was no relationship between literacy and Model T share. But literacy, perhaps because it proxies for something like median income, is strongly correlated with per capita ownership of all cars, both Model T and non-Model T (columns 3-6). The coefficient of 14 in column (4), for instance, means that a one-percentage

point increase in the share of a county's population that was literate was associated with 14 more Model Ts per 10,000 people.

The coefficients on the state fixed effects are also themselves of interest. In the specification in column (4), in which Model Ts per capita is the dependent variable, the largest positive state fixed effects are Kansas, Iowa, and Nebraska. Conditional on rural share of the population, income tax returns, and literacy, there were more Model Ts in these states than would be expected. The coefficient on Kansas is 754 compared to, for instance, a coefficient on New York of 202. Conditional on the controls, there were 550 more Model Ts per 10,000 people in a county in Kansas than in a county in New York. The Model T had a particular appeal in the Great Plains, an appeal only partly explained by the rural, literate population.

To sum up, there is strong evidence that the Model T appealed to a distinct market. That the introduction of the Model T was associated with a larger increase in car ownership in rural states fits with the county-level evidence that Model Ts were more popular in rural areas. Of course, Model Ts were not only bought in rural areas. There would have been no way for Model Ts to be roughly half of all cars in the country in the mid-1920s without large numbers being bought in urban areas. Manhattan had a uniquely low share of Model Ts, but there were still 19,773 Model Ts in Manhattan on January 1, 1923. The point is that the disproportionately large number of Model Ts purchased in rural areas supports the hypothesis that the Model T opened up a new market for cars, thus contributing to the car becoming a mass market good.

6 The Model T abroad

We began by documenting the anomalous U.S. car ownership lead in 1929, anomalous in the sense that is was larger than one would expect given ownership differences for telephones and radios, and anomalous in the sense that the lead is not obviously explained by income or population density. We argue that the Model T is part of the explanation, since the Model T explains part of why the United States so quickly adopted the car and since the Model T was much less successful abroad.

A few numbers illustrate the small numbers of Model Ts sold abroad. In 1924, Ford's U.S. production totaled 1,797,331 cars and trucks. Of these, 142,641 were exported. Ford in Canada produced another 71,726 cars and trucks, and Ford in England another 27,497.[24] Production

[24]These figures are from Wilkins and Hill (2011), appendix 3, p. 436.

in other countries was small. The small number of Model Ts sold abroad was probably not a reflection of the Model Ts appeal to foreign consumers, at least outside Europe.[25] In 1914, for instance, Model T sales in Canada exceeded the sales of all other cars in Canada combined (Wilkins and Hill, 2011, p. 43); 45 percent of cars in Canada were Model Ts in 1926, close to the Model T share of cars in the United States. But since Canada had only about half the U.S. level of cars per capita, this meant it had only about half the number of Model Ts per capita (Wilkins and Hill, 2011, p. 132).

A large obstacle to Ford selling a larger number of Model Ts in Canada and elsewhere abroad was price. Tables 5 and 6 shows prices of the Model T around the world in 1914 and 1922. The first four rows of table 5 show prices in the United States. Within the United States, consumers paid more the further they were from Detroit; the price in San Francisco and Los Angeles was $75 (roughly 15 percent) more than the price in Detroit. To learn about Model T prices abroad, we collected prices from newspaper advertisements. We searched the following datasets – Readex World Newspaper Archives, CLR Global Press Archives, Proquest Historical Newspapers, and Hathitrust– as well as the digitized newspaper holdings of the National Libraries across Europe and Oceania. We used the search terms "Ford Motor" and "Universal Car," a Ford trademark. We found data on prices in 18 countries in 1914 and 13 countries in 1922. While there is large variation, tables 5 and 6 show that in all cases the Model T cost more abroad than it did in the United States; it cost roughly 20-50 percent more in Canada, and roughly 20-130 percent more elsewhere.[26]

One source of the Model T's higher price abroad is obvious. Most countries imposed high tariffs on the import of cars from the United States. Until 1926, for instance, Canada imposed

[25] In Europe, Ford and American car manufacturers more generally faced more difficulties appealing to the local market (Foreman-Peck, 1982, pp. 873-876). Ford in particular struggled against the obstacle of Henry Ford's unwillingness to modify the Model T for different markets.

[26] One might wonder whether the price differences across countries are large enough to plausibly explain the cross-country differences in car ownership. Unfortunately, without knowledge of price elasticities of demand across country, we cannot provide a quantitative answer. But it is easy to imagine small price differences adding up to large effects. Suppose the elasticity of demand for new car sales were one, so that cars costing 20 percent more in Canada meant 20 percent fewer were sold every year there. Then after 5 years, one might have half the cars in Canada that one did in the U.S. Add in the fact that fewer cars mean less political support for roads, meaning fewer people want to buy cars, and one can easily see how even a modest price difference can more than explain the large cross-country differences in car ownership that we see.

In any case, we are agnostic about the exact quantitative effect of the price differences. Our contribution is to document the price differences and to note their likely qualitative importance in explaining cross-country car ownership differences.

Table 5 – Price of a Model T in 1914 (U.S. dollars)

	5-seater	2-seater	Source
Detroit	$550	$500	McCalley (1994), p. 171
Des Moines	$580	$530	Freight rate from *Ford Times*, March 1914
Los Angeles & San Francisco	$625	$575	Freight rate from *Ford Times*, March 1914
New York City	$572	$522	Freight rate from *Ford Times*, March 1914
Queensland, Australia	$1,036		*The Wyalong Advocate and Mining, Agricultural and Pastoral Gazette*, 17 January 1914
Toronto, Canada	$650	$600	*Toronto Star*, 23 May 1914
Auckland, New Zealand	$1,011	$937	*Waikato Argus*, Volume XXXV, Issue 5510, 16 January 1914
Budapest, Austria-Hungary	$933	$852	*Allgemeine Autombil-Zeitung* vol. 12, 1914, p. 12
Vienna, Austria-Hungary	$933	$852	*Allgemeine Autombil-Zeitung* vol. 12, 1914, p. 12
Prague, Austria-Hungary	$933	$852	*Allgemeine Autombil-Zeitung* vol. 12, 1914, p. 12
Trieste, Austria-Hungary	$933	$852	*Allgemeine Autombil-Zeitung* vol. 12, 1914, p. 12
Copenhagen, Denmark	$815	$735	*Copenhagen*, 12 February 1914
Manchester, England	$666	$616	*Guardian*, 31 July 1914
Paris, France		$762	*L'Illustration*, 26 July 1913
Hamburg, Germany	$714	$595	*Illustrirte Zeitung*, 4 June 1914
Burgos, Spain	$1,080	$980	*Diario de Burgos*, no. 6927, 14 January 1914
Stockholm, Sweden	$872		*Svensk Motor Tidning*, vol. 8, 1914, p. IX
Buenos Aires, Argentina	$826	$720	*Caras y Caretas*, 10 October 1914
Havana, Cuba	$1,050		*Diario de la Marina*, 24 February 1914
Java, Indonesia	$1,000		*De Sumatra Post*, 2 June 1914
Riga, Latvia	$800	$740	*Valmieras Zinotajs*, 24 May 1914
Mexico City, Mexico	$1,350	$1,000	*Mexican Herald*, 25 February 1914
Lagos, Nigeria	$740	$641	*Lagos Standard*, 11 March 1914
Harare, Rhodesia	$1,060	$972	*Rhodesia Herald*, 10 May 1914
Moscow, Russia	$1,171	$1,081	*Kurier Warszawski*, 7 June 1914
St. Petersburg, Russia	$1,171	$1,081	*Windausche Zeitung*, 24 May 1914

Notes: Exchange rates are from Mood (1930). The UK price roughly matches that for 1913 reported in Foreman-Peck et al. (1995), p. 13.

Table 6 – Price of a Model T in 1922 (U.S. dollars)

	Sedan	Touring 5-seater	Runabout 2-seater	Source
Detroit*	$645	$348	$319	McCalley (1994), p. 306
San Juan, Puerto Rico	$862	$482	$442	*El Mundo*, Nov. 10, 1922
New South Wales, Australia		$1,158		*Mudgee Guardian*, March 20, 1922
Windsor, Canada	$909	$523	$484	*Windsor Star*
Aalst, Belgium	$1,323	$899	$840	*The People's Voice*, Feb. 12, 1922
Skive, Denmark	$1,105	$726	$634	*Skive Folkeblad*, June 30, 1922
Dover, England	$1,245	$715	$668	*Dover Express*, Aug 2 1922
Paris, France	$1,327	$779	$716	*Journal de Ruffec*, Oct. 8, 1922
Reykjavík, Iceland	$1,049	$664	$647	*Tölublað Vísir*, Oct. 13, 1922
Luxembourg, Luxembourg	$1,340	$776	$717	*L'Independance Luxembourgeoise*, 3 March 1922
Overijssel, Netherlands	$988	$654	$635	*Overijssels Dagblad*, July 4 1922
Tilburg, Netherlands	$1,016		$672	*Het Patroonsblad*, Aug. 23, 1922
Freiburg, Switzerland		$779	$570	*Freiburger Nachrichten*, Sept 14, 1922
Rio de Janeiro		$582		*Jornal do Commercio*, Dec 3 1922
Shanghai, China	$1,505	$864	$809	*Weekly Review of the Far East*, July 16, 1922
Havana, Cuba	$924	$519		*El Mundo*, Feb 10, 1922
Santo Domingo, Dominican Rep.		$600		*Listin Diario*, March. 22, 1922
Batavia, Dutch East Indies	$1,486	$978		*Sluyters' Monthly*, Feb. 1922
Calcutta, India	$1,474	$779		*Civilian and Military Gazette*, March 21, 1922
Veracruz, Mexico		$1,295	$1,235	*El Dictamen*, August 10, 1922
Coastal Ports, South Africa	$1,545	$1,081	$900	*Eastern Province Herald*, April 29, 1922
Caracas, Venezuela		$732		*El Universal*, June 14 1922

Notes: Exchange rates are from Mood (1930). *These prices were in effect 1/16/22-10/16/22; on 10/17/22 prices of all Model T types were reduced by $50 (McCalley, 1994, p. 306).

a 35 percent tariff on imported cars and a roughly 30 percent tariff on imported car parts (Melanson, 2009). In 1914, the tariff on cars imported to Japan was also 35 percent; Argentina and Norway imposed tariffs of 12 percent (U.S. Department of Commerce, 1914).

Tariffs alone, however, are an incomplete explanation. First, they do not explain why price differences appear to have sometimes exceeded the tariff. Second, the tariff explanation leaves open the question of why Ford could not manufacture cars abroad at the same cost as he did in the United States. As Foreman-Peck (1982) details, production by American car manufacturers abroad was hampered by limited economies of scale, limited managerial expertise, and more expensive input costs. The comparison to Canada is again instructive; it shows the difficulty of replicating the success of mass production in Highland Park even when production abroad meant production only 15 miles from Highland Park. The Ford motor company of Canada began operations in Windsor Canada, just across the river from Detroit, in 1904. The Ford plant in Windsor (then Walkerville) was at one point the largest automobile factory in the British empire (Wilkins and Hill, 2011, p. 113). But Ford in Windsor could not manufacture cars at the same cost or at least sell them at the same price as the company did in Michigan. Certainly there were few barriers to knowledge; engineers and managers could easily travel back and forth between Windsor and Detroit. Nor were economies of scale the obvious problem. Ford Canada sold Model Ts not only in Canada, but also throughout the British empire (except to Great Britain itself). And Henry Ford himself thought that Ford Canada did not suffer any cost disadvantages from its scale (Aikman, 1926, p. 77). Yet before World War Two, the magic of Ford's mass production in Michigan did not even extend across the Detroit river.

7 Conclusion

Perhaps no single consumer product transformed American life more than the Model T. When Nevins (1954) said that mass production of the Model T was a "lever to move the world" (p. 447), he was engaging in little exaggeration. We have shown that the introduction of the Model T was associated with the transformation of the car from a luxury to a mass-market good, and we have argued that the relative lack of success of the Model T abroad likely explains part of the U.S. car ownership lead.

That the United States adopted the car so quickly—in part a consequence of the Model T—mattered not only for the interwar economy. It still matters today. Today the United States

continues to have an unusually large number of vehicles per capita. In 2019 data, the United States had a quarter more vehicles per capita than Canada, and a third more than western Europe.[27] The enduring U.S. car ownership lead has many causes, of course. But one is path dependence from the years of the Model T. That the United States adopted the car decades earlier than other countries meant U.S. cities began to be (re)designed for cars sooner; it meant that cars changed culture earlier; and it meant that public transportation faced competition from the car earlier, before it was protected by large-scale public involvement. By contrast, in Europe cars only became widespread after World World Two, when governments were large and heavily involved in providing public transportation.

It was not until 1974, for instance, that France reached the per-capita level of vehicle ownership reached by California in 1926.[28] In 1926, public transit was extensive in California, with, for instance, a well-used streetcar network in the Los Angeles area of more than 1,000 miles (Morrison, 2021). But this public transit was privately provided and could not compete against cheap car transportation. In 1974, by contrast, public transit in France was public; it did not need to win a competition with the car to survive. When readers of this paper in California drive to work and those in France take a train, we may see the long shadow of the Model T.

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A Car registration data in Canada

Data on motor vehicle registrations in Canada was published annually before World War Two by the Dominion Bureau of Statistics, Transportation and Public Utilities Branch. These publications, titled "The Highway and Motor Vehicle in Canada" reported registrations for each province, with some data also given at a more local level. We take all data from Dominion Bureau of Statistics (1939), pp. 28-33. Provinces began collecting registration data at different times. Ontario, the first province to do so, began in 1904. By 1909, data are available for all of Canada except Prince Edward Island and the Yukon and Northwest territories. So that changes in car registrations do not reflect changes in geography, we take "Canada" before 1941 to be the provinces with car registration data beginning in 1909, e.g. the entire country except Prince Edward Island and the Yukon and Northwest territories.[29]

By 1923 all provinces separately reported registration numbers for passenger cars, commercial vehicles, and motorcycles. Earlier in the period, however, there is often only a number given for passenger car registrations or total registrations. We use the total number of motor vehicles in a province when data for passenger cars alone are unavailable. This biases upward the number of passenger cars per capita in Canada in early years.

A complication arises with the data for Ontario. According to Dominion Bureau of Statistics (1939), p. 5:

> Before reciprocal arrangements were made in regard to the operation of motor vehicles registered in other provinces and in the United States a large proportion of the cars registered in Ontario were owned outside the province, principally in the United States.

We do not want to count cars owned in the United States as part of the stock of cars in Canada, so do our best to exclude these cars from the Canadian count. Dominion Bureau of Statistics (1939), p. 5 gives numbers for outside registrations in 1906 (659 outside registrations), 1908 (1,165), and 1914 (6,405). It also specifies that outside registrations were an issue only between 1906 and 1916; by 1917, there were a minimal number (386) of outside registrations. We estimate outside registrations in years for which no exact figures were given (i.e. in 1907, 1909-1913, and 1915-1916) by assuming that outside registrations grew at the rate between the two closest years for which a figure is given. i.e. We estimate that outside registrations in 1915 were $or_{1914} * (1 + g)$, where or_{1914} is the number of outside registrations given for 1914 and g is the annual growth rate of outside registrations between 1908 and 1914.

For computing per-capita figures, population data for Canada are Census figures from series A2-14. We interpolate between Census years (1901, 1911, 1921, and so on) using the method outlined in the note to figure 2. Motor vehicle registrations appear to be end-of-year (or close to end-of-year) numbers. See, e.g. Dominion Bureau of Statistics (1939), pp. 36-37. The 1901 Canadian Census reported population as of March 1st; the 1911-1931 Census reported population as of June 1st. Given our argument that car adoption was much more rapid in the United States than abroad, we choose to accept an upward bias in per capita vehicle figures for Canada by associating motor vehicles as of 12/31 in year t with population on June 1st of year t.

[29] Newfoundland and Labrador did not become part of Canada until 1949. Present-day Nunavut was split from the Northwest Territories in 1999.