LUND UNIVERSITY
School of Economics and Management
**Master Programme in Economic History**

# On the Road to the Automobile Age
# Sweden 1923-1973

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*Abstract:* Europe, following the American model, became a Car Society during the Golden Age. In Sweden, mass-motorization spread faster and approximately ten years earlier than in the rest of the continent. This study aims to pinpoint factors explaining this advance. In general, living standards are considered as the determinant of private car diffusion; population dispersion is also assumed to be an accelerating factor. Admittedly Sweden had a favorable economic situation and a sparse population, yet, demand for cars was certainly not only driven by individual income and low population density. In this paper, other factors, such as the existence of a powerful national automobile industry, favorable political ideology toward the Car Society and very efficient transfers of American technology, will be studied and combined to a regional analysis to grasp the characteristics of the Swedish mass-motorization process.

*Keywords:* Mass motorization, private car ownership, Sweden

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*"I think that cars today are almost the exact equivalent of the great Gothic cathedrals: I mean the supreme creation of an era, conceived with passion by unknown artists, and consumed in image if not in usage by a whole population which appropriates them as a purely magical object."*

**Roland Barthes**[1]

*What forces drove the demand for cars during the diffusion phase in Sweden?*

## 1 INTRODUCTION

In 2011, over 600 million passenger cars were travelling the world´s roads. This number is increasing very rapidly in developing countries whereas the market has come to saturation in the developed world. In the later, there are approximately 500 cars per thousand inhabitants; one car for two persons.

Cars have become extremely pervasive in our societies and, since the mid twentieth century, they dominate, *par excellence,* transportation means. Moreover, it seems that this hegemony will still remain for a long time as there is a sort of "path-dependence"[2] around this technology. This symbol of consumerist societies has conditioned in a very unique manner the organization of social and public spaces. One could speak of a Car Society, or, as Flink, of "An Automobile Age". (Flink, The Automobile Age, 1988)

As it is still a new phenomenon, economic historians have not studied the diffusion process and its implications as much as they have, for example, studied railroads in the nineteenth century. Economists, sociologist or geographers have approached the topic but the historical perspective still lacks of substance. Therefore, if one understands issues concerning the present or the

[1] "*Je crois que l'automobile est aujourd'hui l'équivalent assez exact des grandes cathédrales gothiques : je veux dire une grande création d'époque, conçue passionnément par des artistes inconnus, consommée dans son image, sinon dans son usage, par un peuple entier qui s'approprie en elle un objet parfaitement magique. »*
(Barthes, 1957)

[2] On the concept of path-dependence read Paul David. (David, 2007)

probable future of the Car Society, one does not know the dynamics of its diffusion. Yet, the later is crucial to comprehend the former.

In this essay, I will look at the historical diffusion process of cars during the course of the twentieth century in western societies. I want to provide a historical approach of the dynamics and conditions of the diffusion process. I will focus on one country's case, Sweden, and carry through my analysis for the years 1923 to 1973. I will attempt to explain the earliness and the rapidity of the phenomenon in Sweden and I will try to highlight regional patterns within Sweden.

## 1.1 Hypothesis

It is always assumed that private car ownership rates increase at the same pace as Gross Domestic Product (GDP) per capita. According to most theories, there is a very linear causal relationship between individual income and car ownership. (Elsässer, Bilismen, 2006; Flink, The Automobile Age, 1988) In this paper, I want to go past this simple explanation and weigh up other determinants that could have influenced the demand for cars. Of course, I do not dismiss the obvious correlation between GDP per capita and car ownership but I question the quality of such a narrow explanation. I believe that one should look at forces that pushed the demand. Indeed, I do not think that a rational demand, based on individuals' evaluation of cars benefits and practical characteristics, was itself capable of driving the diffusion.

Yet, I do not want to debate whether car diffusion was a supply or a demand driven phenomenon. I assume it was a dynamic and relatively gradual process, not entirely bottom-up nor top-down but a little bit of each. I want to grasp the downstream conditions of demand formation during the first phase of cars diffusion by going beyond the strict focus on demand and supply interactions. I believe that a historical approach is needed to have a better hindsight and to improve a strict economic comprehension.

Mass production and mass consumption of cars started in the United States and expanded first in Western offshoots, several decades before Europe. The large scale diffusion in the old continent really started in 1945 and stretched until 1970. In Sweden, this process happened

earlier and faster than in the rest of Europe. In 1945, France or the United Kingdom still had a higher car ownership rate than Sweden, respectively 36, 42 and 28 cars per thousand inhabitants. In 1955, though, the trend had reversed, and Sweden had the highest European rate with 75 cars per thousand inhabitants, for 48 and 60 in France and United Kingdom. (Bilismen i Sverige, 1948-1975)

The earliness of the diffusion in Sweden has several causes. As it was preserved from war destructions, GDP per capita was higher. The living standards explanations seems thus to fit this case. Moreover, Sweden is vast and its low population density can have accelerated the demand for cars, as it did in the United States in the 1930s. Even though these basic explanations turn out be valid, they do not provide a complete comprehension of the phenomenon.

Looking at the Norwegian case enables to highlight the specificity of the Swedish early diffusion. The situation there was similar to the Swedish one. It is a large country with low population density that had been relatively protected by war destruction (even if, on the contrary to Sweden, it was a belligerent) and it just had a slightly lower GDP per capita. Yet, if per capita GDP increased by 15 percent between 1950 and 1955, car ownership only raised by 67 percent whereas, in Sweden, GDP increased by 12 percent and car ownership by 170 percent. (Bilismen i Sverige, 1948-1975; Maddison, 2001) Lindgren and Pettersson have precisely carried out a comparative study between the Swedish and the Norwegian cases. (Lindgren & Pettersson, 2009)

There must thus have been other forces involved in the diffusion process in Sweden. BlomKvist or Lundin, among others, have studied the influence that international organizations promoting automobiles had had in Sweden, notably the International Road Federation and its local branch, the Swedish Road Federation. (Blomkvist, 2004; Lundin, 2004) It has also been shown that political decisions were very favorable to the Car Society in Sweden, on the contrary to Norway (Ostby, 2004), even to the detriment of other transportation means. (Anel, Hedborg, Ingelstam, & Lönnroth, 1971) Moreover, the strength of a relatively well developed national car industry favored obviously the diffusion of cars. (Elsässer, Svensk Bilindustri -en framgångshistoria, 1995) In other words, for numerous reasons, the American technology transfer was a great success in Sweden.

## 1.2 Plan

In this essay, I will combine the different aspects of the issue and attempt to assess causality of factors at regional, national and European levels. As a historical approach of the topic is quite new, my study will, at the same time, be: descriptive, portraying the diffusion pattern in Sweden and comparing it with other countries cases; exploratory, examining regional patterns and evaluating unexplored factors; and causal, grading the importance of each factors.

I will limit the study to the years 1923-1973. In 1923, the diffusion had barely started and the first statistics about cars were collected, whereas, in the mid 1970s, the diffusion stage was over, the ownership rate being close to the current one. 1973 is also a symbolic year, being the year of the first oil crisis and to some extent the first questioning of the "automobile system".

In a first part, I will give a general presentation of the automobile in western societies. I will define the terminology and mention the alternatives to cars that existed, horses and railroads notably. Then, I will describe the pattern of diffusion, from invention to market saturation, and present its economic and social impacts. I will mainly focus on the United-States example as the first big scale diffusion happened there already in the 1920s. Finally, I will discuss the characteristics of the Car Society, the concept of path dependence and the future of automobile.

In a second part, I will examine the diffusion in Sweden. I will evaluate its advance compared to other European countries and I will weigh up the importance of the two main explanatory factors: living standards and population dispersion. I will check correlations between GDP and car ownership, measure the impact of short term fluctuations, and I will look at urbanization rates and population density.

In a third part, I will examine different aspects of the diffusion process to strengthen the weak points of the basic explanation. I will portray the economic situation of Sweden at the end of the Second World War and look at its car industry. I will present the channels of American technology transfer and discuss the political decisions that were taken concerning automobiles and roads.

Finally, I will attempt, thanks to simple regressions, to evaluate the role of every variable in the Swedish diffusion process, such as income, urbanization and population density, length of roads or state expenditures on roads. I will run regressions for three benchmark years, 1953, 1960, 1970, taking observations by county. Indeed, I assume that convergence was not completely achieved in the 1950s and to look at differences between counties (area, income, urbanization…) could enable to highlight the forces that created a demand for cars.

## 1.3 The Data

All my data are secondary aggregate data. Data concerning population (total, density…) come from Statistics Sweden. Data on economic performance and living standards, such as GDP per capita, were produced by researchers from Lund University or by Angus Maddison. The rest of the data on cars were collected from *Bilismen I Sverige*, a statistical yearbook on motor vehicles released since 1948. Data on automobiles for other countries were collected from *Bilismen I Sverige* too, except data for the United-States that all come from the U.S. Bureau of Census.

I have at my disposal annual Gross Domestic Product per capita in market prices base 1930 for the whole period (1923-1973). I know the number of registered cars from 1923 to 1973. As I have population figures, I could calculate the number of inhabitants per car, or of cars per thousand inhabitants. From the year 1947, I know the number of registered cars of Swedish brand (Volvo or Saab). I also gathered figures for the production of Swedish cars, the extent of productions destined for home consumption and for exports. From the year 1948, I have the length of roads in kilometers. I have at my disposal the total state income from taxes on cars for the whole period, 1923-1973. Finally, I have the amount of the state expenditures on maintenance and construction of roads from 1923 to 1973. I also have data by county, including state assessed income tax, population figures, urbanization rates, cars registrations, roads length and state expenditures. Additionally, I have some aggregate data on other European countries: Austria, Belgium, Canada, Denmark, Finland, France, Italy, Norway, Portugal, United Kingdom, and the United-States.

I would have liked to have regionalized figures for GDP per capita. Lennart Schön and a group of researchers at Lund University are currently proceeding to this collect but results are unfortunately not yet available. I had therefore to use a proxy: the assessed state tax per individual.

### 1.4 Aims and Implications

My work could have several implications. First, it will give new insights and broaden the overview of private cars history in Sweden. It will explore causes of cars diffusion, such as pro-American lobby or industrial interests, which are often neglected. Moreover, it will give a new regional picture of the diffusion patterns of cars; indeed, so far no regional analysis has been carried out and differences in car ownership between regions are not known yet.

Second, my analysis could serve as a ground for further micro approaches that would study the historical formation of demand for cars. It could be interesting to study cars diffusion at a micro level, with longitudinal data on cars ownership and to get a social and economic understanding at an individual level. However, I wanted first to have a global comprehension at an aggregate level and, therefore, in this paper, I rule out on purpose micro explanations, concentrating on prices and demand elasticity, to focus my attention on the big level frame.

Finally, it could contribute to the current debate on the automobile age. To have a historical comprehension of driving forces for cars' demand could improve discussion about adaption and evolution of this hegemonic system -so pervasive but yet so seldom questioned.

# 2 THE AUTOMOBILE IN THE TWENTIETH CENTURY'S WESTERN WORLD

## 2.1Definitions

The automobile system is obviously not limited to cars and includes other vehicles, notably busses and trucks. Nevertheless, trucks are intended merely to transport goods and are of professional use, and busses are just a public alternative to urban private transportation. That is why I will study solely the private cars diffusion and not collective or good transportation. The private car is in the center of attention to comprehend automobile diffusion. (Elsässer, Bilismen, 2006, p. 23) (Thorburn, 2000, p. 58) Cars are in essence a mean for individual transportation of people, on the contrary to railroads which are collective and concerning to larger extent goods transportation. Individual cars are the most important and the most visible characteristic of the automobile system, and trucks or busses are somewhat marginal. In Sweden, in 1950, out of the 280,971 vehicles on the roads, only 2 percent were busses and 28 percent trucks, for 69 percent of cars. (Bilismen i Sverige, 1948-1975) Moreover, in this essay, I foremost want to comprehend the forces that influence the demand of individuals for cars.

Before studying the diffusion of private cars, one has to understand their functions. In the beginning, cars had different purpose than today. Only their diffusion and their improvement enabled afterward to extend their use. Indeed, until the 1970s, private cars were mainly used for short distance trips, especially in Europe where a dense railroad system was developed. In Sweden, as in the rest of Europe, they were used mostly for trips to and from work, then for grocery shopping and for leisure but to go on excursions within a short distance. Railroads remained the main transportation mean for longer distances. (Thorburn, 2000, pp. 61-63) In 1952, the average travelled distance by car was 16 kilometers whereas this average was 209 kilometers for trains. (Sjöberg, 1953, p. 31) In 1971, only half the people who owned a car would use it for vacation trips and the ones who did were younger. (The Automobile in Swedish Society. Motor Transport: People's Use and Attitudes, 1971) Cars were not either (and they are even less today) used much in cities as they are not practical for intra-urban transportation. In 1960, there were, in Stockholm city, 130 cars per thousand inhabitants whereas the national average was 145, even though the income per inhabitant was higher in Stockholm. (Bilismen i

Sverige, 1948-1975). During the first phase of the diffusion, cars were thus used for short distance peri-urban or rural transportation.

## 2.2 Alternatives to cars

To grasp the success of cars and to question the forces behind the diffusion process, one should have a brief knowledge of the alternatives that existed for short distance trips. For long distances, railroads were already well developed before cars were invented but they were not adapted for intra and peri-urban transportation. Cars were actually created at a critical time when cities were suffering from their increasing density engendered by urbanization processes.

In the second half of the nineteenth century, horse powered vehicles increased outstandingly. Indeed, the rising size of cities entailed a new need for transportation and at this epoch the only available vehicle for short distance trips were horse-pulled cars. One can understand the success of motor cars when one knows the drawbacks of animal powered vehicles.

First, excreta were a great public health problem. Every day, there were 2.5 million pounds of manure and 60.000 gallons of urine left by horses in New-York streets at the end of the nineteenth century. (Flink, The Automobile Age, 1988, p. 136) These dejections aggravated dissemination of diseases such as tetanus and engendered all kind of hygienic problems; the dust of dried manure caused for example respiratory infections. (McShane, 1994, p. 18) Moreover, flies that multiplied due to the use of horses contributed to the spread of diseases. Finally, carcasses of dead horses were a main problem for cities. According to Mc Shane, every year 15.000 dead horses were removed from New-York streets at the beginning of the twentieth century.

Second, horses were a very dangerous mean of transportation. In his book that debunks naive nostalgia for the past, *The Good Old Days-They Were Terrible!,* Otto Bettmann maintains that it was a challenge for pedestrians to cross Broadway; frequent accidents cost the life of thousands of people. Moreover, horses often kicked and bite pedestrians. (Bettmann, 1974, pp. 19-32; McShane, 1994, pp. 45-57) Roger Roots estimates, thanks to a per-mile based comparison, that automobile travel is much safer than horse-powered travel, even if the absolute number of

deaths increased with the diffusion of cars as people travelled a lot more. According to him, considering the speed and the distance attained by cars, their dangers compared to horse-pulled vehicles have been often overstated and their benefits understated. (Roots, 2007)

The description of horse transportation's dangers is sometimes mentioned in literature. For instance, in his historical novel published in 1859, *A tale of two cities*, Charles Dickens denounces well the violence of urban traffic in the nineteenth century. He depicts horse carriages as the symbol of the *bourgeoisie* contempt for the lower class.

> "With a wild rattle and clatter, and an inhuman abandonment of consideration not easy to be understood in these days, the carriage dashed through streets and swept round corners, with women screaming before it, and men clutching each other and clutching children out of its way. At last, swooping at a street corner by a fountain, one of its wheels came to a sickening little jolt, and there was a loud cry from a number of voices, and the horses reared and plunged. But for the latter inconvenience, the carriage probably would not have stopped; carriages were often known to drive on, and leave their wounded behind, and why not? […]" (Dickens, pp. 133-134)

Third, horses caused traffic congestion as they took a lot of space. Compared to cars, they were relatively slow and they could also collapse or die on the street. Traffic jams in nineteenth century cities were said to be worse than nowadays. (Bettmann, 1974; McShane, 1994)

Finally, horses were in no way a good mean of democratized transportation as they were too expensive. Having a horse required a stable and a chauffeur and horse lifespan was approximately of four years, nothing that could afford even middle class people. (McShane, 1994, p. 18)

In the upsurge of urban traffic, there was also another actor, the bicycle. The first type of bicycle, a velocipede with a high front wheel and pedals attached directly to it, was designed by French engineers in the mid-nineteenth century. Despite a relative success, it was more a "fashionable toy" (McShane, 1994, p. 54) and bicycles only gained importance for practical purposes with the invention of the "safety bike" in 1889. This modern bike, with rubber

pneumatic tires and gears, became quickly popular and widely diffused. However, the scarcity of documentation and estimates make any assessment of its objective importance in short-distance transportation very difficult. Moreover, the drawbacks of bicycle transportation (lack of paved roads, bad weather, sweat or non-proper attire) did not permit it to be the undisputed mean of urban transportation and it never was a solution to traffic problems. (McShane, 1994)

Railroads, if they had been a symbol of prosperity in the mid nineteenth century, were not really adapted to short distance intra-urban and peri-urban transportation. They caused accident and smoke pollution. (McShane, 1994) Bettmann blames railroads, that he calls “iron horses”, for causing chaos in cities. Some non-dangerous elevated railroads were developed, however, smoke and noise problems of steam engines remained. (McShane, 1994, p. 25) Electric trolley cars came as a good solution. Yet, they were not flexible and infrastructures investments were very high, limiting the diffusion potential. Bettman still very critical, accuses them for being chaotic, unorganized and expensive. (Bettmann, 1974, pp. 19-32)

There were no possibilities of increasing horse transportation in cities like New-York and their carrying capacity could not either be increased. As for railroads, trolley cars and bicycles, they were only partial solutions. Yet, urbanization continued and cities increased in size, and residential zones kept expanding, causing thus a greater need for transportation means. Cars came as a good alternative and they participated to improve life conditions in densely populated cities. Cars were more flexible, much more hygienic, safer and especially cheaper than horses and electric trolley cars.

## 2.3 From invention to diffusion

In this essay, automobiles are obviously always comprehended as vehicles with internal combustion engines. Automobiles went though, through many innovations before the internal combustion engine came as a breakthrough in the technology.

The first real automobile was steam-powered and was designed in 1769 by the French engineer, Nicolas Joseph Cugnot, for military purposes, to pull cannons. However, the very first steam engines were not efficient at all, less than horses, and it took until the end of the nineteenth

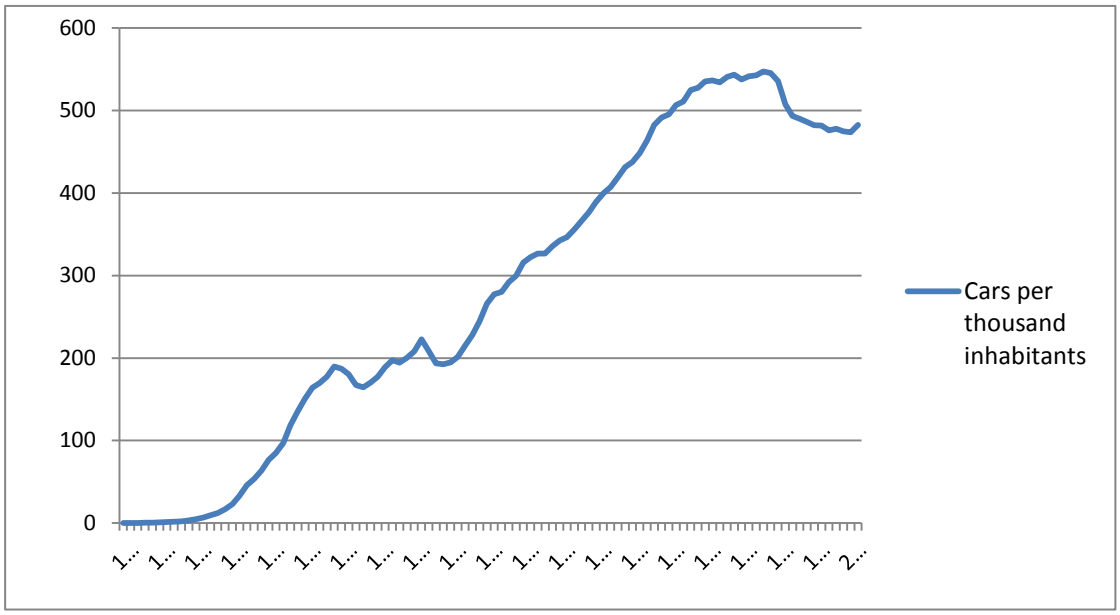
century to develop smaller steamers that had instantaneous energy production.(concerning the failure of the steam engine, read Mc Shane (McShane, 1994)) At this period a real emulation developed around automobile. There were also some attempts to create electric cars. Yet, one knows the problems encountered by electric cars nowadays so one can suppose the great price and inefficiency of such a vehicle at this time.

The major turn in automotive engineering came with the creation of the gasoline automobile with internal combustion. The first successful one was built by the French Etienne Lenoir but the first real practical vehicle was the result of technological innovations that occurred simultaneously from independent sources. Indeed, Daimler and Benz developed their vehicle independently in the mid 1880s. Production started in the 1890s in Paris were, progressively, settled a cluster of car manufacturing. Panhard and Levassor, and then Peugeot in 1891, were the first great scale manufacturers to specialize in car production. At that time, France's automotive industry was ahead and the Automobile Club of France was founded in 1895 to promote the development of motor vehicles. (Flink, The Automobile Age, 1988, pp. 1-14)

Mass diffusion of automobile happened in the United-States, much earlier and at a faster pace than anywhere else. It was achieved when mass production met mass consumption. This became a reality with the Ford T model that had a standardized production. This car had a relatively modest price in 1909 (905$) and it attracted a lot of customers. This commercial success, combined with the organizational genie of Ford, engendered a virtuous circle. Indeed, the great scale sales enabled the company to use mass production methods and to keep reducing the price (500$ in 1914) to, in the end, broaden even more the market. (Barker, 1985, p. 5; Flink, Three Stages of American Automobile Consciousness, 1972, pp. 458-459) In 1914, Ford applied assembly-line to the production, a new labor organization that would revolutionize not only the automotive industry but the entire world economy. The everyday car for everyone was born and the diffusion of automobile was at a point of no return. As Christopher Wells says in an article on the Ford T, this model enabled "to bridge the technological and social chasm that divided mobility". It combined reliability, durability, power, speed and it was quite inexpensive. (Wells, 2007, p. 522) Until the 1920s, the Ford T dominated the automobile

market. In 1923, it represented 55 percent of American automobile production. (Wells, 2007, p. 497)

On the graph I, below, one can see the sharp increase in car ownership around the 1910s. The diffusion was very rapid until the Great Depression of the 1930s.




**Graph I: Cars per Thousand Inhabitants in the United-States, 1900-2001**
**Data from** (The 2011 Statistical Abstract. The National Data Book , 2011)

It shows obviously a very similar trend to the one followed by Europe after the War. In 1905, there was less than a car per thousand inhabitants (0.9) while in 1930, at the eve of the Great economic crisis, the car ownership had reached 187 cars per thousand, a level that Europe would attain in the 1970s.(Table I) One can therefore understand why America is considered as the continent of automobile.

| Yeas | Cars per Thousand Inhabitants |
|---|---|
| 1905 | 0.9 |
| 1910 | 5 |
| 1915 | 23 |
| 1920 | 76 |
| 1925 | 151 |
| 1930 | 187 |

**Table I: Cars per thousand inhabitants, United-States, 1905-1930**
**Data from** (Bilismen i Sverige, 1948-1975)

## 2.4 The Car Society

Automobile became a dominant economic and social feature of twentieth century's developed nations. Its diffusion had a very important and unique economic impact and automobile developed a certain kind of hegemony over western societies. On one hand, it reduced the relative distance between people and activities and, on the other hand, it constituted the leading industrial sector for several decades. In 1963, in the United-states, one out of six jobs was provided by the automotive industry. (Flink, Three Stages of American Automobile Consciousness, 1972, p. 472) According to Holmberg and Hydén, since the 1970s, automobiles, directly or indirectly, create 10 percent of the Swedish employment. (Holmberg & Hydén, 1996, p. 16) The revolutionary labor organization of the Ford system is another example of the importance of the automobile industry. The supply chain appeared first with mass production of cars and was then applied to numerous other industries.

The economic potential of automobiles had been understood very early by contemporaries. The craze for this machine was strong since the very first years in the United-States. In 1902, in a sport news magazine, Outing Magazine, a journalist sums up quite well the implications of automobile for a nation.

> "No country can command its full strength until all its parts are easily accessible, and its people and their common interests are brought into the closest commercial and social union. […] What greater benefits may accrue from the automobile with good roads everywhere and speedy means of transportation within reach of each individual for himself and the product of his factory farm, cannot thus early be estimated. […] The millions of our rural population will be brought into closer relations with the towns and with neighbors, and the loneliness of farm life, which drives so many to the cities, with detriment to all, will no longer retard our agricultural growth, nor prevent a proper distribution of population welfare." (Lampton, 1902, p. 699)

The further diffusion of cars entailed urban changes. It enabled cities to grow out of their center and peri-urban areas extended exponentially. Cars affected the housing market and led to a

desertion of downtowns by upper and middle classes. It also, for example, determined the creation of supermarkets that were designed for customers with cars, as they were located outside of city center to benefit from lower housing price. Automobile stood in the heart of the consumerist society's expansion.

Apart from economic aspects, automobile also had, more than any other manufactured good, a social and cultural function established in the consumerist society. Cars can definitely not be reduced to a technology and many sociologists or historians have studied the symbolic aspect of car ownership.

Bourdieusian theories consider automobile as a status symbol, a tool of class distinction. Gartman defines two roles for the automobile, to "provide identity in sheet metal and autonomy in movement". He also defines three different ages of automobile with different motivations and distinction in individual car ownership. (Gartman, 2004) Clay Mc Shane even argues that the success of automobile is due to a change in urban culture. In his analysis, mainly valid for the United-States, he rejects linear explanations of an epidemic diffusion process that would have its roots in technological changes; he does not consider it as an objectively inevitable phenomenon. He links therefore suburbanization, gender gaps, and status identity to the study of automobile diffusion. (McShane, 1994)

> "Clearly cars served a multiplicity of emotional needs beyond providing transportation. They granted ersatz sense of both economic and gender status, in a culture where both were becoming harder to define. Consumers obtained a feeling of control and liberation in a society that was increasingly bureaucratized and regulated." (McShane, 1994, p. 147)

Withal, the Car Society is now, more than ever, in the center of concerns and worries as it has to face rising issues while being in a sort of path-dependence situation.

Path-dependence describes every "dynamic process whose evolution is governed by its own history" (David, 2007, p. 92) and applies to self-reinforcing mechanisms and lock-in situations of Pareto inefficiency. A famous example, studied in 1985 by Paul David, is the hegemony of

QWERTY keyboards despite their obvious inefficiency. This concept can be used to comprehend mass motorization and private cars diffusion as, in the establishment of the Car Society, history mattered more than anything else. The automobile system corresponds to the definition in the sense that decisions taken in the past have determined greatly future choices (foremost concerning city planning) and that "self-reinforcing dynamics consisting of scale economies and complementarity effects" are observable. (Schreyögg, Sydow, & Holtmann, 2011) Automobile will thus continue for a long time to be the dominant mode of personal transportation. It would be too difficult and costly to try to change societies organized around automobile; one could at best transform it very gradually.

Yet, it has to confront two major problems; first, the depletion of petroleum resources that still remain the main source of energy for cars, and, second, environmental issues that are becoming more and more visible.

Problems of production and prices of oil were raised after 1973 when the Organization of the Arab Petroleum Exporting Countries (OAPEC) used oil supply as a diplomatic weapon (to defend the Arab cause against Israel), reduced their production and started to decide the price unilaterally. (Flink, The Automobile Age, 1988, p. 389) In addition to diplomatic problems, the dependence to oil is very problematic as oil reserves seem to be very limited. Automobiles will have to rely on another source of energy in the near future and alternative cars, such as electric ones, are being developed by the automotive industry that is still struggling to find vehicles as efficient as gasoline internal-combustion engines.

Environmental issues have come up since the 1950s and their importance kept increasing. Since the Motor Vehicle Air Pollution and Control Act was signed in California in 1965 to impose standards on pollutants emitted by cars -considered as the first Act to regulate pollution caused by automobiles- automobile has been attacked and pinpointed as a major source of air pollution, foremost with the realization of global warming. (Flink, The Automobile Age, 1988, p. 387) This awareness reinforces the need to find alternative to combustion engines.

Understanding the historical diffusion process of automobile can provide certain hindsight to tackle these raising issues.

# 3 UNDERSTANDING THE DIFFUSION PATTERN IN SWEDEN

Thanks to a broad overview of international automobile's history, characteristics and issues, one can now look in detail at the diffusion pattern in Sweden and attempt to explain the forces that drove it.

## 3.1 The Swedish Advance

There were motor vehicles in Sweden already at the end of the nineteenth century, yet automobiles only became a social and economic reality after the First World War. In the 1920s, the Swedish railroads network was completed and living standards were steadily increasing in a country more and more prosperous.

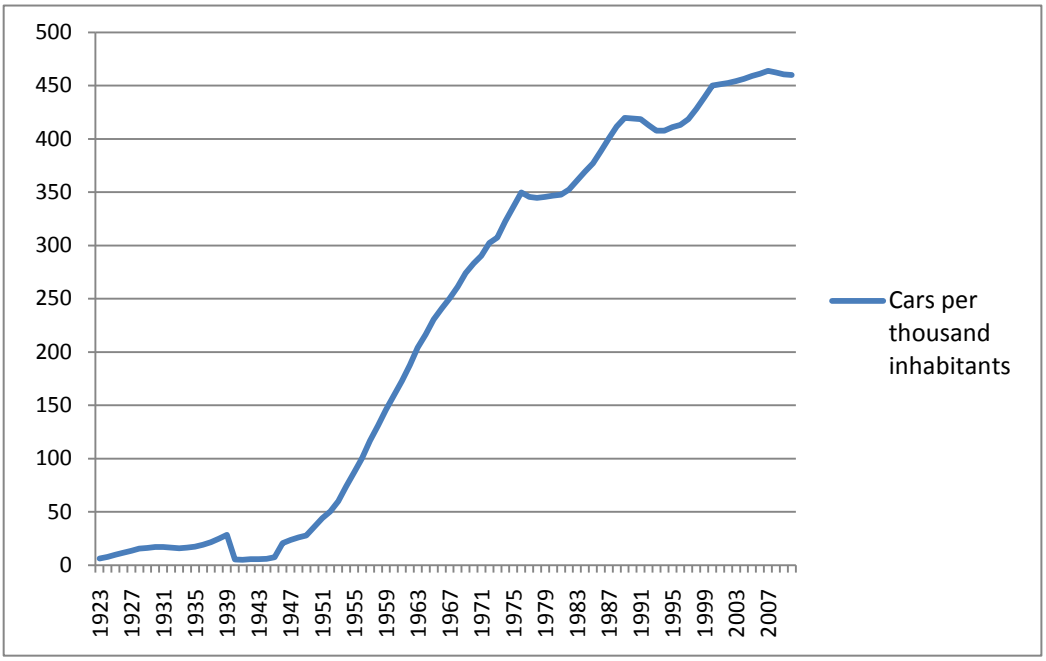
The first statistics on automobile precisely date from 1923. In 1923, there were 37,823 private passenger cars travelling the Swedish roads, a total of six cars per thousand inhabitants or 159 inhabitants per car. The diffusion was relatively fast in the 1920s, with a car ownership increasing by 149 percent between 1923 and 1928. This five years period had actually the second highest percentage increase after the period 1943-1948. (Table II)

However, levels were so low in 1923 that this observation is not so relevant. Moreover, the 1920s trend was not continued and was completely stopped by the 1930s Great Depression. There was barely any increase in car ownership rates between 1928 and 1933.

Once the Swedish economy started to recover, the rate went up again but rather slowly until the Second World War. This was a major obstacle for cars diffusion and the rate of growth was even negative until the year 1943. During the first years of the war the car ownership rate fell, to reach its level of 1923. There were only six cars per thousand inhabitants registered. (Table II)

| Periods | Percentage of change |
|---|---|
| **1923-1928** | 149 |
| **1928-1933** | 5 |
| **1933-1938** | 58 |
| **1938-1943** | -77 |
| **1943-1948** | 396 |
| **1948-1953** | 140 |
| **1953-1958** | 125 |
| **1958-1963** | 60 |
| **1963-1968** | 33 |
| **1968-1973** | 21 |
| **1973-1978** | 14 |
| **1978-1983** | 5 |
| **1983-1988** | 16 |
| **1988-1993** | 2 |
| **1993-1998** | 6 |
| **1998-2003** | 8 |
| **2003-2008** | 5 |

**Table II: Percentage of Change of Car Ownership over 5 years periods, Sweden 1923-2008**
**Data from** (Bilismen i Sverige, 1948-1975)




**Graph II:Cars per Thousand Inhabitants in Sweden, 1923-2010**
**Data from** (Bilismen i Sverige, 1948-1975)

The car diffusion really started after the War. The percentage of change between the year 1945 and 1946 was of 176 percent and of 396 percent between 1943 and 1948. The growth rate was very strong until the late 1950s before it started to decline as the market was becoming saturated.

One can see the dramatic growth of car ownership rate between 1945 and 1970 on the graph above. (Graph II) In 1945, in the beginning of Europe's Golden Age, there were eight cars per thousand inhabitants or 133 inhabitants per car. In 1970, at the end of Europe's Golden Age, there were 283 cars per thousand inhabitants or 3.5 inhabitants per car.

Since the late 1980s, the car ownership rate has stagnated around 450 cars per thousand inhabitants or approximately one car for two persons, a normal figure for a developed country. (Table III) If, nowadays, every OECD country has more or less the same car ownership rate, it was not the case during the diffusion period and Sweden was ahead in Europe.

| Years | Cars per 1000 thousand inhabitants |
|---|---|
| **1925** | 10 |
| **1930** | 17 |
| **1935** | 17 |
| **1940** | 5 |
| **1945** | 8 |
| **1950** | 36 |
| **1955** | 75 |
| **1960** | 159 |
| **1965** | 231 |
| **1970** | 283 |
| **1975** | 336 |
| **1980** | 347 |
| **1985** | 377 |
| **1990** | 419 |
| **1995** | 411 |
| **2000** | 450 |
| **2005** | 459 |
| **2010** | 460 |

**Table III: Number of cars per thousand inhabitants, Sweden 1925-2010**
**Data from** (Bilismen i Sverige, 1948-1975)

From the 1920s, as we have seen previously, the Western off-shots, and especially the United-States, had a much higher car ownership rate than Europe and they remained ahead until the 1990s. In Europe, there were two countries that were quite open to car culture and had a relatively high car density, England and France. Yet, the post war diffusion was faster in Sweden and in 1955 it reached the highest density of cars in Europe, with 75 cars per thousand inhabitants. (Table IV)

A comparison of figures between Sweden and other northern countries illustrates very well the extent of the Swedish advance. Norway and especially Finland were always at least ten years behind. Denmark started from roughly the same level in 1950 but the diffusion was much slower; between 1950 and 1970 the car density increased by approximately 700 percent in Denmark whereas it increased by almost 900 percent in Sweden. Denmark had a 5 years delay on the Swedish trend.

| Countries | 1950 | 1955 | 1960 | 1965 | 1970 |
|---|---|---|---|---|---|
| **Sweden** | **28** | **75** | **145** | **215** | **273** |
| Norway | 19 | 31 | 54 | 111 | 180 |
| Denmark | 25 | 43 | 77 | 142 | 208 |
| Finland | 5 | 17 | 37 | 89 | 140 |
| United Kingdom | 42 | 60 | 93 | 155 | 201 |
| France | 36 | 48 | 95 | 163 | 234 |
| Belgium | 25 | 49 | 76 | 132 | 184 |
| Italy | 6 | 15 | 33 | 89 | 168 |
| Austria | 5 | 10 | 49 | 97 | 149 |
| Portugal | 7 | 10 | 17 | 23 | 46 |
| **Average** | **20** | **36** | **68** | **122** | **178** |
| Canada | 120 | 163 | 212 | 261 | 303 |
| USA | 234 | 289 | 327 | 370 | 422 |

**Table IV: Number of cars per thousand inhabitants, 12 western countries, 1950-1970**
**Data from** (Bilismen i Sverige, 1948-1975)

## 3.2 Explanations by living standards and economic situation

The increase in car ownership is obviously tightly linked to levels of per capita GDP. This aspect has been much emphasized by historians. The earliness of the diffusion in the United-States is, for instance, explained by higher living standards than in Europe. (Elsässer, Bilismen, 2006, p. 19) Flink puts also an emphasis on income's role and affirms that working class in the United-States did not own a car until the 1950s. (Flink, The Automobile Age, 1988, p. 132)

The simple observation of GDP per capita levels and car ownership rates gives us an idea of the relationship between the two variables. One can see on the table V, displaying GDP per capita

and car ownership in percentage of American figures in 1970, that countries with highest levels of GDP per capita, Sweden, Canada and France, also have the highest car ownership rates.

Sweden had the highest GDP per capita level and the highest car ownership rate of European countries. Conversely, countries that were behind in economic terms in 1970, such as Portugal, Italy or Finland, also had fewer cars. (Table V)

| Countries | Car ownership (% of USA) | GDP per capita (% of USA) |
|---|---|---|
| USA | 100 | 100 |
| Sweden | 65 | 85 |
| Denmark | 49 | 84 |
| Canada | 72 | 82 |
| France | 55 | 78 |
| United-Kingdom | 48 | 72 |
| Belgium | 44 | 71 |
| Norway | 43 | 67 |
| Austria | 35 | 65 |
| Finland | 33 | 64 |
| Italy | 40 | 64 |
| Portugal | 11 | 38 |

**Table V: Car Ownership and GDP per capita in 12 western countries, United-States base 100, 1970**
**Data from** (Bilismen i Sverige, 1948-1975) (Maddison, 2001)

In Sweden, over the period 1923-2000, the coefficient of correlation between GDP per capita and cars per thousand inhabitants is close to one (0.99). This perfect correlation is not only valid for Sweden but for every country. For the United-States, the coefficient of correlation between disposable personal income and car ownership rate for the period 1929-2000 is slightly lower but still very high, 0.9. Fluctuations in car ownership rate and wealth had common trends and evolved in the same direction. Yet, despite the very close relationship between these two variables, it is not possible to assess any causal mechanism.

Relatively to its European neighbor, Sweden was precisely in a favorable economic situation after the war. The Swedish economy recovered relatively fast from the 1930s crisis and economic growth was higher than in many other industrialized countries until the 1950s. (Schön, 2010) Sweden, not only started from a higher level -confirming the living standard explanation- but investments could also be directed toward sectors favorable to the development of automobile. Growth was thereby slower than other European countries during the post war years due to its economic advance, but consumption increased faster. (Schön, 2010) It rose by more than 100 percent between 1950 and 1970 and public consumption even more than private consumption. According to Magnusson, this large share of public consumption directed private consumption toward durable goods, such as cars. Private

consumption of durable goods had the strongest growth in the 1950s, 5.7 percent per year. (Magnusson, 1997, pp. 433-437)

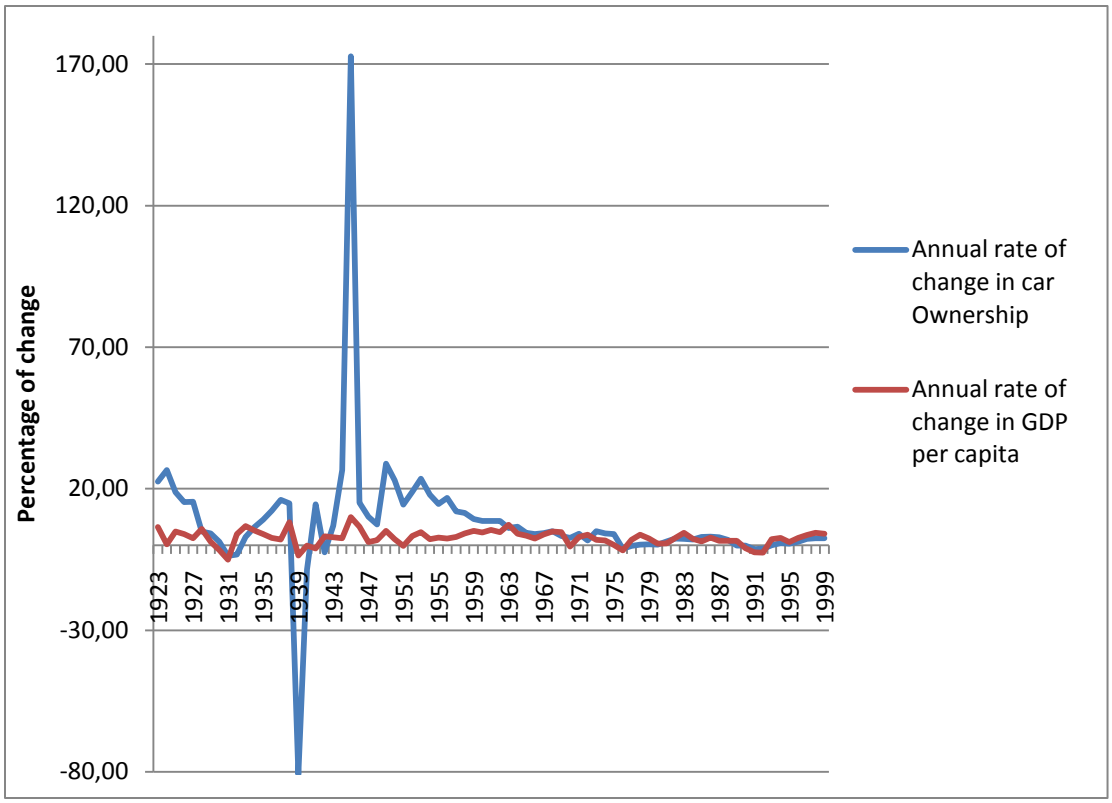
The fact that Sweden did not suffer from wartime destruction is also obviously tightly linked to this observation. Public spending could be oriented on road infrastructures for example (bridges, highway…) and not on reconstruction. In most European countries, public investments were made in industrial sector and not in transports and services. Per Ostby emphasizes this aspect for the Norwegian case. (Ostby, 2004, pp. 250-251)

Additionally, Sweden was affected by the global trade embargo during the war and was not able to import any manufactured goods, especially not cars. During the five years of the war, Sweden imported a very low annual average of 500 cars, with a rock-bottom of 194 in 1942. Production was also severely hit by the impossibility of importing raw material; Swedish car producers manufactured in average 300 cars per year during the war. The production was anyway not intended for private consumption but had functional purpose; the production of trucks and busses increased therefore to some extent. (Thorburn, 2000) In every instance, when the war stopped, production and imports started again and Swedes, in mass, were ready to buy cars that they had not been able to buy for external reasons. They had important savings and buying a car appeared first on the list.

Yet, these historical evidences only confirm the importance of an economic threshold needed for the take-off of mass motorization. To give a better assessment of the relationship between income and automobile ownership one should look at short term fluctuations. On the graph IV, displaying the annual rate of change of both variables for the period 1923-2000 in Sweden, one can see how car ownership reacts to short term fluctuations of GDP.

After 1960, once the market was saturated and the diffusion phase achieved, they fluctuated at the same pace, following a very parallel trend, but before 1939, the short term variations of the two variables were much less linked. As for the very high rates of change in car ownership of 1939 (negative, -80 percent) and 1946 (positive, + 170 percent), they were just caused by the war and related to trade embargo. Coefficients of correlation between annual rates of change of GDP per capita and of car ownership are 0.3 for the period 1923-1939, 0.55 for the period 1944-

1974 and 0.74 for the period 1980-2000. The more cars are diffused, the more sensitive to GDP annual fluctuations their ownership is.




**Graph IV: Annual rate of change in car ownership and GDP per capita, Sweden, 1923-2000**
**Data from** (Bilismen i Sverige, 1948-1975) (Krantz & Schön, Swedish Historical National

In brief, levels of GDP are more correlated with car ownership rate than short term fluctuations of GDP are, even though both correlations are strong. This observation proves the validity of the main hypothesis. Living standards are the main determinant to automobile diffusion. Björn Elsässer maintains precisely that the diffusion of private cars requires a minimum level of GDP per capita, between 5000 and 1000 USD (USD of 2000), and affirms that Sweden, in the 1950s, was precisely in this interval. He credits a snowball effect for further diffusion. (Elsässer, Bilismen, 2006, p. 23) The importance of a threshold seems to be confirmed by our findings (correlations and cross country comparison). The reaction of automobile ownership to short

term GDP fluctuations after 1960 could be explained by a level of saturation of the market, where rate of change is very low but more sensitive to economic fluctuations.

Though, the interval argument has weaknesses. For example, the demand for cars was higher in Sweden than in other European countries with similar living standards. The case of the Norwegian delay in car diffusion has been studied by Lindgren and Pettersson (Lindgren & Pettersson, 2009), and it concerns also other countries. On table V, one can also notice that, with almost the same GDP per capita, Sweden and Denmark had though very different car ownership rates. Moreover, in Sweden, the average annual growth rate of per capita GDP was approximately 3% during the 1950s whereas it reached 4.5% in the 1960s. Private consumption also only increased by 1.8 percent per year during the 1950s and by 3 percent during the 1960s. Yet, the strongest increase of car ownership was in the 1950s, on the contrary to numerous European countries that had their automobile diffusion in the 1960s. (Magnusson, 1997, p. 433) Finally, the differential between short and long term influences of income reinforces the idea that a certain GDP level was crucial to engender diffusion but that rapidity and earliness of the first phase of diffusion may depend on non-economic factors.

In brief, the Swedish automobile diffusion was 10 years early compared to other European countries, and, even if it can be due to the absence of war time destruction, a slight economic advance or important savings, it cannot be fully explained by economic performance. GDP level is clearly a necessary condition but not a sufficient one; it does not include the whole causal mechanism.

### 3.3 The roles of urbanization and population density

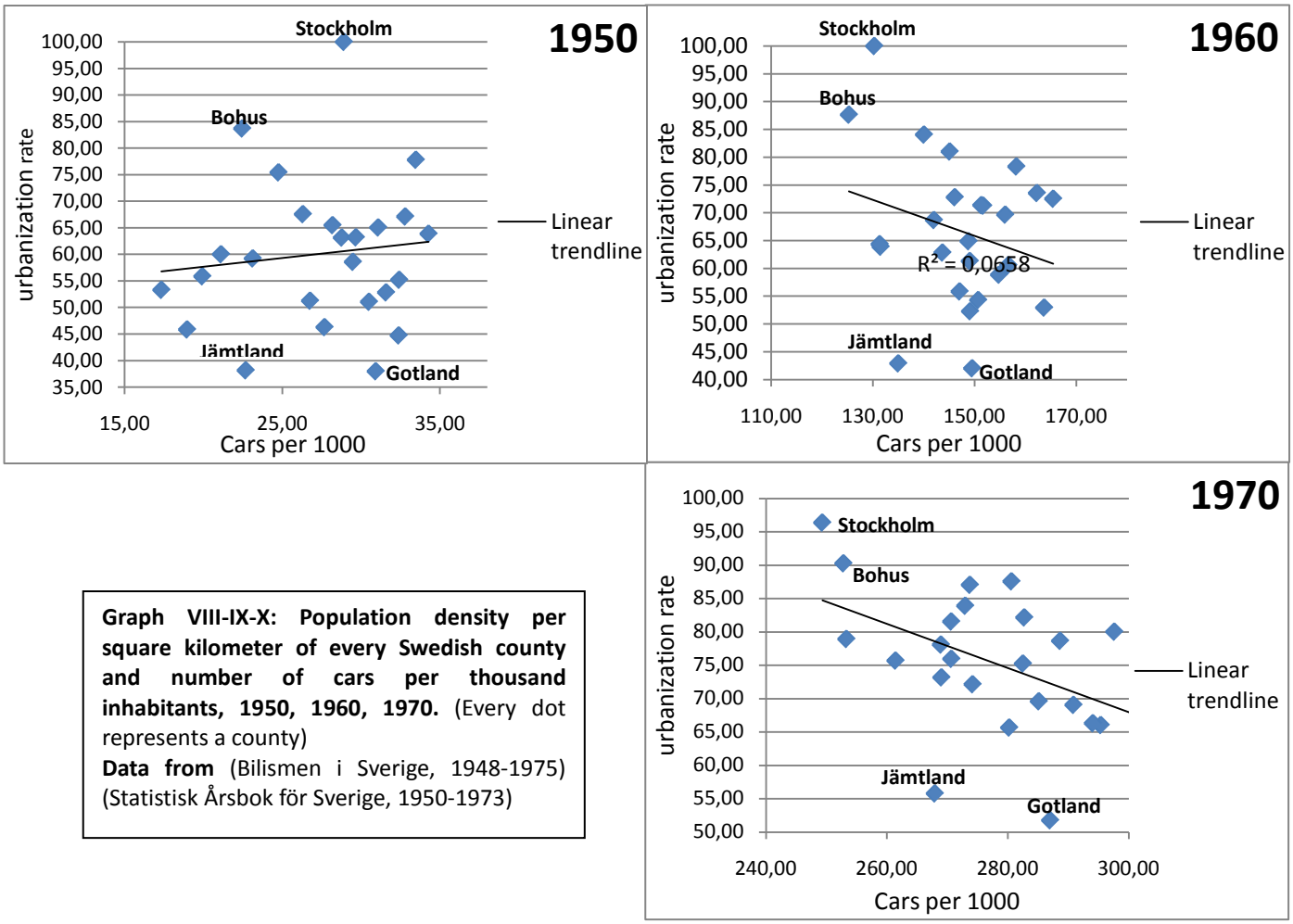
Besides living standards, the roles of population dispersion and urbanization have to be emphasized. These demographic and geographical factors seem to be the second most important necessary conditions that boosted automobile diffusion. (Elsässer, Svensk Bilindustri - en framgångshistoria, 1995; Flink, The Automobile Age, 1988) As both variables are linked and their impact is similar, they have to be analyzed in the same section.

I decided to examine these two variables at a county level because I believe that their influence on car ownership rate can be assessed, in the Swedish case, thanks to regional evidence. Indeed, political and economical factors stay quite equal while urbanization and population density differ according to county. Sweden was, in the second half of the twentieth century, quite homogenous in economic terms. Additionally it is unified and not federal, political decisions concern thus every county. On the contrary, counties have very particular geographical and demographic characteristics. Some are large with sparse population and low urbanization rates (Västernorrlands län, Jämtlands län…), others are very vast, not very populated but with high urbanization rates (Gävleborgs län, Kopparbergs län…), or some have a small area and are densely populated and highly urbanized (Stockholms län, Bohus län…). Moreover, urbanization and population density evolved over time independently in every county.

It is assumed for the American case that dispersion of population and low rates of urbanization favored the mass diffusion of automobiles. I insist on the term mass diffusion here because the early market of luxury cars had developed first in urban centers whereas the latter democratization of automobile concerned mostly rural areas. It has also been shown that in the United-States car ownership declined gradually with increasing urbanization. (Flink, The Automobile Age, 1988, pp. 131-132; Elsässer, Svensk Bilindustri -en framgångshistoria, 1995, p. 13) In Sweden, the pattern was similar. Population dispersion influenced the diffusion in the very beginning and then, in the 1960s and 1970s, car ownership started to decline with extent urbanization.

Coefficients of correlation between car ownership and urbanization rate[3] increase negatively over time. In 1950, the coefficient is a low and positive (0.11). The positive sign could confirm the fact that until the war, in the 1930s, cars diffused mostly as luxury goods in urban areas. However, it is too low to assess any correlation. In 1960, it is still low but negative (-0.26) and in 1970 it starts to become significant, -0.46. Yet, the phenomenon does not seem to be explained by the fact that car ownership really increased in rural counties but that it relatively decreased in urban areas. One can see this trend on the graphs below. (Graphs V, VI, VII)

[3] The urbanization rate here is the percentage of inhabitants living in localities over 200 inhabitants.



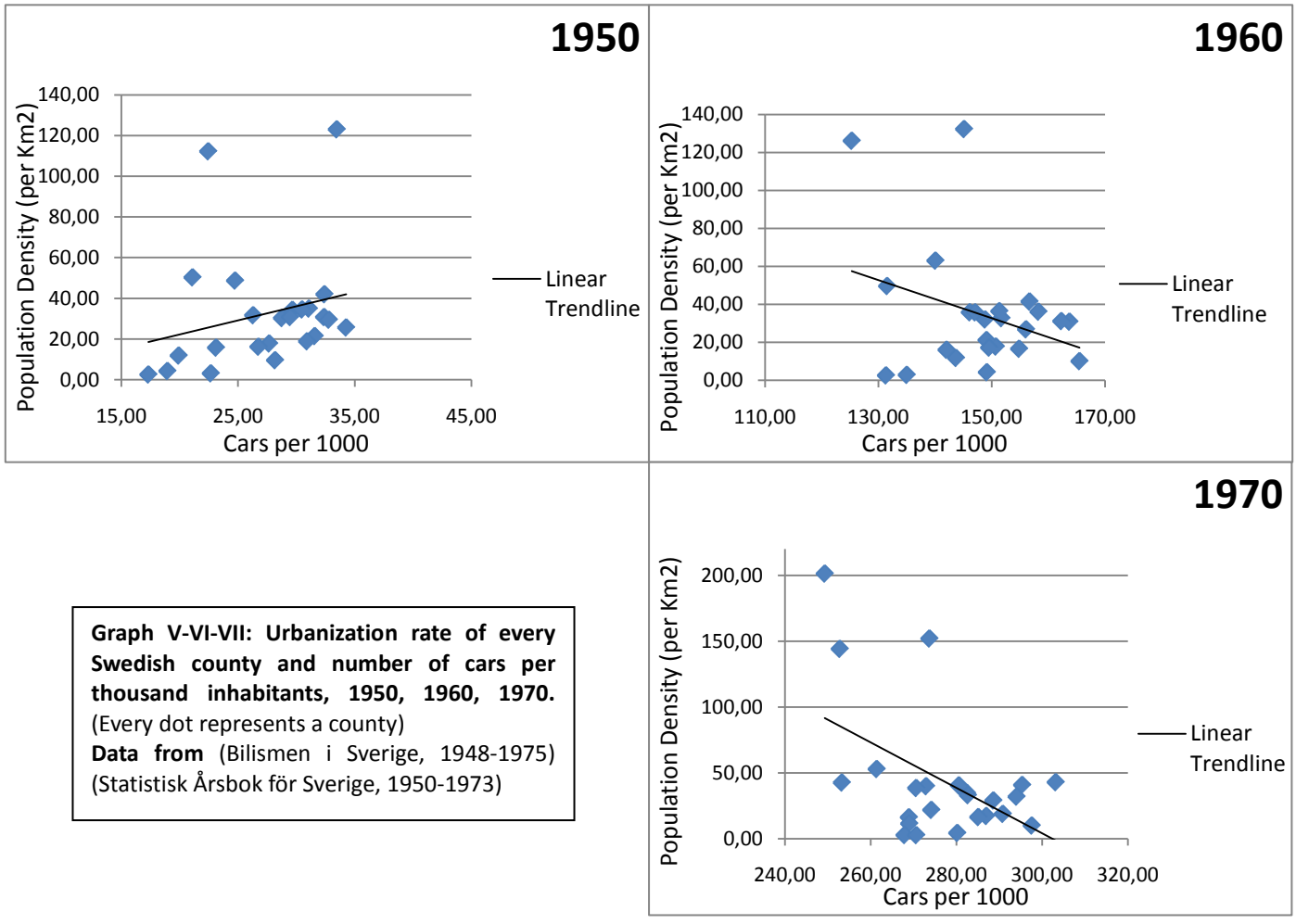

**Graph VIII-IX-X: Population density per square kilometer of every Swedish county and number of cars per thousand inhabitants, 1950, 1960, 1970.** (Every dot represents a county)
**Data from** (Bilismen i Sverige, 1948-1975) (Statistisk Årsbok för Sverige, 1950-1973)

However, when one excludes the two outliers (Göteborg and Stockholm) the trend gets smoother. The positive relationship between urbanization and car ownership is even stronger in 1950 with a coefficient of correlation of 0.28 and, on the contrary, with a coefficient of -0.23, the negative relationship is not as obvious in 1970. In 1950 and 1960, there are still more cars in urbanized areas, with the exception of the two major cities, Göteborg and Stockholm. Only from the 1970s, there is a clearer negative link between urbanization and car ownership.

In the two counties with highest urbanization rates (Stockholm län and Bohus län), the car ownership rate declines relatively to other counties over the three periods, whereas, in the two counties with lowest urbanization rates (Gotlands län and Jämtlands län), it does not increase relatively to other counties. The extent of urbanization is proved to have a negative impact on

automobile diffusion, the correlation is quite clear on the scatters, but the positive impact of rural population is on the contrary not obvious.

The pattern is approximately the same with population density. (Graphs VII, IX, X) Car ownership is similarly correlated with population than it is with urbanization. In 1950, the coefficient of correlation is not significant but positive (0.07), in 1960 the correlation is becoming stronger and negative (-0.34) and in 1970, the correlation is quite significant (-0.5). However, here, the two outliers bias even more the results. When excluding Göteborg and Stockholm counties, the coefficient of correlation appears to be much higher in 1950 (0.48) and much lower low in 1970 (-0.1).




**Graph V-VI-VII: Urbanization rate of every Swedish county and number of cars per thousand inhabitants, 1950, 1960, 1970.** (Every dot represents a county)
**Data from** (Bilismen i Sverige, 1948-1975) (Statistisk Årsbok för Sverige, 1950-1973)

In conclusion, there were more cars in counties with sparse population dispersion in the first years of diffusion. Yet, there were also more cars in urban centers, but that has mostly to do with income effect (urban areas being wealthier than rural areas). In 1960s and 1970s, population dispersion was not longer determining for further diffusion but urbanization on the contrary had a negative impact on car ownership. In the 1960s the car ownership growth became slower in major urban centers (Stockholm or Göteborg for example) and in the 1970s it started to relatively diminish as well in other urbanized parts (Uppsala, Östgöta).

In that respect, the Swedish pattern of private car diffusion, from the 1950s to the 1970s, was quite similar to the one followed by the United-States in the 1920 and 1930s.

# 4 COMPLEMENTARY EXPLANATIONS

There were though other factors than economic performance and living standards, urbanization and population density, that were specific to the Swedish automobile diffusion and that could explain its earliness and rapidity. Maybe the most obvious characteristic would be the presence of a powerful car industry. However, the most important factors are less visible. These factors are a successful mix of Swedish political decisions favorable to mass motorization (pull) and of international lobbying and transfer of technology (push).

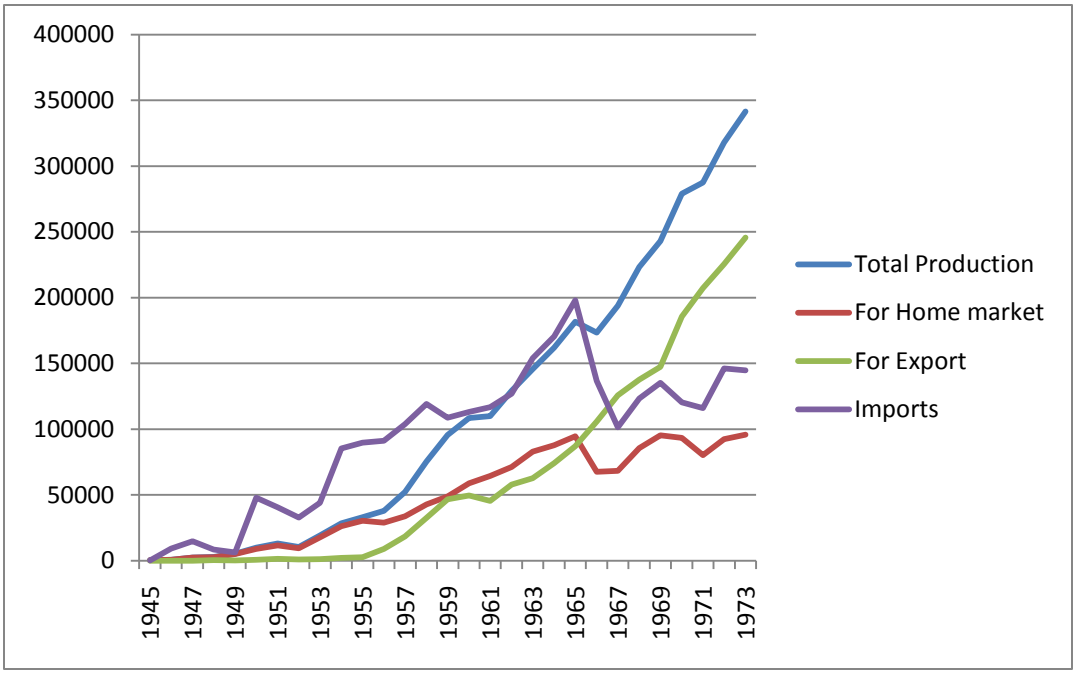
## 4.1 The Swedish automobile industry

The Swedish economic policy in force since the 1930s also generated a favorable environment for the development of an industry such as the automotive one. The activist approach of the state permitted to establish a tight link with private industry. Road construction and automobile industry constituted the major development block after the war and benefited thus from important public investments. (Schön, 2010, pp. 284-285)

I precisely believe that the importance of the Swedish automobile industry have played a major role in accentuating the diffusion. Sweden had, and still has, a relatively big automotive industry. Other small European countries, such as the Netherlands, Belgium, Norway or Denmark, never had, or did not succeed to develop, an automobile industry, whereas, it has a very pronounced role in the Swedish economy. Indeed, the automobile industry's share of value added of all manufacturing industry is very important in Sweden. In 1988, it reached 11.6 percent compared to 6.4 percent in the United-States, only Germany had a higher share of 11.8 percent. (Elsässer, Svensk Bilindustri -en framgångshistoria, 1995, p. 59)

The industry quickly developed after the war. As previously said, imports exploded when trade embargo were removed but production increased proportionally more during the period 1950 to 1970. The two Swedish automobile manufacturers are Saab and Volvo and their real expansion began only after the war. Saab did not exist as a car producer before and Volvo had a very marginal production of private cars. Volvo was founded in Gothenburg in 1926 by Assar

Gabrielsson and Gustaf Larson. The company developed and strengthened during the war, producing mostly busses and trucks, but also boat motors, tractors and plane motors. Before the war, they had concentrated on sales to the public sector. In 1942, Volvo was the 33rd largest Swedish company in terms of employees; in 1970 it was second behind *Allmänna Svenska Elektriska Aktiebolaget* (an electrical company). Saab transformed from a plane manufacturer to a car producer after the war. The first Saab arrived on the Swedish private cars market in 1950. In 1964, Saab was the ninth largest employer of Sweden. (Elsässer, Svensk Bilindustri -en framgångshistoria, 1995, p. 77)




**Graph XI: Total production of private cars: production for the home market and for exports. Total imports of private cars. Sweden, 1945-1973.**
**Data from** (Bilismen i Sverige, 1948-1975)

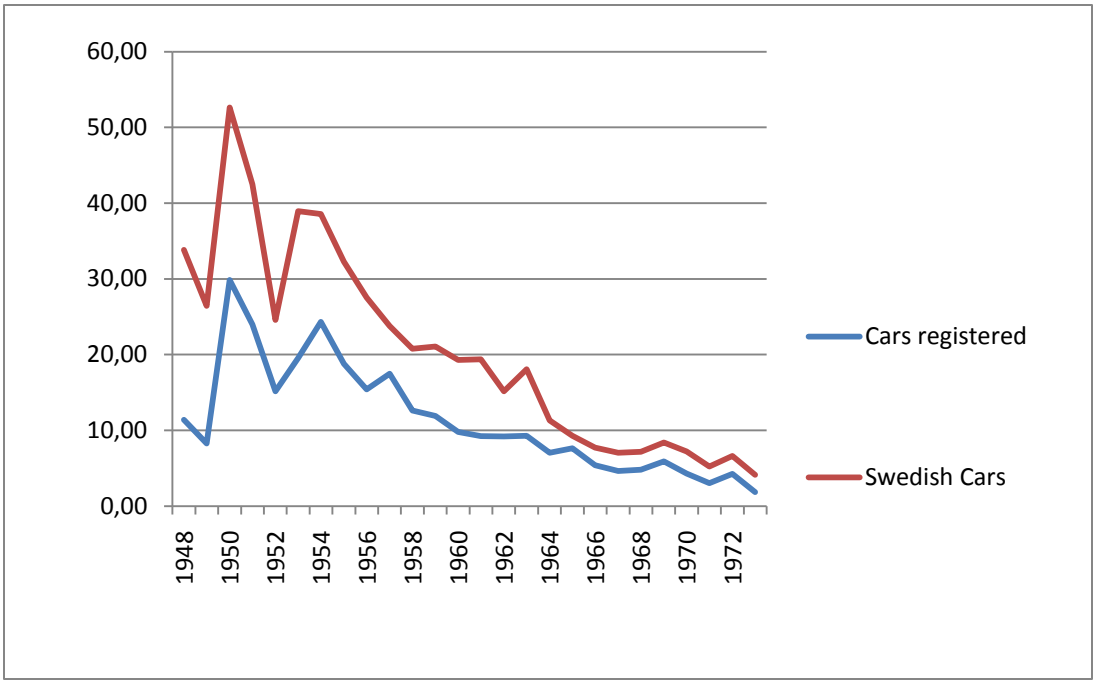
The production of private cars increased faster in Sweden than in any other European countries. The increase was particularly strong in the 1950s. During this decade, the annual growth rate of private cars production was 23.9 percent. Its share of the world private car production went from 0.1 percent in 1950 to 1.2 percent in 1970. The production of busses and trucks was even more important; it reached 14 percent of the world production in 1994. (Elsässer, Svensk Bilindustri -en framgångshistoria, 1995, p. 66) Sweden had always been, on international markets, specialized in the production of trucks and busses (Krantz, Studier i Svensk Godstransportutveckling med särskild hänsyn till lastbilismens expansion efter 1920, 1972);

exports of private cars only increased later, in the course of the 1960s. Sweden had to wait until 1967 to become a net exporter of private cars.(graph XI) The strong increase in production, right after the war, was therefore solely directed for home market and it could partly explain the sudden acceleration of automobile ownership.

As one can see on table VII, from 1950, the percentage of Swedish automobiles on the roads kept rising until the 1970s to reach 40 percent; a percentage that is nowadays approximately the same. In 1947, approximately 6% of all cars owned in Sweden were a Volvo or a Saab whereas in 1973, there were over 40%. The number of Swedish cars increased more than proportionally. (Graph XII)

| Years | Percentage of Swedish Cars |
|---|---|
| 1950 | 9,8 |
| 1955 | 17,6 |
| 1960 | 25,9 |
| 1965 | 34 |
| 1970 | 38,3 |

**Table VII: Percentage of Swedish cars owned in Sweden, 1950-1970**
**Data from** (Bilismen i Sverige, 1948-1975)




**Graph XII: Annual percentage of change in the total number of cars and in the total number of Swedish manufactured cars, Sweden, 1948, 1973.**
**Data from** (Bilismen i Sverige, 1948-1975)

The opposite causal mechanism could also be defended, as a rapid diffusion of cars certainly encouraged the further development of the industry. However, the chronology, the place of this industry in the development block and the ties of the Swedish state with large companies, seem to suggest that the Swedish car industry had a triggering role in the rapid diffusion of automobile. The influence of the automobile industry on the expansion of the Car Society was at the same time direct, by supporting the pro-automobile lobbies, or indirect, by benefiting from governmental policies that wanted to develop the Swedish automobile industry and which invested on roads and implemented favorable policies.

## 4.2 "Push and Pull": American transfers of technology and political decisions

To understand the diffusion of mass motorization in post-war Europe, one cannot forget the determining influence of American organizations and policies, either helping the transfer of technology or participating in the pro-automobile lobbying. Moreover, national political decisions have to be considered as the different receptions of mass motorization greatly influenced the pace of the diffusion in each country. To simplify, there were one mechanism of pushing toward the Car Society orchestrated by American sources and one mechanism of pulling depending on political decisions. These aspects have recently been emphasized by several scholars. (Blomkvist, 2004; Seely, Klingner, & Klein, 2004; Lundin, 2004)

The pushing forces determined highway and traffic engineering transfers. The International Road Federation (IRF), the Bureau of Public Roads and Yale University's Bureau of Street Traffic Research took an active participation in this process of technology transfer. The IRF, the main actor for automobile promotion, was created in 1948 by American multinational companies. Most of them were dealing with car, oil or rubber sectors. Shell was the most important support. They wanted to strengthen the industry that had severely been hit by the war. One of the main activities was to initiate the development of national road federations in Europe. In 1948, only five countries had a local branch of the IRF: France, Great Britain, Switzerland, The Netherlands and Sweden. They were the richest countries and the ones where automobile was the most spread. International Road Federation through its local branch, the Swedish Road

Federation, shaped road policies and helped to put Sweden in a very advanced situation in terms of private cars ownership. This federation was initially founded by the Royal Automobile Club in 1914. Supposed to federate the engineering community charged of roads construction, it was a "politically neutral provider of technical knowledge and expertise" (Blomkvist, 2004, p. 278). It reorganized in 1947 and got diverse economic support from industries and, in 1948, it became the Swedish national branch of the IRF.

The transfer of technology was a great success in Sweden, more than in any other European country. Thanks to strong "pulling" forces, it went fast and did not encounter any obstacles. The machinery and the building technology were directly imported from North America. (Seely, Klingner, & Klein, 2004) Per Lundin argues that the American engineering model was literally transposed to Sweden. He talks of American number copied. (Lundin, 2004) This transfer was performed in most European countries but the pushing force was not sufficient itself and the adoption of mass motorization was largely dependent on the reception made by the country.

It was certainly easier in Sweden, partly because the state had not to focus on reconstruction and could invest in different sectors such as transports, as argued in the previous part of this paper. However, the role of ideology seems to have been even more determining. The diffusion of automobile had to be accompanied by a sort of positivism. The first slogan of the IRF speaks for itself: "Better Roads Mean Better Living". (Blomkvist, 2004, p. 282) In Sweden, this ideology was precisely broadly accepted and the Car Society was seen as an ideal for the future and for the present economy. Swedish Social Democracy provided also a positivist frame that was decisive for mass motorization expansion. With its tradition of allying technology and welfare in a progressive manner, it insured this neutral and technocratic frame required for a fast technology transfer. According to Blomkvist, road federations kept "technifying" the road issues "to legitimate [their] efforts as non political" (Blomkvist, 2004, p. 278). The Federation was though ambiguous in its relation with both the state and the industry, and neutrality and technocracy were to a certain extent a cover for their activities. In a very committed book, entitled *"Ska vi asfaltera Sverige?",* Anel et al. denounce the attitude of the Swedish State and maintain that market forces were prominent in the political decision process. They deplore the sacrifice of railways to asphalt. (Anel, Hedborg, Ingelstam, & Lönnroth, 1971)

The support to automobile diffusion was achieved through a series of laws and plans. Adopted in the late 1950s and early 1960s, they favored the development of road transportation, often to the detriment of railroads. (Anel, Hedborg, Ingelstam, & Lönnroth, 1971) The most important decision was the unanimous adoption by the Swedish Parliament of the Road Plan in 1959. Quite unique in Europe, this plan, in the vein of the Marshall Plan, had the aim to develop and modernize the country's network of roads "to suit the needs of mass motorization". (Blomkvist, 2004, p. 288) The Marshall Plan, and all programs of European cooperation after the war, had the idea to develop a system of European traffic arteries to interconnect all national roads. In view of this, Sweden switched to driving on the right side in 1967, like the rest of continental Europe.

Additionally, even though Sweden supported its own automobile industry, there were very low restrictions on imports of cars. In most European countries, that were also producers of cars, taxes on import were very high. From the 1930s to the 1960s they oscillated around 30 percent in France, the United-Kingdom, Italy and Germany. In Sweden, as in the USA, taxes were much lower, around 15 percent. (Elsässer, Svensk Bilindustri -en framgångshistoria, 1995, p. 39). So even if the national industry expanded greatly after the war, imports were extremely important in absolute numbers, especially in the late 1940s.

To grasp the quality of the pro-automobile environment that insured the success of the technology transfer in Sweden, one could make a comparison with the Norwegian case. Per Ostby studied the diffusion of automobile in Norway and showed that, like in Sweden, the automobile system was strongly pushed by international sources. Yet, on the contrary to Sweden, there was a political resistance to the car society. There were restrictions on sales and imports of cars, and barely any investments on roads and transports. Car was seen as "an immoral and even threatening technology". (Ostby, 2004, p. 248) It was solely considered as a luxury item until the 1960. However, the number of cars increased in spite of restrictions and in spite of the small extent of investments in road infrastructures. Policies had thus to change and, during the course of the 1960s, gradual adjustments were made for the use of motor vehicles. This example actually challenges the initial hypothesis of this paper, that individual demand could not have determined the diffusion of cars but that higher authorities had to play a role.

Indeed, in the Norwegian case, state policies had to adapt to an increasing demand that was solely driven by individual will and made possible by higher income. The desire for cars was the key factor for diffusion. The unfavorable environment just slowed down the process and delayed it by ten years. Yet, diffusion of automobile was not a free process. Indeed, when the government shifted its position, its role radically changed from restrictions to promotion. Ostby speaks of "educating the nation" (Ostby, 2004, p. 254) In Norway, the institution that participated in that process, the equivalent of the Swedish Road Federation, was the Information Council for Road Traffic. It was not a simple lobbying force as it was a mix of all motor trade's organization. It had thus ambiguous roles, acting for both commercial and social interests.

To sum up, the success of the diffusion in Sweden, as well as in Norway ten years later, was the result of the marriage of science, politics and industry in a technocratic way and, in both cases, the technocratic expertise came from the United-States through the International Road Federation.

## 5 REGRESSIONS

So far in this paper, I have described patterns of automobile diffusion and I have shown the advance of Sweden in terms of private car ownership during the Golden Age. In my attempt to explain general diffusion process of mass motorization and to understand the specificity of the Swedish pattern, I have highlighted different determinant factors, according to previous findings and literature on the topic, and I evaluated their role with descriptive statistics. In this final part, I will go further and I will weigh up these factors thanks to regressions.

In the case of automobile diffusion, knowing that income per capita is the main variable, running a regression with a time series model is very difficult if not impossible. Indeed, every model that will include both income and time will be biased as both evolve together and as it is very difficult to separate income effect from time trend. (Jansson, Cardebring, & Junghard, 1986, s. 11) It is why when I tried to assess the role of living standards by checking the correlation between GDP per capita time series and car ownership time series I found such high coefficient as 0.98. Time and GDP per capita during this period have a coefficient of correlation of 0.98, as well as time and car ownership.

I decided thus to run a cross sectional regression for the counties in Sweden. Indeed, Sweden is a vast country with 24 counties having very different geographical, demographic and economic characteristics. The causes and explanations of private car diffusion can thus be highlighted by such a regional analysis.

As one can see on table VI, there were some significant differences in car ownership rates between the counties. Moreover, these differences evolved quickly during the diffusion phase of automobile and the respective situation of each county differs greatly. The county with the highest rate is never the same. In 1950, Jönköpings county has the highest, in 1960 it is Skaraborgs county and in 1970, Kristianstads. One can also see a convergence of northern counties. In 1950, Västerbottens, Norrbottens and Jämtlands counties have figure a way under average and in 1970 they are either above or close to average. Finally, one can remark, as previously assessed in this paper, the relative decline of automobile in very urbanized counties (Stockholm, Göteborg).

| Counties | cars per thousand 1950 | cars per thousand 1960 | cars per thousand 1970 |
|---|---|---|---|
| **02 Stockholms län** | 25 | 140 | 249 |
| **03 Uppsala län** | 29 | 152 | 253 |
| **04 Södermanlands län** | 30 | 151 | 273 |
| **05 Östergötlands län** | 31 | 146 | 271 |
| **06 Jönköpings län** | 34 | 156 | 289 |
| **07 Kronobergs län** | 28 | 151 | 291 |
| **08 Kalmar län** | 32 | 149 | 274 |
| **09 Gotlands län** | 31 | 150 | 287 |
| **10 Blekinge län** | 21 | 132 | 261 |
| **11 Kristianstads län** | 32 | 157 | 303 |
| **12 Malmöhus län** | 33 | 145 | 274 |
| **13 Hallands län** | 30 | 147 | 295 |
| **14 Göteborgs och Bohus län** | 22 | 125 | 253 |
| **15 Älvsborgs län** | 29 | 149 | 282 |
| **16 Skaraborgs län** | 32 | 164 | 294 |
| **17 Värmlands län** | 27 | 155 | 285 |
| **18 Örebro län** | 33 | 162 | 283 |
| **19 Västmanlands län** | 26 | 158 | 281 |
| **20 Kopparbergs län** | 28 | 165 | 298 |
| **21 Gävleborgs län** | 23 | 142 | 269 |
| **22 Västernorrlands län** | 20 | 144 | 269 |
| **23 Jämtlands län** | 23 | 135 | 268 |
| **24 Västerbottens län** | 19 | 149 | 280 |
| **25 Norrbottens län** | 17 | 131 | 271 |
| **National Average** | **27** | **147** | **277** |

**Table VI: Number of cars pet thousand inhabitants in the 25 Swedish counties (24 after 1967), 1950, 1960 and 1970.**
**Data from** (Bilismen i Sverige, 1948-1975)

As factors determining automobile diffusion certainly changed over time, according to the diffusion phase, I will also take three bench mark years and will compare the results and the independent variables of each model. I choose 1953, 1960 and 1970 as most change happened during this time period and as data were the most complete from 1953. The observations of the regressions will be the 24 Swedish counties. Stockholm city is ruled out on purpose, as this county was merged with Stockholm's county in 1967 and as I want to have the same number of observations for every regression. Moreover, this county was limited to the city itself and that characteristic could have biased the calculations.

The aim of this analysis is to explain levels of private car ownership according to counties. The dependent variable will then obviously be the number of cars per inhabitants. Based on theories and findings discussed in previous parts, I selected a series of independent variables. I opted for a proxy for GDP per capita as it does not yet exist by county for these periods. The proxy is the average assessment for State income tax per inhabitant. I assumed that the amount of this progressive tax gives a good estimate of individual income. I included also, population density, urbanization rate, length of roads, state expenditures on roads (investment and maintenance) in crowns spent per car, the length of roads and also the density of roads networks (kilometer of roads per square kilometer). I will see which factors are the most important according to the period. Initial regression models, including all independent variables, are displayed in *appendix*. Models displayed below are the best ones, the most robust and most significant.

| | | |
|---|---|---|
| **Multiple R** | 0,937 | |
| **R Square** | 0,878 | |
| **Adjusted R Square** | 0,852 | |
| **Observations** | 24 | |
| **Significance F** | 2,03E-08 | |
| **Variables** | **Coefficients** | **P-Value** |
| Population Density | -0,543 | 7,34E-08*** |
| Income | 0,902 | 9,8E-05*** |
| State Expenditures | -0,676 | 2,15E-08*** |
| Roads network | 0,522 | 1,42E-06*** |

**Multivariate Regression, 24 Swedish Counties, 1953**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Population Density (inhabitants per square kilometres) (logged)

- Average assessment for State income tax, crowns per inhabitant (logged)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

-Kilometers of roads per square kilometres (logged)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

The results of the regression for 1953 are displayed above. Four independent variables were kept: population density, the proxy for income per capita, state expenditures on roads and road networks density.

The adjusted R-Square of 0.85 is very high for a cross sectional regression. 85 percent of car ownership differential between the 24 counties is explained by these four factors. The overall significance is good, F is very low and the null hypothesis can be rejected. Additionally, the P-value of every independent variable is also very low. The model is thus very robust.

The independent variable representing income has a positive coefficient. It confirms the initial hypothesis. The wealthier a county, the more cars there were. The density of road networks, calculated as kilometers of roads per square kilometers, has also a positive coefficient. It logically means that counties having a better road network also had more cars. In 1953, income and asphalt were the two positive determinants for private car ownership.

Population density is also significant but negative. Urbanization had to be dropped, having a too low P-value. In this cross-sectional analysis, the role of population dispersion seems to be important, and that confirms our previous findings. In an early diffusion phase, the less densely populated a county, the more cars it had; urbanization rates, on the contrary, did not have any significant impact.

Finally, the last interesting finding showed by this regression is the negative relationship between state expenditures on roads and car ownership. This seemingly surprising result is actually quite normal. Of course, the relationship is not functional and it does not explain differences in automobile ownership but it shows the direction of public investments. As we previously said, the state was really involved in the development of Swedish road networks and investments were directed toward counties having the less developed ones. Yet, these counties had logically lower car ownership rates because, on one hand, roads were not asphalted and one another hand, but to a lesser extent, because these counties were relatively poorer. This strong empirical evidence, of the state involvement in developing road networks to enable automobile to diffuse homogenously all around Sweden, is also confirmed by the strong negative correlation found between roads density and state expenditures (-0.7)

For the year 1960, with the same independent variables, it was not possible to get a good R-square and a significant model. The results of the best regression are displayed below but the adjusted R-square is too low to be considered, 0.3. Moreover, the F-test and independent

variables' P-values are quite high and the null hypothesis cannot always be rejected. Only State expenditures on roads and population density seem to be significant.

Income was not significant at all and the R-square was too low when it was included in the regression so I decided to rule out this variable. It means therefore that, in 1960, income was not determining for car diffusion. Automobile prices had indeed decreased and everyone could afford a car. Population density has still a negative coefficient but lower than in 1950. If population dispersion had been important in the 1950s, in 1960 the relation was less pronounced.

| | | |
|---|---|---|
| **Multiple R** | 0.651 | |
| **R Square** | 0.423 | |
| **Adjusted R Square** | 0.302 | |
| **Observations** | 24 | |
| **Significance F** | 0.026 | |
| **Variables** | **Coefficients** | **P-Value** |
| Population Density | -0.083 | 0.012** |
| Urbanization | 0.015 | 0.091* |
| State Expenditures on Roads | -0.177 | 0.035** |
| Length of Roads | 0.036 | 0.316 |

**Multivariate Regression, 24 Swedish Counties, 1960**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Population Density (inhabitants per square kilometres) (logged)

-Urbanization rate (percentage)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

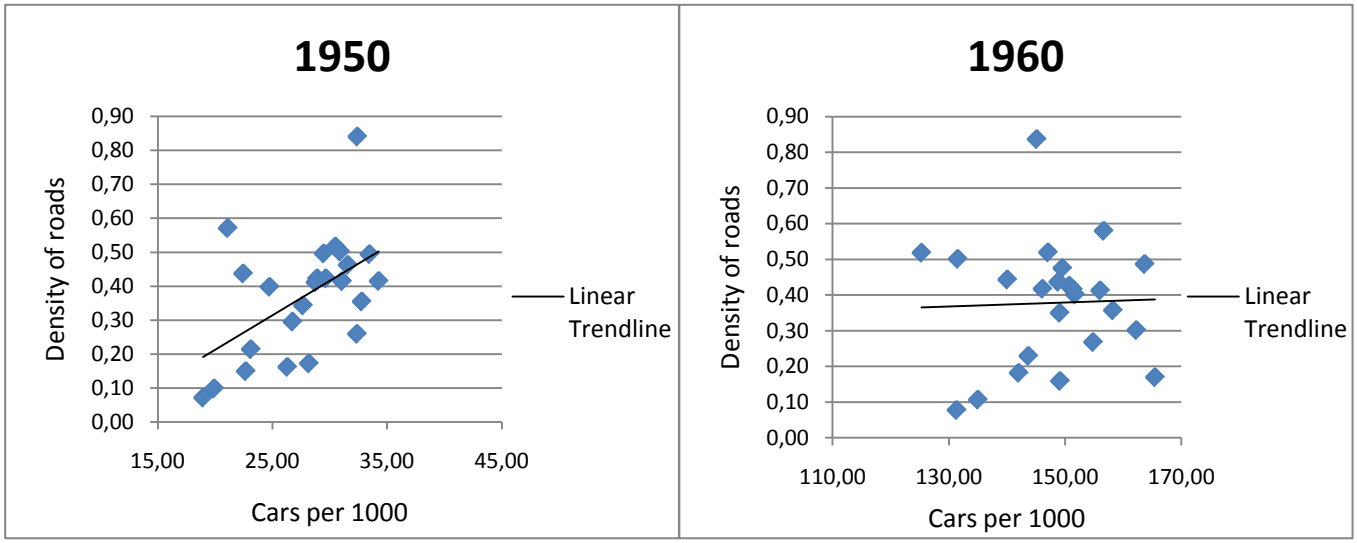
-Total length of roads in kilometres (logged)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

The interesting observation from this regression is the low coefficient for state expenditure. Indeed, it is much lower than in 1953 and it can mean that the State policy was changing as there was a convergence between counties in terms of road infrastructures. But it can also be due to economic convergence: the poorer counties of 1950s were wealthier and had thus more cars, even though the state was still investing there to develop road networks. Between 1950 and 1970, the state expenditure per car was indeed very high in northern counties, such as Norrbotten and Jämtland. However, this observation is difficult to interpret as these counties

are very vast and sparsely populated. It is obvious that investments per car will be much higher than in very populated counties having a small area and thus low lengths of roads. I looked therefore at expenditures on roads per kilometer of roads. Göteborg and Stockholm had by far the highest ranks. But once again, that is not very interpretable as roads infrastructures in cities cost more than rarely used countryside roads.

The important role of road infrastructure during the beginning of automobile diffusion is also assessed by looking at the correlation between road networks density (expressed in kilometers of roads per square kilometer) and car ownership rate. The coefficient of correlation between the two variables is quite high in 1950 (0.6) but close to zero for 1960 and 1970 (respectively 0.03 and 0.05). In 1950, the more developed the road network, the more cars there were. One can conclude that, until the 1950s, the diffusion of automobile was limited by the state of roads as there was a lack of asphalted roads. From 1960, road networks had improved to a point where the number of cars was not longer influenced by this factor. (graph XI and XII)




**Graph XI-XII: Kilometers of roads per square kilometer of every Swedish county and number of cars per thousand inhabitants, 1950, 1960.** (Every dot represents a county)
**Source:** (Bilismen i Sverige, 1948-1975)

On the contrary to the previous regression, the regression for 1970 gave good results. The best model only includes four independent variables: the proxy for income per capita, urbanization rate, state expenditures on roads and total length of roads. The adjusted R square is quite high, 0.64. The F test is good, the null hypothesis can be rejected, and P-values are reasonably low.

| | | |
|---|---|---|
| **Multiple R** | 0.838 | |
| **R Square** | 0.703 | |
| **Adjusted R Square** | 0.641 | |
| **Observations** | 24 | |
| **Significance F** | 7.52E-05 | |
| **Variables** | **Coefficients** | **P-Value** |
| Income | -0.180 | 0.076* |
| Urbanization | -0.002 | 0.081* |
| State Expenditures on Roads | -0.100 | 4.27E-05*** |
| Length of Roads | 0.056 | 0.003*** |

**Multivariate Regression, 24 Swedish Counties, 1970**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Average assessment for State income tax, crowns per inhabitant (logged)

-Urbanization rate (percentage)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

-Total length of roads in kilometres (logged)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

Income has a negative coefficient. This is also confirmed by coefficients of correlation. Income and car ownership are positively correlated in 1950 and 1960 but in 1970 the coefficient is quite high and negative (-0.49). That is easily explainable by urbanization expansion. Urbanization and income are indeed strongly correlated (0.8 in 1970) and as previously argued urbanization and car ownership are negatively correlated. People are generally wealthier in cities and cities tend to have a lower car ownership rate; a negative relationship between income and car ownership can thus indirectly be found.

In this regression, population density had to be dropped as it was not significant. That is directly in line with the previous findings. Population dispersion had no impact on car ownership after 1960.

This regression also corroborates the observation of the previous regression. State expenditures' coefficient is even lower than in 1960 and 1950. The state still spent more where the car ownership rate was low but the automobile market had come to a situation of saturation, the differential between counties becoming less pronounced, and roads infrastructures had converged thanks to investments.

Length of roads was not significant in previous years models and had to be dropped, but for the 1970 model, it is significant. The relation between length of roads and car ownership is certainly due to the fact that counties with the largest areas, and thus the longest roads, started to have relatively more cars than smaller counties more urbanized. It is therefore a confirmation of the negative effect of urbanization on car ownership.

This series of regression enables to draw several conclusions.

-The role of income on mass motorization expansion was limited to the 1950s. In the 1970s, the relation with income is even negative (explained by inter relation with urbanization).

-In the very beginning of automobile diffusion, the absence of asphalted roads seems to have been quite a hinder.

-Population dispersion had a positive influence in the 1950s but the relation disappeared completely in the 1960s.

-Urbanization had a negative impact on automobile diffusion in the later phase of diffusion. In the early phase, it had a positive effect but that can be explained by an income effect, cities being generally wealthier than the countryside.

-The importance of state expenditures on roads is permanent during the whole period of diffusion. State investments had the aim to develop roads in counties where cars were less diffused and to lead a convergence of regions in terms of road infrastructures and networks.

-In 1970, the mass motorization reached its peak. Cars were affordable by everyone and roads networks were fully developed.

# 6 CONCLUDING REMARKS

Mass motorization happened almost ten years earlier in Sweden than in the rest of Europe. From 1955, it had the highest private car ownership rate in Europe, with 75 cars per thousand inhabitants. Even France or United-Kingdom that had a strong automobile culture and tradition were behind.

Living standards, so to speak GDP per capita, were decisive for automobile diffusion. The correlation between car ownership and GDP is almost perfect. The economic performances of a country are decisive for the expansion of automobile and the idea of a GDP threshold conditioning diffusion can be maintained. This threshold was reached by Sweden in the early 1950s. Sweden's favorable economic situation after the war (in comparison to other European countries), the absence of wartime destructions, the high level of savings and the thus logical capacity to invest in roads infrastructures and transport sectors corroborate these observations and explain partly the Swedish advance.

Similarly to income, population density's influence on automobile ownership was limited to the very beginning of the diffusion. Urbanization, on the contrary, was not significant in the early years but started to have a negative impact after the 1960s. Automobile ownership relatively declined with urbanization but did not, however, significantly increase in rural areas in the 1960s and 1970s.

These two lines of argumentation explain only partially the earliness of the Swedish diffusion. Why, for example, did it happen faster and earlier there than in Denmark or the United-Kingdom, two countries having high living standards, or than in Norway which has similar geographical features? Moreover, increase in car ownership in the 1950s was more than proportionally than GDP and consumption increase. Finally, GDP and time are so correlated that it is very difficult to assess anything with time series. Living standards are certainly a necessary condition but not a sufficient one; they do explain neither the intensity nor the earliness of the phenomenon. External factors shed light on the process.

The success of the Swedish automobile industry accompanied the expansion of mass motorization. This leading sector was in the center of a development block and one of the largest employers of the country. Swedish manufactured cars also gained a huge popularity and, by 1970, 40 percent of cars on the Swedish roads were either a Saab or a Volvo. Therefore, when one knows the very tight relation that the Social democracy has always entertained with large companies, one can understand the favorable political decisions that were taken during the 1950s to develop mass motorization and implicitly to encourage the national industry.

The diffusion of automobile in Europe owes also much to American pro-automobile lobbying groups. In Sweden, their action was extremely successful thanks to, as previously stated, a particular economic situation and favorable political decisions. Sweden copied the American model, “importing” technology and expertise. The state did not restrict imports for example and invested large amounts to develop road networks, homogenously in the country. The 1959 Road Plan was one of the greatest actions in that matter.

The roles of income, as well as population dispersion, were limited to the beginning of the diffusion phase. Wealth was solely determining as a threshold. Logically, when cars became an affordable good for everyone, income stopped playing a crucial role. Sweden’s advance in the 1950s can thus be partially explained by its sparse population and its favorable economic situation. Yet, infrastructure conditions, so to speak kilometers of asphalted roads, were also a key factor in the early years of mass motorization process. In that sense, the state initiative was crucial, and their investments, supported by a strong ideology, determined the pattern of automobile diffusion in Sweden. The example of the Norwegian case is very eloquent. One can see that living standards and individual demand determined and forced mass motorization but that the pace and the schedule of the diffusion were fixed by external factors.

This macro level historical analysis of the forces that drove mass motorization in Sweden could now be completed by a micro analysis. Longitudinal data on automobile ownership in the diffusion phase and an emphasis on price elasticity and micro economic phenomenon would help to grasp diffusion mechanisms not visible in a macro approach.

WORD COUNT (excluding tables, legends, table of contents and bibliography): approx 12,400

# Appendix

**Initial Regression Model, 1953**

| | | |
|---|---|---|
| **Multiple R** | 0,943529 | |
| **R Square** | 0,890247 | |
| **Adjusted R Square** | 0,85151 | |
| **Observations** | 24 | |
| **Significance F** | 2,83E-07 | |
| **Variables** | **Coefficients** | **P-Value** |
| Population Density | -0,491 | 3,83E-05*** |
| Income | 1,040 | 0,000113*** |
| State Expenditures | -0,677 | 5,66E-08*** |
| Roads network | 0,454 | 0,000311*** |
| Length of roads | -0,013 | 0,741527 |
| Urbanization | -0,001 | 0,260711 |

**Multivariate Regression, 24 Swedish Counties, 1953**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Population Density (inhabitants per square kilometres) (logged)

-Average assessment for State income tax, crowns per inhabitant (logged)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

- Kilometers of roads per square kilometres (logged)

-Total length of roads in kilometres (logged)

-Urbanization rate (percentage)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

For this regression, the only available urbanization rate[4] closest in time was the rate for 1951. I choose it, assuming it did not dramatically change between 1951 and 1953.

[4] Percentage of inhabitants living in localities over 200 inhabitants.

**Initial Regression Model, 1960**

| | | |
|---|---|---|
| **Multiple R** | 0,665 | |
| **R Square** | 0,442 | |
| **Adjusted R Square** | 0,244 | |
| **Observations** | 24 | |
| **Significance F** | 0,089 | |
| **Variables** | **Coefficients** | **P-Value** |
| Population Density | -0,192 | 0,031** |
| Income | 0,140 | 0,638 |
| State Expenditures | -0,203 | 0,016** |
| Roads network | 0,181 | 0,113 |
| Length of roads | 0,0132 | 0,752 |
| Urbanization | 0,002 | 0,568 |

**Multivariate Regression, 24 Swedish Counties, 1960**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Population Density (inhabitants per square kilometres) (logged)

-Average assessment for State income tax, crowns per inhabitant (logged)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

- Kilometers of roads per square kilometres (logged)

-Total length of roads in kilometres (logged)

-Urbanization rate (percentage)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

**Initial Regression Model, 1970**

| | |
|---|---|
| **Multiple R** | 0,851 |
| **R Square** | 0,724 |
| **Adjusted R Square** | 0,627 |
| **Observations** | 24 |
| **Significance F** | 0,0005 |

| **Variables** | **Coefficients** | **P-Value** |
|---|---|---|
| Population Density | -0,048 | 0,300 |
| Income | -0,032 | 0,846 |
| State Expenditures | -0,102 | 0,002*** |
| Roads network | 0,054 | 0,409 |
| Length of roads | 0,034 | 0,203 |
| Urbanization | -0,001 | 0,382 |

**Multivariate Regression, 24 Swedish Counties, 1970**

**Dependent Variable:**

-Number of Cars per 1000 inhabitants (logged)

**Independents Variables:**

-Population Density (inhabitants per square kilometres) (logged)

-Average assessment for State income tax, crowns per inhabitant (logged)

-State Expenditures on Roads (maintenance and investments) crowns per car (logged)

- Kilometers of roads per square kilometres (logged)

-Total length of roads in kilometres (logged)

-Urbanization rate (percentage)

*0.1>P-value>0.05 **0.05>P-value>0.01 ***0.01>P-value

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