Costs, technology and culture

Propelling the early taxicab, 1900–25

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Historians of transport have come up with several reasons why, at the beginning of automotive history, the petrol-engined car soon appeared to be the preferred means of road transport. Most of the arguments in favour of the internal combustion engine and against the steam engine and the electric motor are technological or economic in nature. However, detailed research into some electric vehicle fleets, especially a well documented eighty-vehicle fleet in Amsterdam between 1909 and 1925, does not support this line of reasoning.[1] In particular, the thesis that the petrol-engine car was technologically or economically superior to its electric or steam-driven competitors seems to be inspired by hindsight rather than based on solid historical evidence.

It is not hard to find tautological definitions of this superiority in the historiography of technology. According to Robin Cowan, for instance, in his study of the nuclear power reactor, 'the superior technology is that which, if it were to be the surviving one, would maximize net benefits from the technology choice process'.[2] The assumption among historians of technology and transport of the petrol engine's technical superiority is open to question. For example, in her analysis of female and male car culture Virginia Scharff bases her argument partly on the alleged technical inferiority of the electric car.[3]

In another case James Foreman-Peck calculated for the United States that the steam car was the most popular because of its low fuel and purchase costs, and that the petrol car became the 'best buy' when the annual distance covered was more than 53,000 km.[4] It is unlikely, however, that money was an issue for early automobile pioneers: in those days anyone who could afford a car was replacing his stable of horses, and sometimes bought several – one for driving out of town, one for shopping, and so on.

The pivotal period, therefore, to investigate this question seems to be the transition phase shortly before and after the recession of 1907, when the market hesitated to expand to buyers willing to motorise on the basis of a limited budget. Like fleet managers they had to choose. Elsewhere I have argued that historical evidence suggests cultural rather than economic and technical factors to explain the choice of the internal combustion engine.[5] Economic considerations were not explicitly included in the analysis, mainly because it is extremely difficult to find coherent data. The most one can say

about it is that incidental cost calculations contradict each other so much that no consistent picture can be drawn from the data.

But what if the car was used not for pleasure but purely as a means of transport, like the taxicab? If costs were ever a decisive argument for or against electric propulsion it would be in this particular field of urban vehicle fleet management. After all, modern versions of fleet management, based on scientific fodder analysis and on the monitoring of individual carriage performance, were already emerging during the second half of the nineteenth century, for instance at the Paris monopoly concern CGV. Although pleasure and utilitarian applications are not directly comparable, certainly not in the case of electric propulsion, if the electric taxicabs proved to be more expensive than petrol-engined cabs, or if their technology proved 'inferior', the case for the electric vehicle would not be strengthened. Fortunately, very detailed logs of an eighty-vehicle electric taxicab fleet in Amsterdam have been preserved, enabling us to test this hypothesis.[6]

The emergence of the petrol-driven taxicab, 1905–14

Most historians' negative attitude towards the electric vehicle as a serious alternative to the petrol-engine car stems from the first generation of electric road propulsion, when several early taxicab experiments proved disastrous, mainly because of defective battery technology.[7] It should be remembered, however, that during the period up to the beginning of the twentieth century not a single large-scale taxicab experiment on the basis of the petrol car was initiated, simply because that type of vehicle was considered too unreliable. However, for the second generation of electric road propulsion, from shortly before the recession of 1907 until the outbreak of the First World War, the situation changed drastically. Not only were reliable batteries appearing on the market, but the petrol-engine car market showed signs of saturation. Petrol-engine car manufacturers, whose products functioned mainly as *peri-urban* adventure machines (operating within and beyond the largest urban areas), started to develop more reliable products which could compete with electric vehicles as reliable *town* cars. Generally speaking, transport historiography has not fully recognised the consequences of this: early car use had a substantial utilitarian component, which, until the urban petrol-engine car appeared on the scene, was realised for the most part by electric propulsion. The taxicab was a new means of propaganda for motoring during this second phase as the successor of the sports car. Moreover the deployment of the taxicab in tough city conditions was regarded as a realistic test of the usefulness of the automobile as a means of transport.

In an atmosphere in which the proponents of electric propulsion were nervous of new failures, the petrol-engine car had a chance in the city. The role of the French automobile industry was decisive here. Thanks to the sales of its taxicabs, Renault had become the largest French manufacturer by 1907. Renault's success was due particularly to the Compagnie française des automobiles de place (CFAP), which started a taxi service in December 1905. Its

fleet expanded swiftly to 2,700 by 1911. In 1914 the CFAP merged with the Compagnie Autos-fiacres (CAF), which contributed another 820 vehicles, mostly Renaults. In 1910, a year before motor taxicabs surpassed the number of horse cabs in Paris, 53 per cent of taxis were Renaults.[8] With the introduction of the taximeter, which first appeared on Paris horse cabs in 1904, effective monitoring of drivers' income became possible. According to the historian Anne Boudou, taxi fares were the secret behind the sudden success of the taxicab in Paris. Since the police prefecture fixed only the maximum fares, with increasing competition taxi fares approached those for horse cabs; meanwhile vehicle speed doubled. The latter advantage was mainly psychological, as in the centre of Paris motorisation saved passengers hardly any time.[9] Between 1905 and 1910 several other large cab companies were established in Paris, although many of them, as well as quite a few horse-cab businesses, failed in the economic crisis of 1907. This was a consequence of a gradual decrease in net profit per car due to the cost of tyres.[10] The first fleets of motor taxicabs and hire cars in Paris were the elixir of life for the early automotive industry. Between 1907 and 1911 the share of taxicabs in the Paris automobile fleet rose from 10 per cent to 44 per cent.[11]

The French automotive industry received another boost in 1907, when the group that was behind the CFAP started a similar company in London, the General Motor Cab Company. Immediately upon its foundation, this company ordered 500 Renault taxicabs of an improved type. An American observer of the London taxicab business estimated that 33 per cent of costs were for petrol, 27 per cent for (solid) rubber tyres and 18 per cent for chassis repairs.[12] In 1909 London had 2,400 motor taxicabs, half of them Renaults. About fifty makes competed for the rest of this lucrative market. The turning point in the change from horse to motor traction was 1910, a year earlier than in Paris. Whereas the motor taxicab was profitable for the large Parisian companies, it was less so in the glutted London cab market, despite cheaper petrol. By September 1911 300 companies owned 7,360 motor cabs in London but, of the fifteen largest companies, only two paid a dividend after 1910.[13]

As in London, the same financial group tried to get a foothold in New York City as the New York Motor Cab Company, although instead of Renaults the competing Darracq marque was chosen. In the United States both the American automotive industry and the domestic horse-cab companies were notably absent from the introduction of motor taxis. New companies filled the vacuum and initiated a rapid process of motorisation. In New York the New York Taxicab Company was especially active. It was a subsidiary of the New York Motor Cab Company, the shares of which were equally distributed among the London and the Paris taxicab groups, and a group of rich New Yorkers. Harry and Walter Allen, importers of Mercedes and De Dietrich automobiles, had established the Motor Carriage Company at about the same time, and in 1907 they merged their company with the Franco-British group. By May 1908 300 Darracqs with taximeters were operating in New York, while another 500 were on order; the previous year a third of the 1,800 cabs in New York were Darracqs.[14] Although not a single American automobile

manufacturer had launched a taxicab model by the winter of 1907, in 1908 they began to catch up. The E. R. Thomas Motor Company in Buffalo was one of the first to do so, followed by the Ford Motor Company, the Cadillac Motor Car Company and other makes. A flood of companies followed in their tracks, but, of the fifty that were counted in New York City in 1911, only eight were left in 1913.[15]

The second-generation American electric taxicab

The considerable European share of the American taxicab fleet reflects the unreliability of the early American petrol car and explains its limited deployment in the cab business. As late as 1911 3,000 of the 5,000 American taxicabs were still European, mostly French (Renault, Darracq, De Dion and Delahaye). The American Taxicab Company operated almost 4,000 of them, distributed among ninety locations.[16] However, this story also suggests that the petrol-engine car had become reliable enough by 1908 to replace the electric cab at the New York Transportation Company and hasten the introduction of new petrol cab fleets in New York and other US cities. And the 1912 bankruptcy of this company, heir to the Electric Vehicle Company's fleet, seems to support the assessment.[17]

But such a conclusion would be unwarranted. Indeed, proof of the delicacy of the balance between the competing propulsion systems is a remarkable initiative in Detroit, the world capital of the petrol-engine motor car. Shortly before the outbreak of the First World War, the Detroit Taxicab & Transfer Company (DTTC), one of the oldest petrol-engine cab companies in the United States, found that passenger car manufacturers were not interested in building a robust automobile in the $2,000 to $2,500 range which could replace its existing fleet of petrol-engine cabs. At 70c for the first mile and 40c for each succeeding mile, and operating costs of between 30c and 35c per mile, the profit margins of this company were very narrow indeed. Moreover, petrol cabs became noisy after a few months of intensive use, and there were complaints about grease and 'gasoline smells'. 'It therefore became necessary,' concluded Mr I. S. Scrimger, of the Detroit firm, 'that we obtain equipment that could be operated more cheaply than gasoline cabs.' Thus the company decided to build its own spacious luxury electric cab.[18]

On 25 June 1914, at two o'clock in the afternoon, the first electric car became operative at the Hotel Pontchartrain. DTTC company engineer W. J. Behn was the designer of the car. By January 1915 ten electric cabs were in use, each covering about 2,200 km a month, and by May 1915 the first cab had driven almost 20,000 km. The DTTC considered this proof of the reliability of its design and held out the prospect of a fleet of seventy cars. This meant that electric cars would have replaced almost all the company's petrol cabs and 'only a very few gasoline cars for very long runs [would] be retained'. When in the summer of 1917 almost 100 cabs were in use, women were being hired as cab drivers; indeed, there was an overwhelming response from more than 500 'patriotic women'. Those selected were given a few hours of

instruction and received the same wages as the men, although they worked only during the day.[19] The DTTC's electric cabs were such a success that customers were prepared to wait half an hour for one, even though the company's petrol cabs were waiting at the taxi stand. The cars were equipped with Goodrich's expensive Silvertown pneumatic tyres and the operating costs remained below 20c, ten to fifteen cents lower than the DDTC's petrol cabs.[20]

The DDTC made use of special electrical charging poles at the cab stands, a practice known as 'curb [kerb] boosting'. New York, Philadelphia, Chicago and St Louis were soon interested in following the example of Motor City. In New York and Philadelphia it did not get beyond the planning stage, but in Chicago a fleet of twelve electric cabs became operational in April 1917 and a few months later six electric cabs were introduced in St Louis. In Chicago the cabs were meant to supplement twenty petrol-engine cabs but 'practically displaced the gas cabs as patrons constantly requested them'.[21]

The electric taxicab in Amsterdam, 1909–26

It is not easy to explain how electric taxicabs could flourish amidst the growing dominance of the petrol-engine variety. The experience of Atax in Amsterdam allows us to analyse the potential 'failure factors' against the background of a well documented fifteen-year experiment with electric taxicab operation.

Compared with other European electric cab companies Atax (Amsterdamsche Taxameter Automobielen Maatschappij) was a latecomer. On 28 December 1908 it was founded as a subsidiary of the Amsterdamsche Rijtuig Maatschappij (ARM). Since the 1880s the horse cab had been the mainstay of ARM's business, but it was suffering increasingly from the competition of cheap public transport.[22] Then, in 1903, Joan Frederik Friderichs joined the ARM's board of directors. Friderichs had been in charge of the construction of d.c. power plants for a Dutch electrical engineering company and in that position he became acquainted with electric batteries, which were used as a buffer to dampen power peaks and compensate for brief periods of overconsumption. Friderichs's familiarity with batteries was the reason why the Accumulatorenfabrik AG (AFA), the largest battery producer in Germany, invited him to run its engineering office in Amsterdam. Friderichs started work for the AFA (which stills exists as Varta) on 1 October 1901.[23]

It took Friderichs, after joining the ARM board of directors in 1903, another five years before he thought it wise to propose the 'motorisation' of the company's fleet. He wrote a report and calculated the costs and benefits to a hypothetical Amsterdam company, referring to the situation in Berlin, Hamburg and Düsseldorf, pointing out that in Hamburg 'owing to the deployment of clean and comfortable electromobiles an enormous increase in traffic took place, despite the extensive streetcar system'. This was a persuasive argument for the ARM board: they saw the electric car as a means to meet the challenge to the taxi from the electric tram. Friderichs advised his fellow board members to apply for an exclusive municipal licence. The

exclusive application for *electric* cabs made delegate Van Gigch wonder 'why only electric propulsion is permitted, as in most big cities such as Paris, Berlin and London gasoline has won over electricity'. Councillor Delprat, chairman of the meeting, stated that applications by competitors using alternative types of propulsion would not be excluded in the future, but for now electric propulsion had been chosen 'because it has proved to be the most desirable for *city traffic* (as in Berlin and Paris) since these carriages do not cause inconvenience by smelling and chugging'.

As we have seen, Delprat was wrong as far as Paris was concerned, but Atax's proposal was accepted with only two opposing votes and the first licence for taximeter vehicles in Amsterdam was issued.[24] The electric cabs were imported from Bremen, where Norddeutsche Automobil- & Motoren AG (Namag) had established successful production under licence of the French Kriéger cab. The Namag cabs, with their electric motor near the front wheels, using compact crown-and-pinion transmission, had been popular during the first large-scale taxicab experiments in Germany before the First World War despite looking rather old-fashioned. Introduced by cab companies like Bedag (Berlin) and Hedag (Hamburg), which were founded by Namag to secure those markets, the experiments showed the viability of the second generation of electric taxicabs – provided they were equipped with lightweight batteries like the Ky model by AFA. Observers of these experiments concluded that electric propulsion for taxicabs *might* be successful if the cabs were used as intensively as possible, in as big a fleet as possible; petrol-engine cabs, by contrast, should be reserved for small fleets, for example where a single taxicab was operated by father and son, with low overheads.[25]

Under the terms of the maintenance contract between Atax and AFA, each battery set would consist of forty-four Ky cells, and this was the real reason why Friderichs, a well informed ex-AFA employee, had waited five years before submitting plans for the motorisation of the ARM fleet. German cab fleet experiments had already shown that the new Ky battery was a marvel of energy density (in kW/kg)and sturdiness. Whatever it lacked in longevity was compensated for by copying the German experiments: the contract specified that the batteries would be charged and maintained at a separate charging station under the responsibility of the AFA, while Atax would simply meet the cost of electricity.[26]

Thus on 4 June 1909 six 'Ataxes' appeared on the streets of Amsterdam to occupy stands at the Centraal Station, the Damrak and the Leidseplein. The day before, the mayor, W. F. van Leeuwen, had made a trial ride. The fourth stand, on the Thorbeckeplein, was not occupied till a few weeks later, when the remaining six cars from Bremen were delivered.[27] The success of the electric cab was immediate and overwhelmed the Atax management. It was even more popular when Atax reduced its rates on 1 October 1909, which led to an increase in short rides (the most lucrative ones) and a rise in gross revenue. Other companies started to smell a profit and the Industrieele Maatschappij Trompenburg as well as Taxi-Auto-Maatschappij (TAM) submitted applications for licences to the city council.[28]

These developments brought the dilemma of 'motive power' back on the agenda of the Atax directors. The council found the complaint of smell against petrol cabs no longer relevant because it:

> is [spread] considerably less by these well built [gasoline GM] vehicles than earlier on, but it seems to have a certain advantage to the public that at least part of the taxi automobiles are not limited to a certain area of operation. Electromobiles certainly are. They cannot drive further than 100 km and so mostly cannot be used for traffic to more distant municipalities.[29]

In the summer of 1910 Atax taxicabs numbered twenty-four electric vehicles, about 19 per cent of the total Amsterdam passenger car fleet. In 1912 a second Atax charging station was opened, in the Beursstraat, and the following year the fleet numbered sixty-two cabs, including ten in Haarlem, where a subsidiary company was established. Later that year the company purchased four second-hand vehicles in Munich, to which it added one more as a 'stand-by' before the outbreak of war in 1914. The cars bought in 1912 and 1913 were partly provided with new bodywork. With fifty-seven drivers, six mechanics, seven men in the battery workshop and thirty-two taxi ranks, Atax deployed one of the largest fleets in the capital, and in April 1911 the milestone of a million kilometres was passed. The company's largest competitor was TAM, with about thirty petrol-engine cars (in 1912). The third player in Amsterdam's motor taxicab business was the Eerste Nederlandsche Taxi-Auto Maatschappij (ENTAM),which started a taxicab service with sixteen German NAGs, fitted with petrol engines. In addition, there were eight car-hire companies and a few garages with luxury cars, some of which would later attempt to compete with the big companies by establishing their own organisation, Automobiel Onderneming (AO).[30] The relative strength of contenders in the Amsterdam cab market can be deduced from the results of a private traffic count by the ARM during the football match between Holland and Germany in the Amsterdam stadium on 5 April 1914. Of the 541 vehicles that passed the checkpoint in the direction of the stadium, 109 were Atax cars, ninety-five were TAM cars, twenty-six were AO cars and twenty-two were ENTAM cars. This means that petrol-engine cabs accounted for a quarter of the journeys counted and electric cabs 20 per cent; an equal share (116 cars) was taken up by private cars, while horse-drawn carriages (with 173 units) formed 32 per cent of the vehicles counted.[31]

In the course of 1913 the maximum speed of about 27 k.p.h. was increased to approximately 36 k.p.h. 'by a change in the construction, so that the only difference to our disadvantage from the gasoline cars could be cancelled out'. The Atax board confidently told their shareholders, 'The thesis, defended by us from the beginning, that the electromobile, even after a lengthy use of already six to seven years now, by replacing cheap parts, runs like a new vehicle, proves more and more to be true.'[32]

This favourable verdict on electric propulsion was supported by the statistics that Friderichs produced, based on a study of the monthly reports. These

showed that after 1910 the average daily distance per taxicab was well over 90 km (with a peak *average* of 120 km at the beginning of 1917). This proved that the initial fear, expressed by some financial backers at the time, that electric cars had too short a range was unfounded.[33]

Nevertheless, the company management worried about the high and varying price of tyres. This was felt to be the more pressing as the fleet expanded and the revenue per car decreased with growing competition. At a meeting of the Atax supervisory directors at the end of 1913 Friderichs mentioned 'that currently, with half as many vehicles again as in 1912, the same gross surplus has been obtained, so that earnings per car were down and fewer kilometres were driven'. Another director, Perk, added, 'a factor that depressed our profit figure . . . [was] the high price we eventually had to [spend] on tyres, which was 10 per cent more than in 1912'. Shortly before the outbreak of the war the problem of price fluctuation was solved by reaching a two-year agreement with the German tyre manufacturer Continental at seven German pfennigs per vehicle kilometre.[34] Not only the price of tyres but higher vehicle speeds led to a lower net profit per vehicle kilometre. This was due to faster wear and tear on the tyres, but especially to the increase in the proportion of 'kilometres empty'. Nevertheless, given the growing number of cabs and taxi ranks in the capital, and increasing competition generally, the daily mileage per car began to fall. As the number of fares per car per day also dropped, the proceeds per vehicle decreased by 22.5 per cent. Friderichs came up with a scheme based on the idea that the drivers would receive a bonus, depending on the number of kilometres covered with passengers and revenue per kilometre. With 137 employees, and a telephone switchboard since January 1914, Atax's daily averages rose, as the annual report for 1914 concluded with satisfaction.[35]

The outbreak of the First World War in August 1914 seemed to halt the ARM's flourishing business, but, after a short slump, the backbone of the ARM, its horse-drawn business, recovered and a period of unprecedented sales and profit growth followed. Nevertheless, a number of worrying developments began to take shape: the cost of fodder doubled and fungal poisoning broke out among the horses, so that forty-eight of them died. Consequently the ARM had to write off more than the usual 17c per 'horse day', an amount that had been obtained by analysis of the normal 'wear and tear' on the horses in preceding years.[36] To compensate, the ARM had been pursuing diversification – even before the war. On 1 June 1912 it established the Amsterdamsche Exploitatie Maatschappij (AEM) as an extension of the petrol car operation, which Autovervoer Maatschappij Trompenburg had started a year earlier. With the take-over of this Spyker subsidiary – set up as a competitor to Atax – petrol-engine cars were included in the ARM fleet for the first time, initially deployed as luxury cars to replace hire carriages.[37]

At Atax twenty-five of the 137 drivers were conscripted into the army upon mobilisation. Their jobs were kept open for them and anyone who returned after demobilisation would be rehired.[38] Like the parent company ARM, Atax suffered from a slump at the outbreak of war, but the situation soon

improved to 'very favourable' (Figure 1). This was due to two factors. Firstly, Friderichs's bonus system started to yield a profit as the revenue per vehicle kilometre began to rise. In Amsterdam it increased from 26.41c/km in 1913 to over 30c/km in 1916.[39] Moreover in two years' time the daily mileage grew to almost 100 km, while the number of rides per day, and proceeds per kilometre, per vehicle and per day, as well as the annual mileage of the fleet, all rose spectacularly. And all this happened with a reduced fleet size. Secondly, the Atax board for long managed to avoid the effects of rising tyre prices thanks to the 'very advantageous contract with Continental'. It even managed to prevent a threatened tyre shortage. At the outbreak of war the contract with Continental seems to have lost its importance, however, for in 1915 the company signed a kilometre contract with the Dutch Hevea factory on the same favourable terms as with Continental. It did not prevent tyre maintenance amounting to 18 per cent of revenue for that year. (Battery maintenance was 12 per cent and electricity costs were 7.5 per cent.)[40]

Soaring revenue encouraged the Atax directors to take a rosy view of the future. It also put them in the mood for expansion and in 1915 they decided to buy a site on the Nassaukade 'intended for the erection of the large Atax centre with factory' that would make the two charging stations on the Keizersgracht and the Beursstraat superfluous. The new centre would garage more than a hundred 'Ataxes' and allow further extension of the electric cab fleet.[41] However, construction was never begun, either during the war or after.

Increased understanding of Atax's cost structure enabled a change in depreciation policy. It appeared, Friderichs wrote, that the taxicab chassis lasted longer than the bodywork. From then on, depreciation of 15 per cent

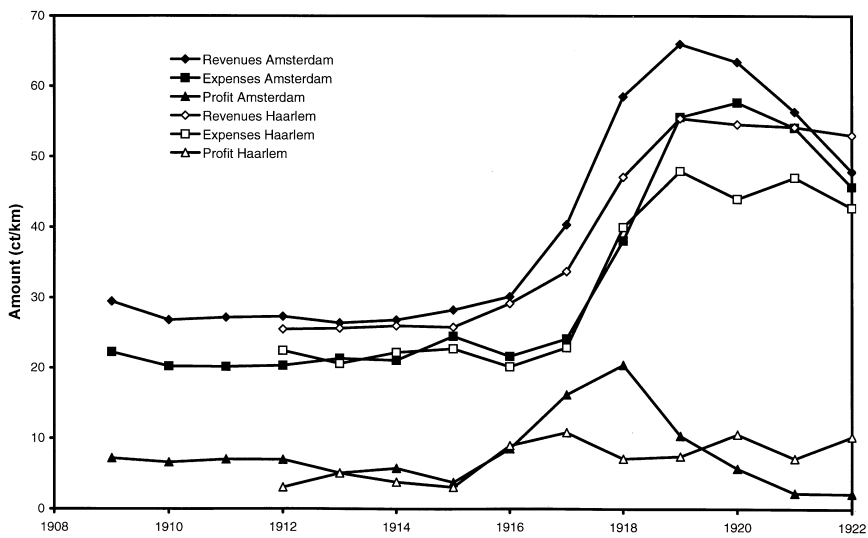

Figure 1 Revenue, expenses and profits of Atax, 1909–22 (Haarlem from 1920), petrol-engine taxis (cents per kilometre driven). *Source* Monthly reports in the Friderichs file, ARM archives

for electric cabs was divided into 10 per cent for chassis and 20 per cent for bodies. This meant that the life span of the chassis was extended to ten years, whereas bodies lasted only five, so that the average life span of the whole car was 7.7 years instead of 6.7 in the old situation. The review of depreciation policy and hence of the total life span of the electric cab was thus due to an increase in the life of the chassis from 6.7 to 10 years.[42] Friderichs mentioned in his report how the Atax fleet had expanded to sixty vehicles through the purchase of second-hand cars before the outbreak of war. The intensive use of the reduced fleet pushed up business returns to a level that, in Friderichs's view, was the maximum that could be achieved. He warned his fellow board members that the situation could not last. And, if 'Atax wants to remain in the lead', he recommended an expansion of the fleet to more than 100 cars, a fleet that could be garaged, charged and maintained in the new centre.[43] He emphasised that Atax's results confirmed his view that:

> electric chassis [were the best choice], because they seemed to promise the best profitability in the course of time. For good reasons, based on experience in Hamburg, among other things, it could be assumed that at such operation all kilometre costs, even after many years of service, would form a stable figure, and the electric chassis would suffer little wear and tear, so that, in contrast with gasoline chassis, minor depreciation would suffice.

The inclusion of tyres and batteries in kilometre contracts and the virtually constant energy costs made maintenance of the chassis and bodies the only uncertain element of costs. Therefore Atax decided to set up a repair fund of 2.5c per kilometre. To everyone's surprise it soon appeared 'that the wages could also be paid from this, despite the fact that the maintenance costs of the bodies were higher than expected; so, the best proof that the maintenance costs of the chassis are very low'. In the meantime the reduced Atax fleet – in 1917 still comprising forty cars – could be kept rolling only by cannibalising chassis that were not in use. Armatures, ball bearings, carbon brush holders, the carbon brushes themselves (the current collectors of the armature) in particular could be stripped from inoperative 'Ataxes'. Meanwhile the worn-out bodies of the first series of chassis were no longer repaired but completely replaced in the ARM coachworks.[44]

Atax's financial success inspired the ARM to make use of its take-over rights. Already in possession of eighty-nine shares of Dfl 500 each in the capital of Dfl 125,000, the parent company acquired most of the remaining 161 shares in autumn 1916. The take-over had become necessary as the rising cost of provender made it increasingly important for the ARM to exploit Atax's revenue potential fully. Above all the costs of 'fodder and stabling' in 1916 had tripled since 1914. Higher rates for horse carriages led to an increase in demand for motor transport. In the Amsterdam taxicab business, this demand was steered in the direction of electric propulsion when on 5 December 1917 'practically all [petrol-engine] motor traffic for private individuals was stopped'. This national driving ban was not lifted until 23

November 1918. It meant an enormous boost for Atax, even though electricity was rationed. Revenue increased even further, thanks to a rise in taxi fares that, ironically enough, the petrol cab companies had applied for. Whereas the daily route and the number of rides per day – after the peak of 1917, when it was 99.8 km and 26.8 rides – decreased, the *proceeds* per kilometre continued to rise, with a record of 66c in 1919. Revenue per vehicle per day reached its peak a year earlier at Dfl 51.25.[45]

After the war, the ARM's turnover and profits continued to grow for another two years, until 1920, when both began to fall. 'The expansion that traffic with mechanically powered vehicles will experience' was, according to the ARM management, the stimulus for the purchase on 1 January 1919 of the biggest petrol-engine taxicab competitor in Amsterdam, the TAM. It was taken over with its complete taxi fleet of sixty cabs, mainly German Opels. This fleet was immediately reorganised so that twenty-two cabs were sold and part of the remaining thirty-eight were dismantled; at the end of that year twenty-eight petrol-engine cabs were operational and ten chassis frames were in stock. The entire petrol vehicle fleet, adjusted for cars dismantled and sold, now comprised thirty-three cabs.

In 1920, however, the boom years seemed to be over. For the first time the ARM annual report referred to 'the depression in trade and industry' as an explanation for the collapse of revenue and profits. In the opinion of the ARM board, an important factor was the new policy of the Amsterdam city council whereby, when someone applied for a taxicab licence, it not only set the rates but also the drivers' terms of employment. In July 1920 the municipality set up an Auto-Centrale (AC) to distribute telephone calls for a taxicab among member companies. The customer was no longer allowed a choice of taxi company or, therefore, the type of motive power. This brought to an end the pre-war support of the local authorities for electric propulsion in the taxicab business. Only at the cab ranks was the customer free to choose his own taxi. The ARM management saw municipal interference in the free taxicab market as a straitjacket; running the business 'now, in fact, comes down to exploitation by the city of Amsterdam at the expense and risk of the entrepreneurs'. And in April 1922 the city imposed a reduction in fares despite loud protests from the Amsterdam taxicab companies.[46]

In 1921, for the first time in the ARM's history, no dividend was paid. That was a major setback after the boom years of 1918 and 1919 when the dividend had reached an unsurpassed 12 per cent. Nor was a dividend paid in the two years after 1921. In 1923 the ARM suffered a loss of more than Dfl 50,000 and the taxicab business that year closed with a deficit, due to a strike that lasted almost eight months. At the resumption of the service on 8 January 1924 new municipal regulations came into force, which, according to the ARM board of directors, enabled 'operation of the taxicab business on a more commercial basis'.[47]

Despite this, the sun was setting on electric taxicab operations and the ARM board did not hesitate to decide its fate. In 1924 it began with a 'renewal of the vehicle fleet of the Stationing business', which was completed

in 1925. The auditors' report mentioned the board's judgement that 'the electric and old gasoline vehicles that are unsuitable will gradually be replaced by gasoline vehicles of a light type (Citroën)'. As a consequence of this decision the 'department of electric automobiles' was liquidated and in 1925 the taxicab fleet consisted of eighty-four cars, eighty-two of which were Citroëns. A year earlier a start had been made on dismantling the batteries, and seventeen electric cabs were scrapped. In mid-February 1926 the last electric Atax completed its final trip on the streets of Amsterdam.[48]

Analysis of conditions for a successful taxicab operation

Two factors made the ARM an important supporter and customer for foreign vehicle technology: the Franco-German electric car with taxicab fleet experience in German cities, and the appearance of a reliable battery at the right moment. With the benefit of hindsight, it seems that the timing of its foundation could not have been better. The pneumatic tyre, however, was more problematic. As it was clear, even before the foundation of Atax, that tyre costs would be higher than battery costs, gaining a maintenance contract for the tyres on a kilometre basis was of great importance. Without such a contract, Friderichs rightly concluded, setting up the company would have been pointless. The Atax initiative was also supported by a municipal policy which favoured electric vehicles over petrol-engine vehicles, a phenomenon which also determined the short-lived success of electric taxicab fleets in several German cities, but which was cut short by the First World War

Analysis, presented graphically in Figures 2–10, shows that the second-generation electric cab only stood a chance against petrol-engine competition when the utilisation per car was intensive. Indeed, car use was surprisingly

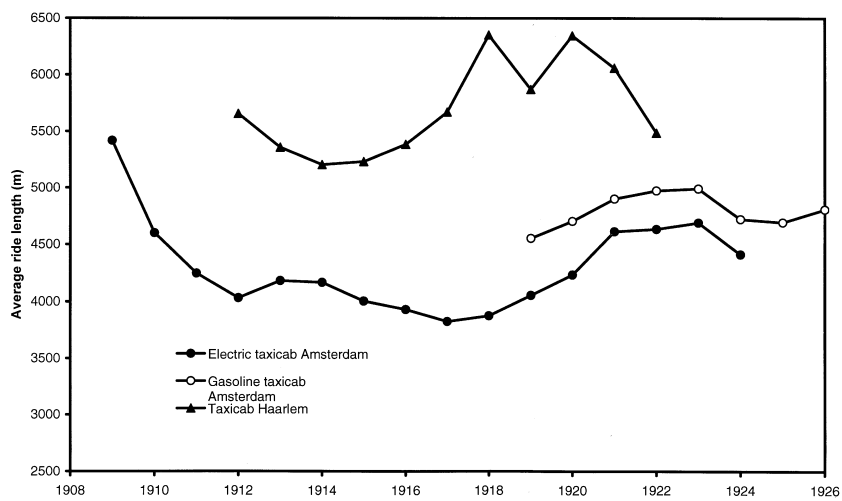

Figure 2 Average ride length at Atax, 1909–26 (Haarlem from 1920), petrol-engine taxicabs. *Source* Monthly reports in the Friderichs file, ARM archives

high at 20,000 km to 35,000 km per year. During the period considered here, the distance per fare was between 4 km and 4.5 km (Figure 2), a value established in 1912 (at a fleet size of about sixty cars), and this figure forms the threshold value for the Amsterdam cab fleet size. Before then, the number of cab stands was so low that larger distances had to be covered to get passengers to their destinations.

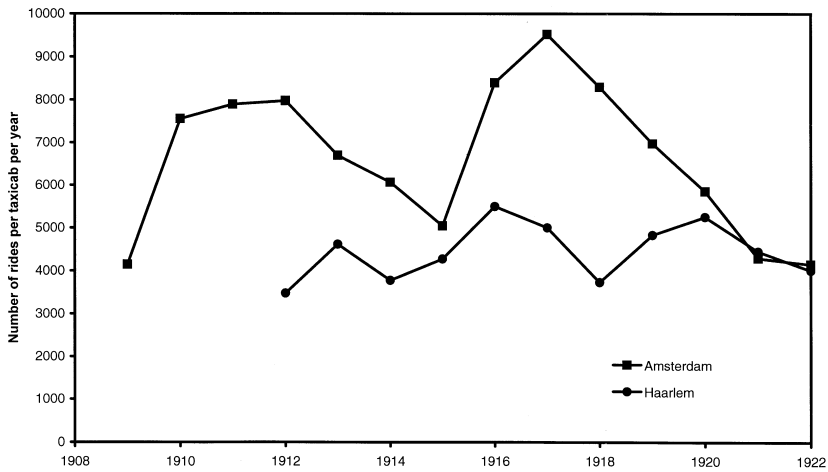

Figure 3 Average number of rides per year per taxicab at Atax, 1909–22 (Haarlem from 1920), petrol-engine taxicabs. *Source* Monthly reports in the Friderichs file, ARM archives

Although the average number of rides per taxi generally shows the same picture as the annual mileage per taxi, Figure 3 shows a considerably higher peak in the years 1916–18. There were 2,000 rides a year more in that period than in the years before the strike, that is, five to six extra rides a day. This explains the explosive rise in company revenue during these years which was caused by the establishment of a bonus system that linked the drivers' wages to the 'full' kilometres covered and to the proceeds per kilometre. The peak in 1918 can be explained by the extra stimulus given to the electric cab by the driving ban on petrol-engine cars that year.

Figure 4 enables a comparison between electric and petrol propulsion over the years 1919–22. A decrease in the costs of the electric cab is noticeable, possibly caused by the parts that were taken from the second-hand cabs from Bremen, Düsseldorf and Munich. At the same time the costs of the petrol cab rose, largely it seems because of an increase in repair expenses (Figure 5) – just as Friderichs had been tirelessly insisting since the earliest days of the Atax enterprise. Eventually the total costs of the petrol-engine cab (in 1921 and 1922) were just below those of the electric cab, because of the compensating effect of the fall in fuel and pneumatic tyre costs in those years (Figure 4). The comparison is the more remarkable, because here a fleet with

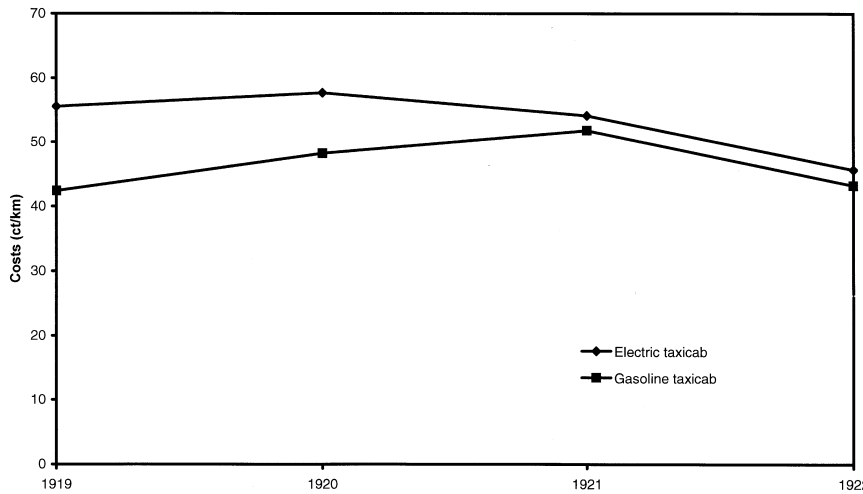

Figure 4 Total expenses of electric and petrol-engine taxicabs for Atax-Amsterdam, 1919–22 (cents per kilometre). *Source* Friderichs, 'Vergelijkende staat Atax and Taxi Amsterdam over de jaren 1919 t/m 1922', ARM archives

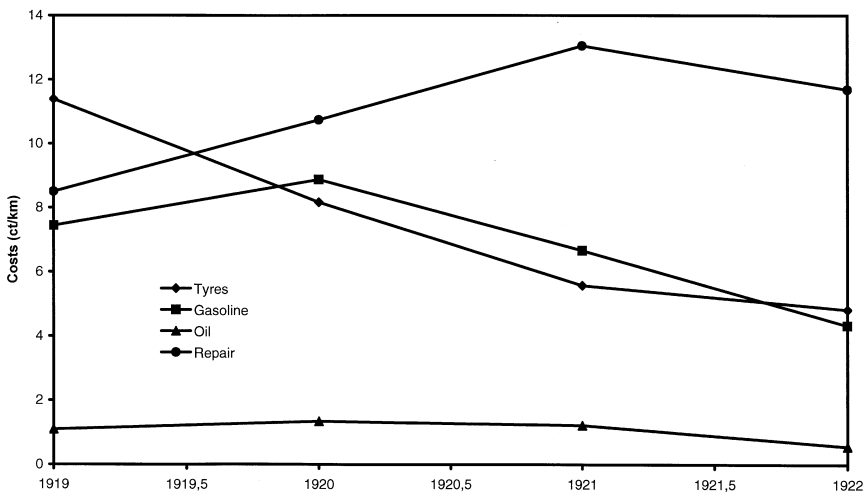

Figure 5a Maintenance and labour costs of the Amsterdam petrol-engine taxicabs of Atax, 1919–22. Maintenance costs (cents per kilometre). *Source* Monthly reports in the Friderichs file, ARM archives

about 40 per cent new petrol cars was opposed by an old-fashioned and 'patched up' electric cab fleet. This makes the question of the motives behind the switch to petrol engines all the more interesting.

The expansion of the taxicab fleet after the First World War could be attributed to the petrol-engine car. Here Atax had to pay for its dependence on a single supplier – and one in shattered Germany. In France no electric

Figure 5b Maintenance and labour costs of the Amsterdam petrol-engine taxicabs of Atax, 1919–22. Drivers' wages and average wages of the other Atax personnel involved with the petrol-engine taxicab (cents per kilometre). *Source* Monthly reports in the Friderichs file, ARM archives

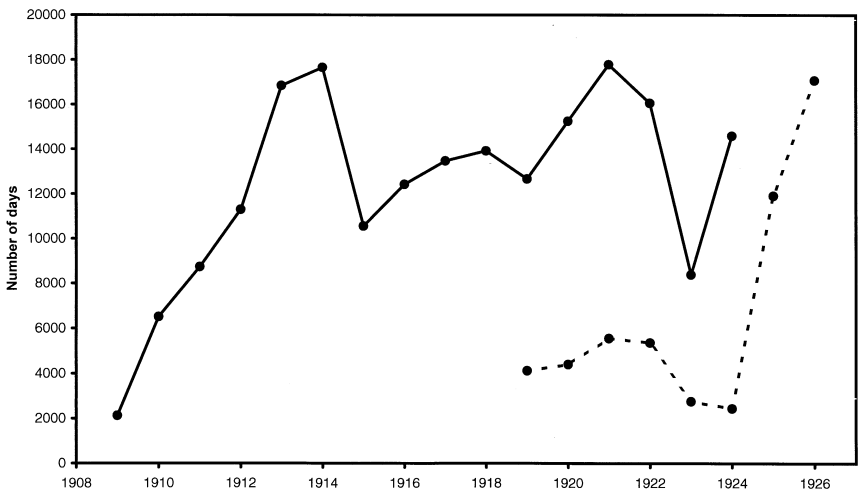

Figure 6 Total operating days of the Amsterdam Atax fleet, 1909–26. Dotted line: petrol-engine cabs. *Source* Monthly reports in the Friderichs file, ARM archives

car manufacturer of any significance remained active and the United States with its electric Bakers and Detroits was too far away. It is true that in the course of the 1920s electric car manufacturers emerged again, but by then the petrol-engine cab was already embedded in the ARM's taxicab fleet.

For the years after 1922 cost specifications of the petrol cab are unfortunately lacking. Figure 6, in combination with Figures 7 and 8, does, however,

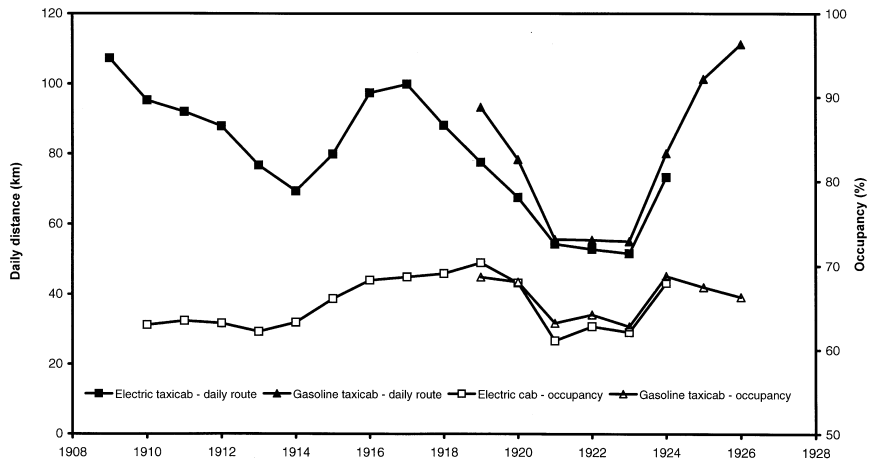

Figure 7 Average daily distance per car and rate of occupancy of Atax in Amsterdam, 1909–26. *Source* Monthly reports in the Friderichs file, ARM archives

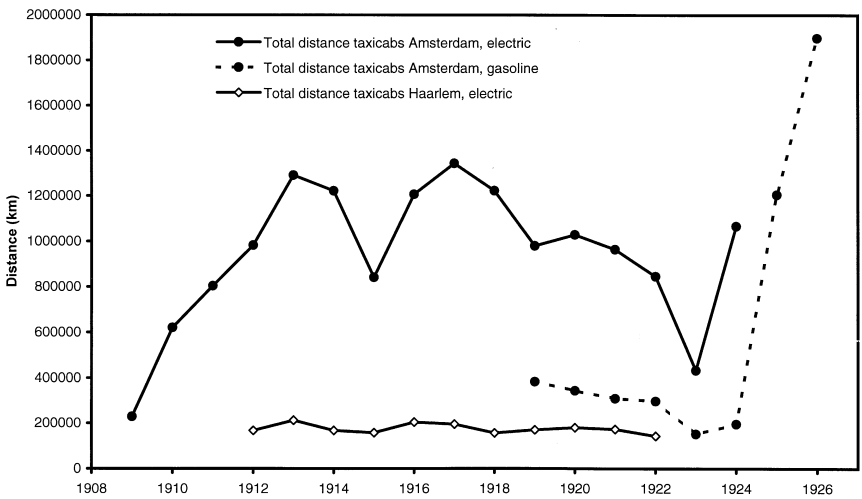

Figure 8a Total annual number of kilometres of the effective Atax fleet and average annual number of kilometres per taxicab. Effective fleet, 1909–26. *Source* Monthly reports in the Friderichs file, ARM archives

offer some insight into the nature of this process of displacement. It appears, for example, that it was not until 1926 that the petrol-engine fleet achieved the same number of effective operating days as the electric cab had done before the war, and with a considerably smaller fleet. This cannot be explained by the total annual mileage of the fleet, which was already higher than that of the electric cab in 1925 (Figure 8). Nor can it be explained by the daily mileage, for that was higher than the electric cab's from the beginning (Figure 7). The only plausible explanation is the reduced availability of petrol propulsion, as a result of its lower *reliability*.

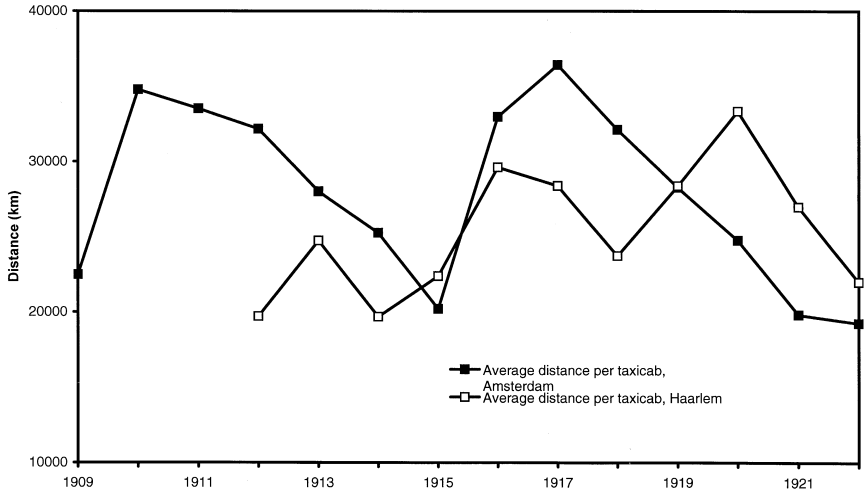

Figure 8b Total annual number of kilometres of the effective Atax fleet and average annual number of kilometres per taxicab. Average per taxicab in Amsterdam and Haarlem, 1909–22. *Source* Monthly reports in the Friderichs file, ARM archives

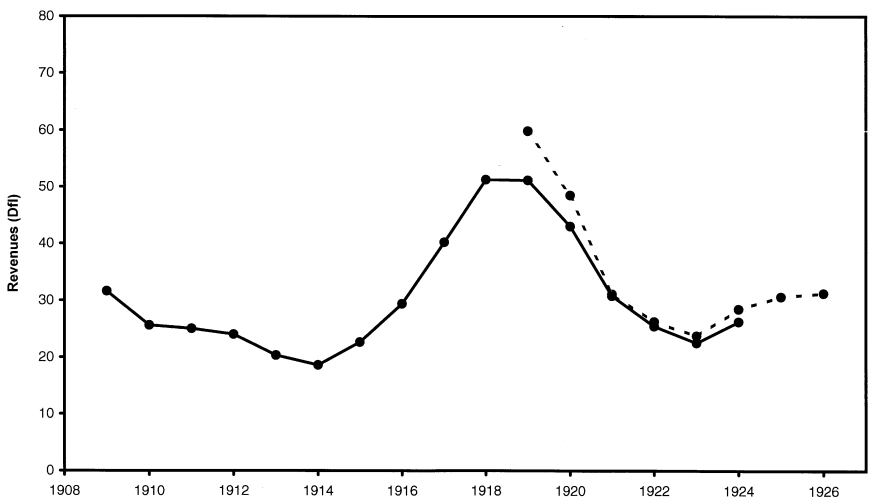

Figure 9 Proceeds per Atax taxicab per day in Amsterdam, 1909–26; dotted line: petrol-engine taxis. *Source* Monthly reports in the Friderichs file, ARM archives

It is remarkable that this lower reliability was largely compensated for by higher speed. In other words, what the petrol engine lost in usability, it gained by earning revenue faster. This is shown in Figures 9 and 2; even though the average ride length was about 6–12 per cent higher at a virtually equal number of rides a day, daily revenue was hardly higher than that of the electric cab (Figure 9). This is confirmed by the average length of the paid ride, which was higher for the petrol cab from the outset. In Amsterdam it fluctuated around 10 per cent higher, in Haarlem it was 11–17 per cent higher than for the

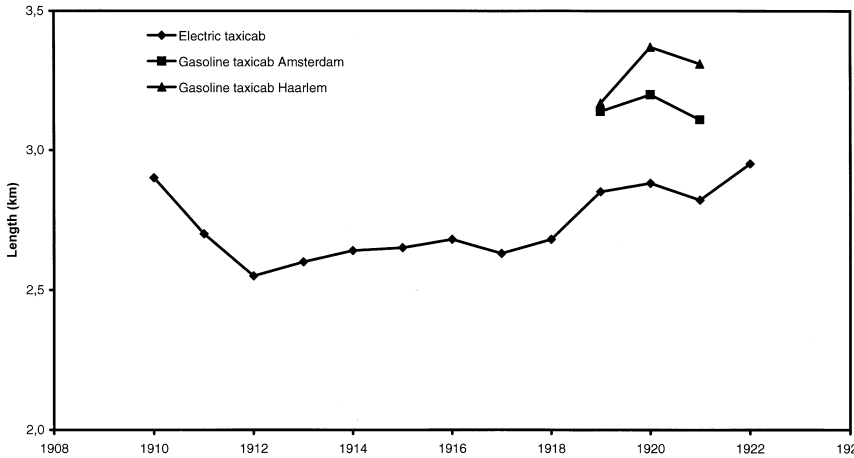

Figure 10 Average length of paid ride, electric taxicab in Amsterdam, 1910–22, and petrol-engine cab in Amsterdam and Haarlem, 1919–21. *Source* calculated from a graph by Friderichs, ARM archives

Amsterdam electric cab (Figure 10). The greater range (and it was *not* beyond the range of the electric cab) did *not* lead to higher daily earnings because of the remarkably comparable occupancy rate (the 'load factor' of the taxicab business) and thus a correspondingly larger number of 'kilometres empty'. A ratio of about a third of kilometres empty seems a usual value at this stage of the second generation and in a town the size of Amsterdam. Thus it can be concluded that the petrol-engine taxicab had caught up in reliability to such an extent that its operation in a large fleet differed little from that of its competitor. And whatever it still lacked in reliability it made up for with its higher speed.

So far as technical factors are concerned it is clear that battery technology had advanced sufficiently that maintenance and maintenance costs no longer presented any problems. What makes Atax's foundation and success interesting is that it took place at a transitional stage of the development of the pneumatic tyre. That at any rate was *not* the reason for the failure of the electric cab project in the Netherlands, because the stimulating factors (among them the wartime 'emergency situation') were much stronger. Nevertheless, it is remarkable that during the war costs were more favourable to the electric than to the petrol-engine vehicle. Given the fact that Amsterdam's roads were well surfaced, one can only conclude that vehicle speed (higher for the petrol car) and wheel slip (also higher for petrol cars, owing to jerky acceleration and gear changing) had a greater influence on tyre wear than axle load (which was higher for the electric car). The tyre and the gear-shifting technology of the petrol-engine car made so much progress during the decade between 1909 and 1919 that the two types of propulsion matched each other as far as overall costs were concerned. Thus we turn to non-rational arguments about the choice of vehicle propulsion, even when considering such a highly 'rational' venture as taxicab fleet operation.

Conclusion

It is not correct to speak of the second-generation taxicab in terms of 'failure', especially if one means this in a technical sense. The secret of the electric taxicab's success was the application of electric propulsion in an intensively used and compact fleet. The conclusion, on the basis of the only well documented early urban electric vehicle fleet experiment, must be that electric propulsion was both technologically and economically 'superior', at least until the outbreak of the First World War, when the reliability of petrol propulsion started to catch up. This process had started around the crisis of 1907 and took the form of a head-on attack on the electric vehicle's most successful market niche – the taxicab.

However, this analysis also shows how the electric cab made a virtue of necessity; out of necessity the longer rides had to be left to petrol-engine rivals. These yielded a larger share of 'kilometres empty', however, and thus prevented profitable large petrol-engine fleet operation before the war in Europe.[49] That, at a later date, the petrol-engine car operated profitably on a compact network, as the Atax story shows, does not alter this fact. It does make clear once more, however, that one cannot look upon these phenomena as perpetual; rather they are time-specific and do not follow automatically from 'the technology'. In this seeming disadvantage the eventual 'victory' of the petrol-driven cab is hidden: given its early unreliability, less intensive use was actually an advantage. The internal combustion engine settled in small market niches that the electric cab could not fill, such as the one-family company. With its low fixed costs and the low purchase price of the car such a company had a chance of surviving. Another, even more important example is the hire car. What had been an emergency solution at the American Electric Vehicle Company, and a possible reason for its demise, formed the 'short cut' that Trompenburg chose to threaten the Atax monopoly in Amsterdam.[50]

Why then could the electric car not extend or maintain its position? Was it not the ideal 'crisis car' and was it not cheaper to maintain in a large fleet than a petrol cab? Apart from the lower capital costs stemming from the advantages of mass production, the conclusion can only be that the petrol cab offered an important *extra function*: namely that of the touring trip outside the city as well as the higher speed that accompanied it. That extra function made it more attractive in the private automobile market and apparently represented such an important boost that electric propulsion was doomed. When Atax was looking for a substitute taxicab the choice of propulsion was clear, since by then the electric passenger car had disappeared from the European market.

As far as intensity of use is concerned, and given the restriction of the life span of the battery to about five months (due to sulphating and low mechanical shock resistance), electric propulsion was eminently suited to the taxicab business. Because of this, mileages of 15,000–20,000 km a year could be reached during its life span.[51] The question then arises of how far these findings can be applied to the entire automobile market, in particular individually owned passenger cars. This analysis has tried to show that pleasure

vehicles cannot be compared to taxicabs, despite their technical similarity. The assumption that the private electric car suffered less wear than the electric taxicab is wrong.[52] In fact for the second generation of electric automobiles the exact opposite is true: the more intensive its use, the more economical its operation.[53]

The least one can say on the basis of the evidence gathered so far is that electric propulsion for individual motorists was more reliable and had a higher longevity than petrol propulsion in the period under consideration, except for the battery. Technical solutions to the problems of sulphatation during standstill and short-circuiting during use were available at the time, but they made electric motoring more expensive. The major argument against electric power, however, was not the cost but the cultural barrier represented by the need to entrust one's car to a public garage, while a petrol-engined car could be parked at home.[54] With the benefit of hindsight, the role of the electric taxicab can be characterised as follows. It did pioneering work during the first phase of horse replacement as a reliable and cheap alternative in the demanding conditions of city traffic. It was the Trojan horse in the struggle between the propulsion systems that led to the victory of the internal combustion engine.

Notes

1 This is based on Gijs Mom, *Geschiedenis van de auto van morgen: cultuur en techniek van de elektrische auto* (Deventer, 1997; an English translation is in preparation).

2 Robin Cowan, 'Nuclear power reactors: a study in technological lock-in', *Journal of Economic History* 1, 3 (1990), p. 543. See for a critique of the concepts of 'inferiority' and 'superiority' in the history of technology Gijs Mom, 'Conceptualizing technical change: interaction between alternative artefacts in the evolution of the automobile', in Helmut Trischler and Stefan Zeilinger in co-operation with Robert Bud and Bernard Finn (eds), *Tackling Transport: proceedings of a joint conference of the Science Museum, the Smithsonian Institution and the Deutsches Museum, Munich, 11–13 October 1998* (forthcoming).

3 Virginia Scharff, *Taking the Wheel: women and the coming of the Motor Age* (New York, 1991); also see Peter J. Hugill, review of Michael Brian Schiffer, with Tamara C. Butts and Kimberly K. Grimm, *Taking Charge: the electric automobile in America* (1994) in *Technology and Culture* 37, 2 (1996), pp. 379–81, who criticised Schiffer's analysis because electric propulsion was 'already rejected for technical reasons that are as valid today as they were eighty years ago'. See for comparable opinions John B. Rae, *The American Automobile Industry* (Boston MA, 1984), pp. 185–6; James J. Flink, *The Automobile Age* (Cambridge MA, 1993), p. 10; James M. Laux, *The European Automobile Industry* (New York, 1992), p. 13.

4 James Foreman-Peck, '"Technological lock-in" and the power source for the motor car', *Discussion Papers in Economic and Social History* (May 1996).

5 'Civilized adventure as a remedy for nervous times: early automobilism and *fin-de-siècle* culture', *History of Technology* 23 (2001), pp. 157–90.

6 Gijs Mom, 'Das "Scheitern" des frühen Elektromobils 1895–1925. Versuch einer Neubewertung', *Technikgeschichte* 64, 4 (1997), pp. 269–85.

7 David A. Kirsch and Gijs P. A. Mom, 'From service to product-based mobility concepts: technical choice and the history of the Electric Vehicle Company', *Business History Review* 76, 1 (2002), pp. 75–110.

8 'L'automobile industriel : les fiacres automobiles à Berlin', *La Locomotion automobile*, 7 September 1906, pp. 149–50, at p. 149; 'Compagnie française des automobiles de place', *Circulaire financière*, 1 April 1906, Archives nationales 65 AQ N26; Anne Boudou, 'Les taxis parisiens de la fondation des Usines Renault aux "Taxis de la Marne" 1898–1914', unpublished Master's thesis, Université de Paris X Nanterre (1982), pp. 67–70, 292–302;

Patrick Fridenson, *Histoire des usines Renault* I, *Naissance de la grande entreprise 1898–1939* (Paris, 1972), pp. 55–63; 'Dans deux ans les taxi-autos remplaceront les chevaux de fiacre', *La Presse*, 25 June 1907, Archives de la Préfecture de police, Paris, box D/b 505, folder 'Taxis'; Adrien Gatoux, 'Les fiacres automobiles', *La Vie automobile*, 6 October 1906, pp. 633–4; F. Girardault, *Les Automobiles industrielles* (Paris, 1910), pp. 361–82; E. Lessard, 'Les fiacres automobiles à Paris', *La Vie automobile*, 1 August 1908, pp. 487–90, at p. 487.

9 Herbert Bauer, 'Automobile im öffentlichen Verkehr von Paris und Berlin', *Allgemeine Automobil-Zeitung* (Vienna), 16 December 1906, pp. 37–45, at p. 41; 'Pariser Automobil-Fiaker', *ibid*., 5May 1907, pp. 45–6; Boudou, 'Les taxis parisiens', pp. 62, 65, 96, 169, 232.

10 Boudou, 'Les taxis parisiens', 267–8, 296; M.P. (Marcel Plessix), 'Le fiacre automobile', *La Locomotion automobile*, 10 August 1906, pp. 81–3, at p. 82; 'Die Rentabilität der neuen Pariser Automobilfiaker. Was die Compagnie française des automobiles de place verdient', *Allgemeine Automobil-Zeitung* (Vienna), 26 August 1906, pp. 4–6.

11 Calculated on the basis of the *Annuaire statistique de la ville de Paris* over the years concerned; Boudou, 'Les taxis parisiens', p. 57; Fridenson, *Histoire des usines Renault*, pp. 56–8. According to Philippe Laneyrie and Jacques Roux, 'Transport traditionnel et innovation technique : l'exemple du taxi en France', *Culture technique*, 19 (March 1989), p. 263, Paris numbered 6,000 cab drivers in 1911, whereas the entire private vehicle fleet in the whole of the Paris region was owned by scarcely 20,000 proprietors.

12 Froissart, 'Les fiacres automobiles de Londres', *La Vie automobile*, 27 June 1907, pp. 473–5; Froissard [*sic*], 'Les fiacres automobiles de Londres (suite et fin)', *ibid*., 3 August 1907, pp. 484–5; 'A propos des fiacres automobiles de Londres', *ibid*., 10 August 1907, pp. 510; Fridenson, *Histoire des usines Renault*, pp. 57–8; Arthur E. A. M. Turner, 'Public motor cab service in London', *Commercial Vehicle*, April 1907, pp. 108–10; *id*., 'Earnings and costs of taxicabs', *Commercial Vehicle*. February 1908, pp. 39–40, at p. 39.

13 G. N. Georgano, *A History of the London Taxicab* (Newton Abbot, 1972), pp. 59–60; Nick Georgano, *The London Taxi*, Shire album 150 (n.p. [London], 1985), pp. 7–9; 'Sind die Automobildroschken rentabel?' *Stahlrad und Automobil*, 24 December 1911, pp. 6–8.

14 James M. Laux, *In First Gear: the French automobile industry to 1914* (Liverpool, 1976), p. 142; 'Electric Vehicle Club of Boston', *The Central Station*, July 1912, pp. 24–6, at p. 26; 'Taximeter cabs for New York', *Commercial Vehicle*, May 1907, p. 146; 'Taximeter cab situation in New York', *ibid*., October 1907, pp. 254–6, at p. 225.

15 'Taxicabs popular in Washington, D.C'., *Commercial Vehicle*, May 1908, pp. 101–2; 'Automobildroschken in England, Amerika und Frankreich', *Allgemeine Automobil-Zeitung* (Vienna), 29 December 1907, p. 40; Harry W. Perry, 'American taxicab construction', *Commercial Vehicle*, March 1908, pp. 54–7; *id*., 'Developments in taximeter cab field', *ibid*., April 1908, pp. 73–5; 'Taximeter made in America', *ibid*., pp. 75–6; 'Electric taxicabs for principal cities', *Electric Vehicles* (US), May 1915, pp 175–6, at p. 175.

16 Russel A. Sommerville, 'Taximètres américains', *La Vie automobile*, 29 April 1911, p. 268; Fridenson, *Histoire des usines Renault*, p. 58.

17 Kirsch and Mom, 'From service to product-based mobility concepts'.

18 S. Scrimger, 'The electric taxicab', Electric Vehicle Association of America (1915); reprinted in *Electric Vehicles*, November 1915, pp. 169–70.

19 'Electric taxicab successful in Detroit', *Electric Vehicles*, February 1915, p. 54; 'Electric taxicabs for New York', *ibid*., January 1916, p. 16; 'Women to drive taxicabs in Detroit', *ibid*., December 1917.

20 'Electric taxicabs for principal cities', p. 175.

21 'Harvey Robinson, electric vehicle expert, sees future for electric taxi', *The Central Station*, January 1916, p. 189; A. Jackson Marshall, 'The electric vehicle situation', *ibid*., December 1917, pp. 173–7, at p. 176; 'A short history of the electric taxi-cab: development leading to the latest models in Chicago', *Electric Vehicles*, July 1916, pp. 1–3; 'The electric taxicab', *NELA Bulletin*, June 1917, p. 502.

22 *Algemeen Handelsblad*, 1 March (? difficult to read) 1905, Municipal archives Amsterdam (GAA), Coll. Hartkamp, sheet 369A/370.

23 Adolph Müller, *25 Jahre der Accumulatoren-Fabrik Aktiengesellschaft 1888–1913* (Berlin, 1913), p. 182. The biographical data are derived entirely from the necrology in *De Ingenieur*, 17 November 1928, pp. 45–6, and the obituary in the internal AFA newsletter *AFA Rundschau* 3–4 (1928), p. 170.

24 Italics in original. In Atax's licence it was emphasised that 'no other motive power than electricity was to be used' (*Gemeenteblad*, Afdeeling 2, 1910, pp. 285–91, 323–65, at p. 332–3).

25 Mom, *Geschiedenis van de auto van morgen*, p. 287.
26 'Contract' (ARM archives); this unsigned copy was dated for Amsterdam on 13 May 1909, for Berlin on 21 May that year.
27 *Algemeen Handelsblad*, 2 June 1909; *Nieuws van den Dag*, 3 June 1909 (GAA, Coll. Hartkamp, sheet 395A).
28 *Algemeen Handelsblad*, 30 September 1909 (GAA, Coll. Hartkamp, sheet 396); the initial distance (at a daytime rate of 40c) was doubled to 1,200 m.
29 *Nieuws van den Dag*, 24 January 1910 (GAA, Coll. Hartkamp, sheet 374/374A).
30 *Jaarverslag Atax* (Atax Annual Report) for 1910 and 1911; unidentified newspaper clipping with the heading 'Gemeenteraad, zitting van 9 maart 1910' (City council, session of 9 March 1910) (GAA, Coll. Hartkamp, sheet 374/375); Atax Minute Book, 'Vergadering van 25 April 1911' (Meeting of 25 April 1911); *Het Leven*, 12 November 1912, p. 327; *Nieuws van den Dag*, 29 February 1912 (GAA, Coll. Hartkamp, sheet 402); TAM, 'Bewijs tot stationneeren met auto's "Taxi"', 12 December 1913 (ARM archives); *Algemeen Handelsblad*, 23 April 1912 (GAA, Coll. Hartkamp); Gijs Mom, '"Äffchen" und Blockbandtaxen', in Ulrich Kubisch *et al*., *Taxi. Das mobilste Gewerbe der Welt* (Berlin, n.d. [1993]), pp. 288–303.
31 Separate sheet with the heading 'Alleen richting Amstelveenscheweg' in Atax Minute Book; fleet size comparable: Vincent van der Vinne, *Spyker 1998–1926* (Amsterdam, 1998), pp. 118, 166.
32 Atax Minute Book, Meeting of 16 May 1913; *ibid*., Meeting of 19 December 1913; *Jaarverslag Atax* for 1912 and 1913. The indication 'six or seven years' cannot refer to Atax and probably refers to the year 1905, when the 'second wave' of electric passenger cars started.
33 Friderichs, 'Stand Ataxbedrijf Amsterdam, November 1912'.
34 Atax Minute Book, Meeting of 19 December 1913; the excerpt is difficult to read: the Dutch word for 'spend' is a guess; Meeting of 6 April 1914.
35 Atax Minute Book, Meeting of 8 April 1915; *Jaarverslag Atax* for 1914; J. F. Friderichs, 'Premiën ter verhooging der gemiddelde opbrengst per KM' (ARM archives).
36 *Jaarverslag ARM* for 1915.
37 Supplement to the *Nederlandsche Staatscourant*, 29 August 1911, No. 202, and 26 June 1912, No. 147; Gijs Mom and Vincent van der Vinne, 'Geschiedenis van de elektrisch aangedreven auto: de eerste en de tweede generatie, 1881–1914', in *id*., *De elektro-auto: een paard van Troje?* (Deventer, 1995), pp. 111–93, at p. 179; *Jaarverslag ARM* for 1912.
38 *Jaarverslag* Atax for 1914; *Jaarverslag ARM* for 1915.
39 J. F. Friderichs, 'Rapport betreffende rentabiliteit Atax in verband met een voorstel voor eene gewijzigde afschrijvings-politiek', 6 (ARM Archives).
40 *Jaarverslag* Atax for 1914 and 1915; Atax Minute Book, Meeting of 8 April 1915; 'Balans "Ataxbedrijf" per 31 december 1918', appendix to *Jaarverslag ARM* for 1918; Perk to 'H.H. Commissarissen der Maatschappij "Atax"', 29 March 1916, appendix to *Jaarverslag Atax* for 1915.
41 Perk to 'H.H. Commissarissen der Amsterdamsche Rijtuig-Maatschappij', 15 March 1915 (ARM archives); *Jaarverslag Atax* for 1915; *Jaarverslag ARM* for 1915 and 1918.
42 J.F. Friderichs, 'Rapport betreffende rentabiliteit Atax'; Perk to 'H.H. Commissarissen der Maatschappij "Atax"', 29 March 1916, p. 3, and Van Dien, Van Uden & Co. to 'de Commissie van onderzoek bedoeld in artikel 17 der statuten van de N.V. Amsterdamsche Taxameter Automobiel [*sic*] Maatschappij "Atax"', 29 March 1916 (henceforth: 'Atax Auditor's Report for 1916'), both appendices to *Jaarverslag Atax* for 1915.
43 Friderichs, 'Rapport betreffende rentabiliteit', pp. 1–2.
44 A. Perk and H. Heijbroek, 'Staat van wijzigingen; balans, 31 december 1916' (ARM archives) 1. Forty vehicles in 1917: 'Toelichting balans per 31 december 1917' (appendix to 'Amsterdamsche Rijtuigmaatschappij; Balans Ataxbedrijf per 31 december 1917', ARM archives); Atax Minute Book, Meeting of 8 April 1915.
45 Friderichs, 'Rapport betreffende rentabiliteit Atax', appendix; *Jaarverslag Atax* for 1916; *Jaarverslag ARM* for 1917 and 1918.
46 *Jaarverslag ARM* for 1919, 1920, 1921 (quotation), 1922.
47 'Veertig jaar taxi's in Amsterdam;' *Jaarverslag ARM* for 1923.
48 Auditor's report to the *Jaarverslag ARM* for 1924, p. 11; *ibid*. for 1925, p. 7; Gijs Mom, '"Äffchen" und Blockbandtaxen', p. 301.
49 Gijs Mom, 'Das Holzbrettchen in der schwarzen Kiste. Die Entwicklung des Elektromobilakkumulators bei und aus der Sicht der Accumulatoren-Fabrik AG (AFA) von 1902–10', *Technikgeschichte*, 63, 2 (1996), pp. 119–51.

50 See, however, Kirsch and Mom, 'From service to product-based mobility concepts', for a more balanced analysis which questions the outright failure of this early experiment.
51 The sulphating phenomenon restricted the *calendar* life span because of the deterioration of the lead plates by sulphate formation, thus causing non-permeable surfaces which blocked the chemical interaction of the active lead compounds and the electrolyte. See Mom, *Geschiedenis van de auto van morgen*, p. 356.
52 'It is clear that a privately owned electric, whether used for light business or pleasure, did not exhaust batteries at the same prodigious rates as New York taxi cabs.' (Schiffer, *Taking Charge*, p. 73.
53 Robert Schwenke, 'Die Elektromobilen auf der Berliner Automobil-Ausstellung 1906, 3.–18. Februar', *Centralblatt*,1 March 1906, pp. 54–7.
54 For a detailed analysis of this aspect of the electric vehicle's user culture see Mom, *Geschiedenis van de auto van morgen*, pp. 519–29.

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