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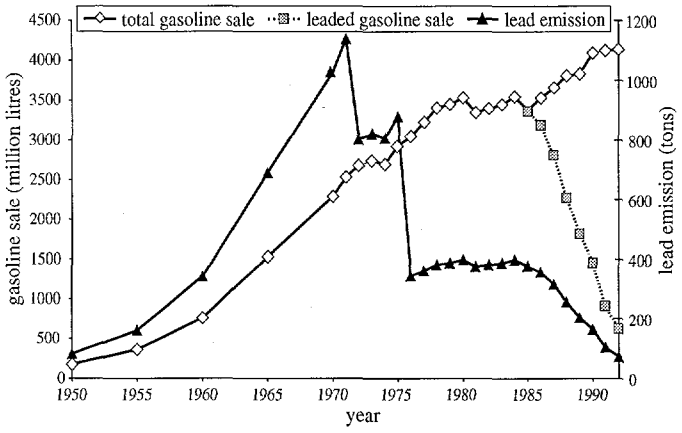
Historical review of European gasoline lead content regulations and their impact on German industrial markets



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Historical review of European gasoline lead content regulations and their impact on German industrial markets

C. Hagner

32 pages with 8 figures and 3 tables

Abstract

Environmental protection policies in the automobile market were not implemented until the motorisation of the masses in the 1960s caused an increasing environmental burden. The rising air pollution was considered a latent danger for humans, animals and plants. In the years up to 1985 the EU passed several regulations to limit the mass pollutants CO, CxHy and NOx. Germany was the first EU-member nation to also be concerned with lead in gasoline, passing reduction regulations as early as in 1971. In 1986, several EU-member nations implemented the supply of unleaded gasoline. This decision was predominantly based on information about widespread forest damage.
The reduction of lead emissions due to these regulations could be verified in different environmental systems. An example of this was the decline of atmospheric lead concentrations and human blood lead levels in Germany. The German mineral oil and automobile markets were also affected. The price trend of unleaded fuel was heavily influenced by tax incentives which benefited not only the gasoline traders but also the consumers. With regard to the distribution system, the market positions particularly of the medium-sized traders and the independent importers were weakened. In the automobile market, favourable terms of competition were experienced by producers who had already gained experience with catalyst systems in the U.S.-market. The gasoline lead content regulations had no effects on further economic indicators, except for competition.

Analyse der Gesetzgebung zur Reduktion des Bleigehalts in Benzin auf europäischer Ebene sowie deren Effekte auf verschiedene Wirtschaftssektoren in Deutschland

Zusammenfassung

Infolge der Massenmotorisierung in den 60er Jahren stieg die Umweltbelastung durch den Automobilverkehr stark an. Luftverschmutzung durch Kraftfahrzeuge wurde erstmalig als latente Gefahr für die Gesundheit von Mensch, Tier und Pflanze wahrgenommen. Dies charakterisierte den Beginn der Umweltpolitik im Automobilsektor. Bis 1985 verabschiedete die Europäische Union (EU) mehrere Rahmenrichtlinien zur Reduktion der Luftschadstoffe CO, CxHy und NOx. 1971 war Deutschland das erste europäische Land, das Gesetze zur Reduktion des Bleigehalts in Benzin erließ. Vor dem Hintergrund der Diskussion um die Gefahr des Waldsterbens wurde seit 1985 nicht nur in Deutschland, sondern ab 1986 auch in einigen anderen Ländern der EU bleifreies Benzin angeboten.
Mit zeitlicher Verzögerung führten diese gesetzlichen Maßnahmen zur Reduktion der Bleikonzentrationen in verschiedenen Umweltmedien, wie z.B. in der Atmosphäre oder auch im Menschen. Ökonomische Auswirkungen hatte die Bleireduktion im Benzin in Deutschland vor allem auf die Mineralöl- und Automobilindustrie. Dabei war die Preisentwicklung für bleifreies Benzin durch steuerliche Anreize stark beeinflußt, die nicht nur den Handel, sondern auch die Autofahrer begünstigte. Im Automobilsektor profitierten vorwiegend die Hersteller, die bereits durch Exporte auf den US-Markt Erfahrungen mit abgasarmen Techniken, wie z.B. dem Katalysator, gesammelt hatten. Abgesehen vom Wettbewerb, hatte die Bleigesetzgebung jedoch keinen Einfluß auf volkswirtschaftliche Indikatoren.

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1 INTRODUCTION

The special property of lead to increase engine performance by preventing self-ignition, i.e., part of the air-fuel mixture exploded rather early when the compression ratio was too high and power was lost, was discovered in the early 1920s. Lead additives, e.g., tetraethyl lead and tetramethyl lead, in gasoline solved the combustion problems of Otto engines. Higher-compression engines could be produced and the use of leaded gasoline increased enormously all over the world.

In the 1960s, increased automobile traffic resulted in severe air pollution problems in high-income countries. Whereas the USA reacted quickly to this challenge and passed the "Clean Air Act Amendments" in 1963, it was not until the 1970s that the problem of environmental legislation was addressed in Europe. In those years, in some European countries environmental damage was perceived as a potential health risk. Reducing air pollution was one of the main topics in the initial development of environmental policies which concluded with gasoline lead content regulations.

In Section 2, the history of automobile emissions in the European Union (EU) and in particular the three steps taken to reduce lead in gasoline are discussed. This raises the question of how the legislation process influenced the atmospheric lead concentrations and human blood lead levels in Germany, which is analysed in Section 2.5. The implications for the particularly concerned mineral oil and automobile industries are discussed with respect to Germany in Section 3. Whether the lead policies influenced national economic indicators is analysed in Section 4.

2 HISTORY OF EUROPEAN UNION AUTOMOBILE EMISSION REGULATIONS

The history of lead use in gasoline can be divided into two main periods, the rise of lead contents in gasoline from the 1930s to the 1970s and the gradual removal of lead from the 1970s to the 1980s. In the following discussion the various regulations in the latter period, the supporters and opponents of the reduction policies and the effects on lead load levels in the environment are reviewed.

2.1 Initial regulations of exhaust pollutants

In 1969, a new government, a coalition of liberal and labour parties, was elected in Germany. For the first time, environmental problems were discussed and the government made a declaration about measures to prevent damage to human health, vegetation, animals and property. In 1971, the German government passed an environmental program that included the reduction of air pollution. It was planned to reduce the total automobile emissions to 10% of the mean value of 1969 by 1980 (Deutscher Bundestag 1971a).

The quantitatively most important pollutants were determined to be carbon monoxide (CO), dust, sulphur oxides (SOx), nitrogen oxides (NOx) and hydrocarbons (CxHy). CO and CxHy were

nearly solely emitted by motor traffic and the mineral oil industry. Several measures were proposed to reduce pollution, such as using low-emission production techniques, installing filtration plants and building high chimneys. One of the first actions of the German government was to amend the "Road Traffic Licensing Regulation" to reduce the emissions of CO and CxHy. Other regulations followed, such as the amendment of the "Technical Instructions to Clear the Air" which included pollution thresholds defined by the VDI-Commission, the enactment of a "National Emissions Control Law" and the establishment of a "National Emissions Monitoring System". However, it was known that the costs of emission reduction would increase exponentially with rising air quality, so the opponents of environmental policy warned of serious negative effects on the German economy (Deutscher Bundestag 1971b).

At a European level, in the years 1970 to 1985, the EU passed five regulations to limit automobile emissions (see Table 1). The first two legislations referred only CO and CxHy. NOx were not limited until 1977. The thresholds were defined for the test of the Economic Commission of European Nations (ECE), which specified the gear, velocity, acceleration, braking and coasting on a test block. The ECE test was less strict than the one already implemented in the USA, and its use implied a decision against a highly ambitious environmental protection policy. During the 15 years of the European legislation process, the thresholds were increased in a stepwise manner (70/220/EWG, 74/290/EWG, 77/102/EWG, 78/665/ EWG, 83/351/EWG).

Table 1: Maximum Automobile Emissions in an ECE test (in g), Allowed by EU–Regulations, 1970-1985

Regulation	CO	CxHy	NOx	CxHy + NOx	Automobiles licensed since
70/220/EWG	100 - 220	8.0 - 12.8	-	-	1,10,1971
74/290/EWG	80 - 176	6.8 - 10.9	-	-	1,10,1976
77/102/EWG	80 - 176	6.8 - 10.9	10 – 16	-	1,10,1980
78/665/EWG	65 - 143	6.0 - 9.6	8.5 - 13.6	-	1,10,1981
83/351/EWG	58 - 110	-	-	19.0 - 28.0	1,10,1986

Source: adapted from Neu (1990).

2.2 Regulation of gasoline lead content

Several years before the EU Commission discussed the problem of automobile lead emissions, the German government was already concerned with lead in gasoline. The need to reduce the lead content in gasoline was first mentioned in the "German Environmental Programm" in 1971. Lead reduction was a basic requirement for an effective procedure to remove pollutants from exhaust gases, provided that fully developed removal techniques existed (Deutscher Bundestag 1971a).

At the end of March 1971, the German government passed the first bill regarding gasoline lead content regulations. The pollution from traffic and particularly the lead emissions from

automobiles had to be stopped. Lead additives in gasoline were being distributed in to the environment with the exhaust fumes, and the toxic agents inhaled by humans. Additionally, toxic lead depositions on plants were being consumed by humans and animals and possibly causing negative health effects (Deutscher Bundestag 1971c).

Several studies, first published in the USA, e.g. Centers for Disease Control (1991), Schwartz (1988), Environmental Protection Agency (1985), Pirkle et al. (1985) and Needleman et al. (1979), showed that lead retarded the mental and physical development of children. Moreover, changes in behaviour such as hyperactivity were observed. Elevated blood lead levels were found to cause increased blood pressure and hypertension in adults, increasing the risk of cardiovascular disease (Lovei 1998).

Schlipköter/Pott (1976) also recorded the incidence of anemia and malfunctions of the neuro-vegetative system in Germany. They could not, however, prove the negative effects of increased lead blood levels on the intelligence and activity of children. They concluded that at that time, in 1976, adults were not endangered by lead poisoning. Even a menace to children could not be scientifically proven. Nevertheless, even though the health risks due to lead emissions were not calculable, it was thought that the sensitive groups in the population should be protected by reduced lead contents in gasoline. Overall, it seemed that the German bill was justified more by reasons of precaution than acute danger (Alfke et al. 1994).

The reduction of the lead content in gasoline was planned in two steps so that the mineral oil industry would have enough time to adapt their production systems. It was thought that the German oil industry had to build up new production systems with alkylation and isomerisation processes to reduce lead additives in fuel. Moreover it was assumed that in spite of the first reduction of lead content in gasoline the total emissions would keep rising due to increasing traffic density. Even if distortions of competition or higher production costs occurred, the German government argued that economic effects had to submit to environmental goals. If the bill led to unacceptable hardship, firms could apply for an exemption permit to produce gasoline with higher lead contents until 1 January 1977. The German army was exempted because it had to buy part of its gasoline from the North Atlantic Treaty Organisation (NATO), which supplied gasoline with lead contents up to 0.84 g Pb/l. The bill was to be amended as soon as it would be possible to produce unleaded gasoline.

The German Ministry of the Interior claimed that exhaust fumes containing lead caused an especially severe level of air pollution in conurbations, i.e., predominantly urban regions including adjacent towns and suburbs, and along roads (Bundesministerium des Inneren 1971). This statement was confirmed by Müller (1974), who determined that atmospheric lead concentrations between conurbations and rural areas differed by about 10^2 to 10^4. Also, the Umweltbundesamt (1976) cited a study from Austria which found that at a distance of 100 m the lead concentration was reduced to one third of its value from to the road.

The Upper House of the German Parliament commented that the second reduction of gasoline lead content should be adopted earlier. Furthermore, they suggested that NATO should adjust their gasoline norms to German thresholds (Deutscher Bundestag 1971c). In August 1971, the

Gasoline Lead Content Regulation passed the German parliament. It was still argued that increasing automobile emissions were considered to be a latent danger for humans, animals and plants. From 1 January 1972, gasoline with lead contents of more than 0.4 g Pb/l was not allowed to be produced in, or imported to, Germany. From 1 January 1976, the lead content had to be reduced to 0.15 g Pb/l. Exemptions were permitted if the reductions of lead content were to cause a supply bottleneck or unacceptable hardships to the German mineral oil industry. These exceptions were limited in time, until 31 December 1973 (≤0.4 g Pb/l gasoline) or 31 December 1977 (≤0.15 g Pb/l gasoline). Those who obtained an exemption permit had to pay a compensation of 0.01-0.02 DM/l gasoline, depending on the lead content. These compensations, it was argued, should forestall competitive disadvantages (Bundesgesetzblatt 1971). Despite an expected production price rise of about 0.02 DM/l gasoline, the politicians attached more importance to environmental goals (Bundesministerium des Inneren 1976).

The Gasoline Lead Content Regulation was amended again on the 25 November 1975. At that time the German government was even more convinced that lead emissions endangered human health. In conurbations, the recommended thresholds of the VDI-Commission (1974) of 1.5 µg Pb/m^3 air (annual average) and 3 µg Pb/m^3 (daily average), which were the maximum levels thought to be harmless for living organisms, were exceeded several times. It was found that 95% of the lead concentrations in the air originated from leaded gasoline were deposited on and accumulated in plants, fodder and animals. Furthermore, reduced lead additives would also diminish the share of CxHy in automobile emissions (Bundesministerium des Inneren 1976).

The Gasoline Lead Content Regulations were typical of the early environmental policy in Germany. High value was attributed to thresholds that were perceived to be safe and that were reinforced by regulatory strategies, whereas economic arguments were considered secondary. Not until the second period of environmental policy did economic targets gain in significance and market instruments became favoured (Peters 1980). Especially the adherents of the neo-classic theory considered the regulation policy as an inefficient instrument. It was expected to cause allocation losses because pollution abatements were not realized with lowest costs (Wicke 1993).

At the European level, the Council of Europe passed a law that would not reduce lead additives in gasoline until July 1978. Thereafter it was forbidden for all EU-member states to produce, import or sell gasoline with more than 0.4 g Pb/l, the German threshold, however, was already fixed at 0.15 g Pb/l gasoline (Rat der Europäischen Gemeinschaften 1978).

2.3 Further regulations of exhaust pollutants and unleaded gasoline

In the 1980s, the discussion about air pollution in Germany was mainly focussed on the reduction of NOx, CO and CxHy. It was based on information about widespread damage to forests which had first been observed in 1981 and the enormous financial effects in Germany of which were analysed in detail by Ewers (1986). It was assumed that the damage to forests was caused not only by acid rain but also by NOx and the photo-oxidisation of chemicals, which were emitted mostly from automobiles (55% of the NOx emissions in 1982). Therefore, the German government

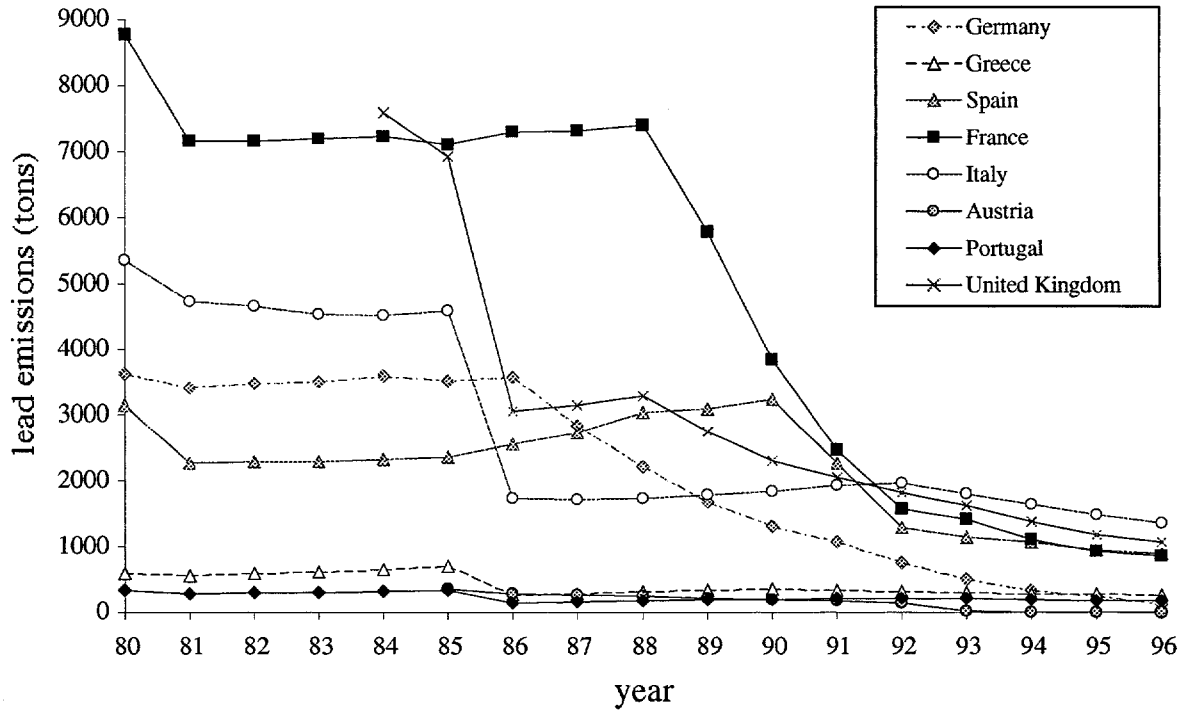
wanted to introduce further emission restrictions such as those in the USA and Japan (Deutscher Bundestag 1984).

In 1983, Germany was the first European country to draft a law for further reductions of total automobile emissions. This law also included the introduction of unleaded gasoline because the largest reductions not only of NOx but also of CO, CxHy and other pollutants could be realized with catalysts. Catalytic converters required unleaded fuel in order to prevent lead, deposited on the catalyst material, from blocking the access of exhaust gases to the catalyst. Lead not only reduced the efficiency of the catalyst, but also could destroy the plates made of platinum and rhodium (Shell International 1985). Further to its national concern, the German government asked the EU Commission to formulate a congruent European bill.

In 1984, Germany also implemented tax incentives for unleaded gasoline and low-emission cars, and in 1988/89 low-emission systems became obligatory. These subsidies were in accord with a European Law which prohibited quantitative import restrictions and discrimination against foreign firms. Again, Germany pleaded for the implementation of a European emission reduction standard and urged the EU Commission to draft new regulations. Without a European agreement, heavy losses were anticipated for the German automobile export industry, which was an important economic sector at that time. Furthermore, traffic across Europe demanded Europe-wide compatibility of cars and fuel (Westheide 1987).

It was not until 1985 that the EU passed a law which obliged the member states to offer Super Unleaded (95 octane) from 1 October 1989, while the supply of unleaded gasoline (92 octane) remained voluntary. At the same time, the level of pollutants was not to be increased. In particular, lead should not be replaced by other harmful additives increasing the octane number. By 1 October 1989 the EU countries were required to build a distribution system for unleaded gasoline. All member states were asked to, if possible, reduce gasoline lead content to a maximum of 0.15 g Pb/l (Rat der Europäischen Gemeinschaften 1985). The response across the EU was very diverse and obviously not linked to emission levels (see Figure 1).

While Germany, Italy and the United Kingdom reacted quickly, France remained the greatest polluter in the EU. In the latter the environmental protection movement was probably too weak to forward the pollutant reduction process. In any case, the French automobile industry disapproved of emission regulations. They were concerned about severe losses of export markets, because the French automobile export relied on the sales of small cars, whose sale prices would rise above average. In Germany, the supply of Super Unleaded (95 octane) and Unleaded (92 octane) gasoline became obligatory already in 1985. The gasoline lead content of unleaded fuel was not allowed to exceed 0.013 g Pb/l. That regulation was at least amended in 1988 (Bundesgesetzblatt 1988).



Data source: Eurostat (1998).

Figure 1: Annual Lead Emissions in Different EU-Nations 1980-1996

In 1987, the EU reduced the total automobile emission thresholds, but the limits were much higher than the Germans had proposed (Rat der Europäischen Gemeinschaften 1987, 1988a). Higher thresholds for automobiles with engines of low cubic capacity enabled the installation of less-expensive emission-reduction technologies. The regulation exposed the different trading policy interests in Europe. The German automobile export industry, which exported mostly cars with engines of high cubic capacity for which expensive catalytic systems were required, was discriminated against. In contrast, French and Italian small car imports were supported.

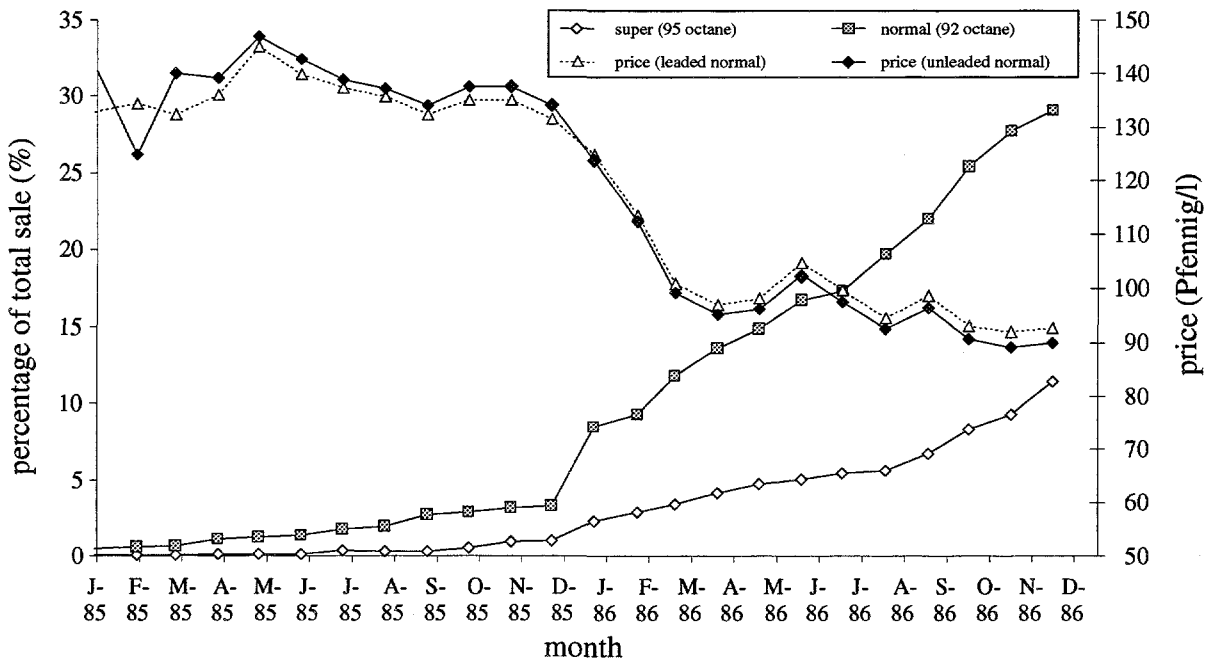
Furthermore, regulatory policy in the EU was based on transnational decision-making. With its emphasis on consensus decision-making, the EU had allowed those countries least willing to regulate to avoid regulatory development within the community (Heaton/Maxwell 1984).

The compliance of exhaust emissions with the EU thresholds was checked using the ECE test, which was less rigorous than the U.S. test (cf. p. 2). This, again, was a decision against German interests. For Germany, the three-way catalyst for NOx reductions was preferable but other European countries favoured the "Magermotor" concept. "Magermotor" cars benefited from the lower velocities in the ECE test, because travelling at high velocities these motors emitted over-average amounts of air pollutants (Ifeu-Institut 1985).

Moreover, in 1987 all EU-member states were allowed to prohibit the production and use of leaded gasoline (92 octane). This was justified by observed health and environmental damage caused by lead (Rat der Europäischen Gemeinschaften 1987). Germany was, as before, the initiator of this EU regulation.

In 1985, the EU regulation regarding emission thresholds had already been converted into German law. Automobiles with an engine of cubic–capacity more than 1400 cm^3 had to meet both the European and the American emission thresholds (Bundesgesetzblatt 1985). In addition, further tax incentives came into effect. The mineral oil tax for leaded gasoline was raised to 0.02 DM/l, and for unleaded gasoline it was lowered to 0.02 DM/l. Temporally limited tax incentives for low-emission cars were implemented, subject to cubic–capacity, and different categories of low emissions were defined. For example, new cars already adhered to the thresholds of step C "limited low emissions" with either a few modifications or the use of non-regulated catalysts. The costs of these technical changes were calculated to be between DM 450 and DM 750. Because of the tax exemption, automobile owners could save DM 911 (cubic–capacity of 600-700 cm^3, first licensed before 1 January 1987) or even DM 1638 (cubic–capacity of 1301-1399 cm^3, first licensed before 1 January 1987). After the period of tax exemption, a tax abatement of DM 500-1000 for low-emission automobiles became effective. These computations illustrate that the costs for installing low-emission systems were highly over-compensated (Ifeu-Institut 1985).

The difference between the German taxes for leaded and unleaded gasoline increased to 0.07 DM/l in 1986, and lowered again to 0.05 DM/l in spring 1989. Finally, taxes on unleaded gasoline were made less than those on leaded gasoline by about 0.08 DM/l (Neu 1990). It took until January 1986 for unleaded gasoline to achieve a considerable market share in Germany, in accordance with the benefits of purchasing unleaded gasoline (see Figure 2). For the first time, in January 1986, unleaded gasoline became cheaper than leaded fuel.



Data sources: Mineralölwirtschaftsverband (1998), Statistisches Bundesamt (1987).

Figure 2: Unleaded Gasoline Sales and Price Trends in Germany 1985/86

Finally in 1989, the emission thresholds for small cars were lowered and Germany increased the tax incentives for this vehicle class (Rat der Europäischen Gemeinschaften 1989).

2.4 Expert's comments to the European automobile emission regulations

The regulations reducing automobile emissions were often criticised. Neu (1990) and Breyer (1982) argued that standards and thresholds averted innovations and technical advances because the producers expected further regulations when new techniques were developed. In general, thresholds gave no financial incentives for technical progress.

Moreover, the politicians had to rely on the technical knowledge of producers and other experts for determining the thresholds. As the automobile market was oligopolistic, the producers tried to delay stronger emission reductions. For example, they claimed that forest damage was not caused by automobile emissions but by SOx depositions and that the catalytic converter was a defective system.

Cansier (1993) advocated taxes which neutralised externalities, i.e., the private and social marginal costs were equal. Emission taxes were thought to be efficient because costs due to environmental policies were minimized. Besides, they incited innovations to reduce the tax payments of the emitter. It would be quite difficult, however, to find the adequate rate of tax. But raising the mineral oil tax complied with the polluter pays principle which was quite popular in those days, according with the people's sense of justness. Finally, the variable costs of automobile use would increase so that the burden on high emitters was greater than that on low emitters.

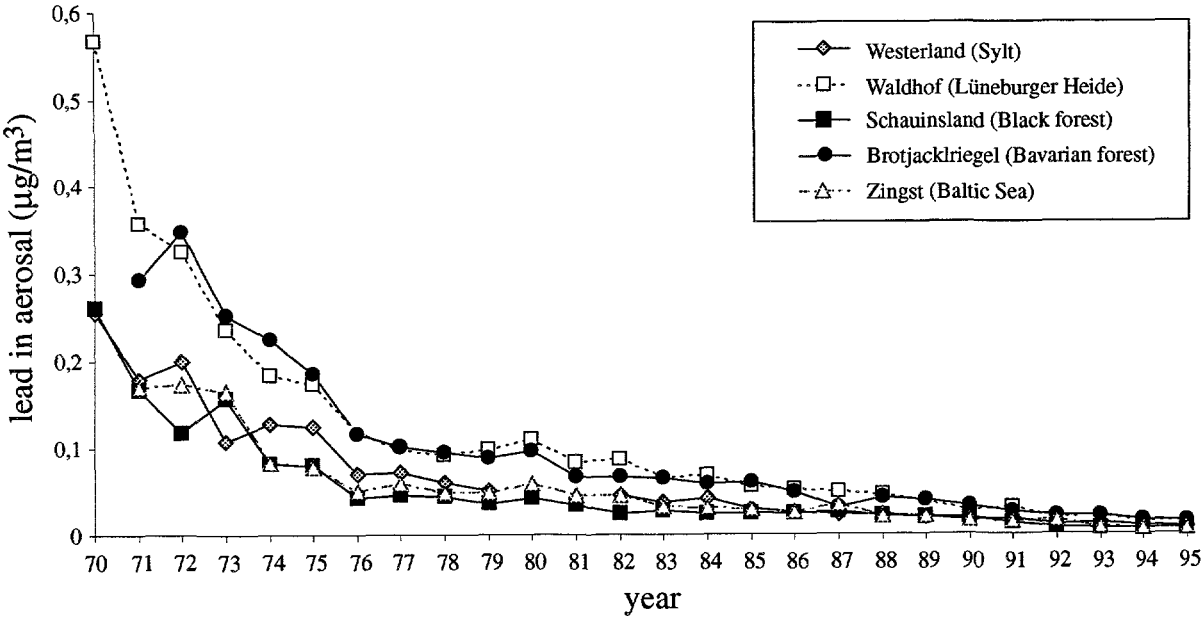
The Ifeu-Institut (1985) criticised the European regulations reducing automobile emissions, concluding that the NOx emissions would not drop for another ten years. Increasing automobile and air traffic would cancel these emission reductions. Furthermore, the thresholds required three-way catalysts only for cars with engines of high cubic capacity, although the other low-emission systems were less efficient, especially at high velocities. They recommended an introduction of a speed limit on motorways (100 km/h) and on streets out of settlements (80 km/h) for the NOx emissions were expected to be reduced from 15% (Verband der Automobilindustrie 1984) to 26% (Holz/Traube 1984).

Lovei (1998) concluded that it was not health dangers or ecological problems but the use of catalysts which had been the main driving force behind the introduction of unleaded gasoline, especially in high-income countries.

2.5 Effects of pollutant reduction policies on lead loads in the enviroment in Germany

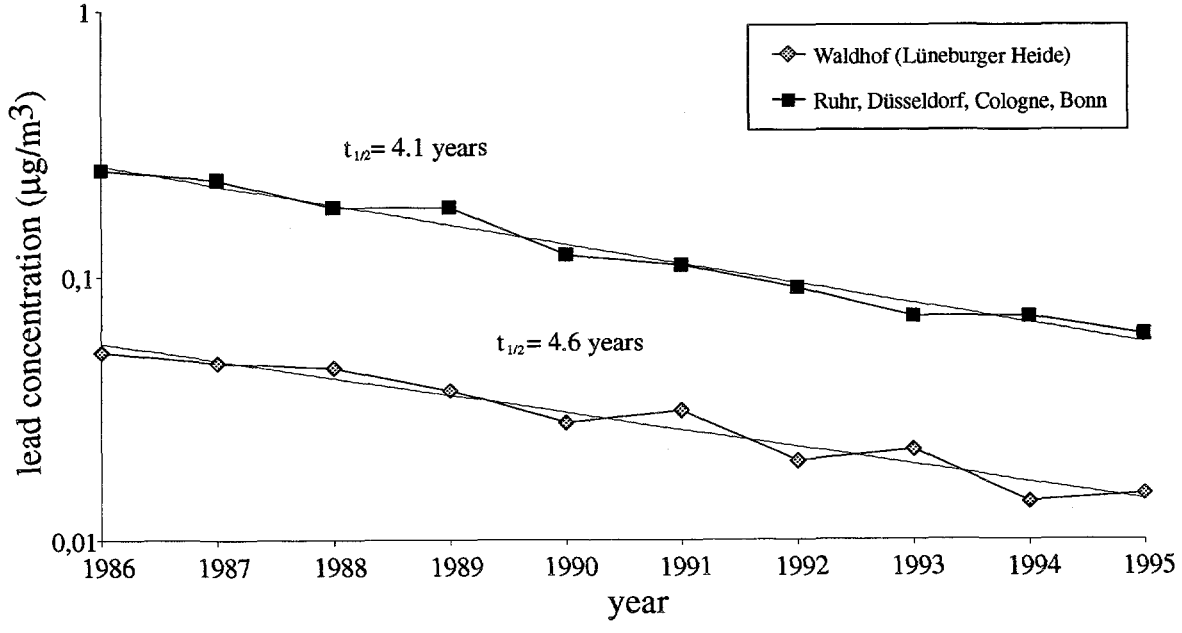
Despite the criticism, the lead reduction policies were quite successful in reducing lead concentrations in the environment. In Germany, an atmospheric Pb-monitoring system was set up in the early 1970s. Figure 3 shows the development of lead concentrations in the atmosphere at five stations. They were located in rural areas so that the data were not influenced by local

emitters and could be interpreted as trends in the long-distance transport of lead. From 1970 to 1995, as it had been expected, a significant reduction of lead concentrations took place. Additionally, the loads were much below the German threshold of 2 µg/m³.



Data source: Umweltbundesamt (1998).

Figure 3: Lead in Aerosol (µg Pb/m³) for 5 Monitoring Stations in Germany, 1970–1995

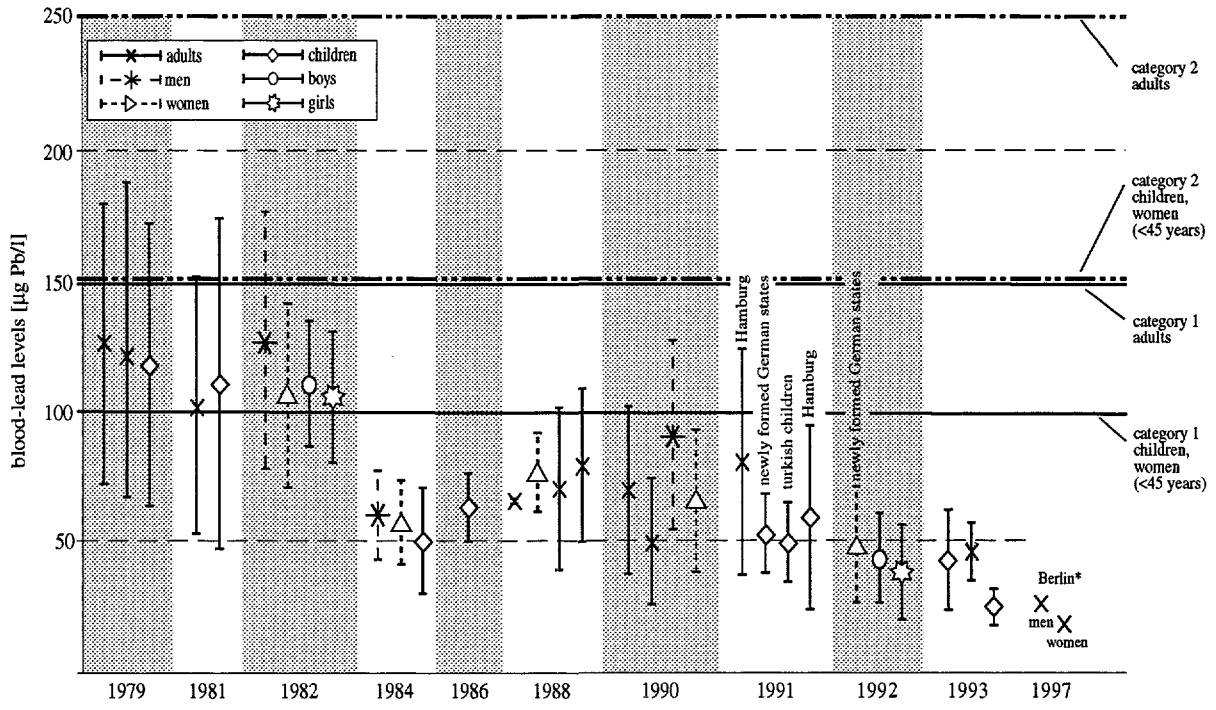


Data sources: Umweltbundesamt (1998) and Landesamt Nordrhein–Westfalen (1998).

Figure 4: Atmospheric Lead Concentration (log µg Pb/m³) in German Conurban and Rural Areas 1986-1995

Caused mainly by automobile traffic, the load levels of lead in the atmosphere were conspicuously higher in urban than in rural areas (Figure 4) (cf. p. 4). This difference was attributed to meteorological reasons and the lower rate of lead emissions from automobiles in rural areas (Umweltbundesamt 1982). Emissions were, however, halved in both areas in four to five years.

The lowering of lead loads could also be ascertained by comparing different studies of human blood lead levels in Germany from 1979 to 1997 (Figure 5). Overall, a significant decline could be observed in all groups of the population. The categories 1 and 2 were defined by the German "Human-Biomonitoring" Commission. Blood lead concentrations below the two thresholds are not expected to cause health dangers (Human-Biomonitoring-Kommission 1995). According to these studies, lead levels were never high enough in the investigated period to cause acute health hazards. The regulations seemed to be based instead on the idea of precaution (cf. p. 4).



*: As the arithmetic mean is not available, the median is shown. In comparison with other studies, the median is up to 10% higher than the arithmetric mean.
The year the samples were taken is within 2 years of the year shown in the graphic. The thresholds of categories 1 and 2 were redefined by the German "Human-Biomonitoring" Commission, most recently in 1995. Category 1: normal burden; category 2: no health dangers were expected, but controls were recommended. For people with blood lead levels above category 2, health dangers cannot be precluded, controls were recommended (Heinzow et al. 1998, Human-Biomonitoring-Kommission 1995).

Data source: Heinzow et al. (1998).

Figure 5: Blood-Lead Levels (µg Pb/l) from Various Studies in Germany, 1979-1997

3 EFFECTS OF GASOLINE LEAD CONTENT REDUCTIONS ON THE MINERAL OIL AND AUTOMOBILE MARKETS IN GERMANY

The lead content reductions particularly affected the mineral oil and automobile industries. Compliance with the new thresholds caused large investment costs in both industries and changed prices and market forces as discussed in the following section.

3.1 Mineral oil market

3.1.1 Refineries

Between the years 1955 and 1985 the number of refineries decreased; a process of concentration took place in the German refinery sector. In 1984, ten of the largest refineries kept a share of 95% of the gasoline production value, and three of these held more than 60%. As is typical for an oligopolistic market, the price leadership varied among the refineries which indicated a tacit cooperation.

In 1984, the import of mineral oil products amounted to about 30% of the domestic demand (Jürgensen 1984). The most important import market was Rotterdam, the Netherlands. Domestic refineries there covered the peaks of demand, and independent importers tried to obtain price advantages. In terms of competition, independent traders were important regulators (Westheide 1987).

During the first reduction of the gasoline lead content to a maximum of 0.4 g Pb/l, the mineral industry incurred no additional investment costs. Although they had tried to avert this environmental regulation, arguing that production costs were increased, they were able to realize a cost reduction due to the reduced requirement of lead additives (Gabriel/Zimmermann 1978). Schulz (1983) also suggested that five or more years before the first reduction of the gasoline lead content came into effect, the mineral oil industry was already able to comply with the lower threshold. But, after the second reduction of the lead content in gasoline came into force in 1976, the fuel production costs increased because new additives with high octane numbers were needed to reach the quality standards for gasoline. The amounts of the additional costs were subject to the type of refinery.

In any case, none of the anticipated bottlenecks in gasoline supply occurred. The German refinery sector had built up large overcapacities so that in 1976 the industrial capacity utilization of German refineries was only 60%. This utilization level was caused by a demand for mineral oil products which did not comply with the production structure. The relative demand for gasoline was much larger than its share in the refining process (Gabriel/Zimmermann 1978). Additionally, imports of gasoline were possible because foreign gasoline producers had very quickly also adapted to the new German lead threshold (Schulz 1983).

In several studies, the investment costs of the refineries to fulfil the regulation demands were estimated. Table 2 shows the results of two such investigations. In both studies, the adaptation

costs were estimated by considering the capital costs (calculational depreciation of 8 years, capital risk of about 6% of the reinstatement value, calculational interest loan of 9%) and material costs (raw material, auxiliary and factory supplies, energy and labour costs). Koppers (1975) calculated the total investment in adaptation measures due to the second reduction of gasoline lead content to be between DM 679.5 million and DM 1038.5 million. These estimates varied according to the type of refinery.

Table 2: Refineries` Capital Expenditures for Reducing Lead Content in Gasoline (to 0.15 g Pb/l) in Germany

	Minimal Capital Expenditure (million DM)	Maximal Capital Expenditure (million DM)
Koppers (1975)	679.5	1038.5
Van Gulick (1975)	649.6	974.5
Difference	29.9 (2.3%)	64.0 (1.6%)

Sources: adapted from Koppers (1975) and Van Gulick (1975).

Another study by Van Gulick (1975) resulted in slightly lower investment costs. The difference was about 1-2%, caused by different octane numbers in both analyses. This shows, that the investment costs varied little between different studies but widely within one analysis. It seemed that the costs could be estimated only very approximately.

Producing gasoline with a maximum lead content of 0.15 g Pb/l led to additional costs of 0.0085 DM/l to 0.0325 DM/l. These calculations were the basis of the tax on importing higher leaded gasoline. It varied between 0.01 DM/l and 0.02 DM/l and was stopped in 1978 when the exemption permits were cancelled (Gabriel/Zimmermann 1978).

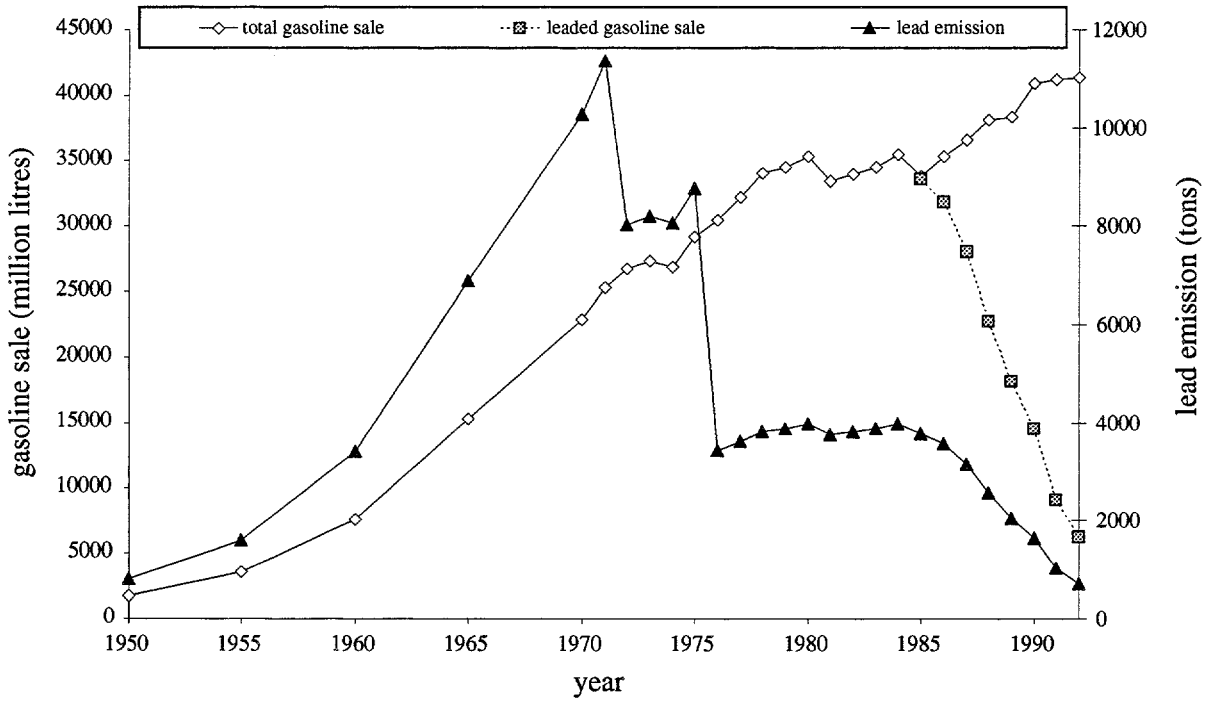
Before the regulation regarding unleaded gasoline came into force in 1985, the mineral oil industry had already built new conversion production plants which could produce gasoline with high octane numbers without lead additives. Therefore, the supply of unleaded gasoline was guaranteed in 1985 (Neu 1990).

3.1.2 Gasoline Supply

From 1950 to 1992, gasoline sales increased substantially (see Figure 6). This development, however, was mitigated by the oil crisis in 1973 and 1979 which initiated two worldwide recessions. These obviously resulted in a decline in the rate of growth of gasoline sales after 1972.

Due to the lead reduction regulations in 1972 and 1976, the total lead emissions first decreased significantly but then rose again. Rising lead emissions could have been avoided if the reduction of total emissions had been the explicit goal and the gasoline lead content had been adjusted accordingly. However, the target of reducing the lead content was finally achieved. In general, regulation policies were highly dedicated to achieving the environmental thresholds, but they were often accompanied by high administration and control costs (Wicke 1991).

Despite the implementation of unleaded gasoline in the autumn of 1985, the lead emissions reduced only slowly in the following years. This was caused by the low market share in the first years and the lower lead reduction amount per litre compared to in the 1970s.



Assumptions: 1 tonne of gasoline is equivalent to 1330 litres. Lead content in gasoline: 1950-1971, 0.6 g Pb/l; 1972-1975, 0.4 g Pb/l; since 1976, 0.15 g Pb/l. Unleaded gasoline: 0.013 g Pb/l.

Data source: Mineralölwirtschaftsverband (1998).

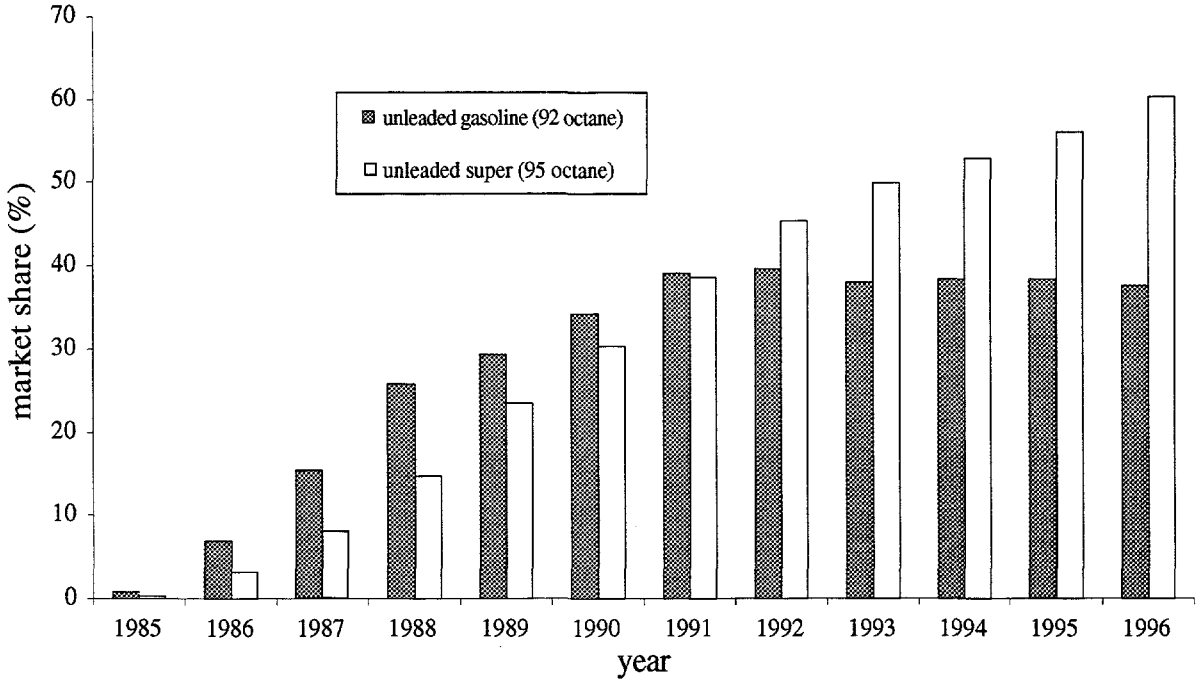
Figure 6: Gasoline Sales and Lead Emissions in Germany, 1950-1992

In the autumn of 1984, a network of unleaded petrol stations was built in Germany. The supply of Super Unleaded (95 octane) started in a few regions in 1985, and in spring the sale of unleaded gasoline (92 and 95 octane) first exceeded 1% of total sales. This can be attributed to the introduction of a tax promotion of unleaded gasoline of about 0.04 DM/l. Nevertheless, the sales volume did not reach the government's expectations.

Several factors negatively influenced the sale of unleaded gasoline. In the beginning, it was more expensive than leaded gasoline. Although the price elasticity of the total demand for gasoline, defined as the percent change in demand due to a price change of 1%, was very low, the demand

for unleaded fuel was highly inelastic, i.e., consumers did not accept higher prices. Furthermore, adaption measures in the motor had to be carried out because the quality norms of Super Unleaded were lower than for leaded Super (98 octane). Another problem was the fact that some of the automobile firms still constructed motors with soft valve seats which needed lead for proper functioning. Lead functioned as lubricant which allowed the automobile industry to use lower-grade and therefore less expensive metals on the engine valve seats (Umweltbundesamt 1980b).

Additionally, the media argued against the use of unleaded fuel. They claimed that unleaded gasoline contained a high percentage of carcinogenic benzene and that gasoline consumption would rise. The negative attitude was shared by many of the automobile garages and petrol stations. They also dissuaded the use of unleaded gasoline because they did not want to change their array of products, which would invoke resultant investment costs (Westheide 1987).
In 1985, unleaded gasoline had a market share of an average of 1% (Figure 7). In 1986, when unleaded gasoline became cheaper than leaded fuel, the market share rose to 6.9% (92 octane) or 3.1% (95 octane) (cf. Figure 2). In 1988, when leaded gasoline (92 octane) was prohibited in Germany, the market share of unleaded gasoline was still not more than 40.4%. It was not until 1997 that the sales of unleaded fuel reached nearly 100% (Mineralölwirtschaftsverband 1998).



Data source: Mineralölwirtschaftsverband (1998).
Figure 7: Market Share of Unleaded Gasoline 1985-1996

Comparing these market shares with the potential total sales of unleaded gasoline, i.e., assuming that all automobiles which for technical reasons could run on unleaded gasoline did so, only 15.1% of the potential consumption was realized in 1986. In 1988, German Shell Inc. (1988)

published a study which concluded that the market share of unleaded gasoline could reach 83% of total sales assuming the owners of all automobiles which tolerated unleaded fuel actually used it.

In 1986, the import of unleaded gasoline varied between 6% and 14% of the unleaded total sales, which was half of the percentage of total fuel imports. As a consequence of high price risks, due to a turnover of about eight to ten weeks, independent importers did not participate in this market segment. Until 1987, unleaded gasoline was not price quoted on the international gasoline market in Rotterdam. No surplusses of unleaded fuel were offered there, which had negative effects on price competition. Therefore, at the beginning of the implementation of unleaded fuel, external trade did not influence the competition in the market for unleaded fuel (Neu 1990).

3.1.3 Gasoline Price Changes

After the first energy crisis in 1973, gasoline prices rose enormously. This increase was not caused by environmental regulations but by the increasing prices of crude oil, increasing freight charges and large refinery overcapacities in Germany (Gabriel/Zimmermann 1978). Due to uniform qualities, the fuel market was characterized by sharp price competition until unleaded gasoline was introduced into the market.

The price trend of unleaded fuel was heavily influenced by tax incentives. At the beginning of 1985, unleaded gasoline (92 octane) was more expensive than leaded fuel by an average of 0.07 DM/l and Super Unleaded was not sold in greater amounts until summer 1985. When, in April 1985, tax incentives of 0.04 DM/l were implemented, the price dropped by about 0.05 DM/l. For competitive reasons, the trade cut the average sales price of unleaded gasoline by about 0.01 DM/l more than the amount of the tax subsidy. The market share rose to 3% of total gasoline sales (92 octane). In 1986, due to tax incentives being increased to 0.07 DM/l gasoline, the consumer prices of unleaded fuel declined, and for the first time it was about 0.02 DM/l cheaper than leaded gasoline. Assuming additional production and distribution costs of 0.035 DM/l, based on a price level in 1983, the tax subsidies were not totally passed on to the consumer (Little 1984).

Furthermore, the price policy of the refineries also determined the price difference between leaded and unleaded gasoline. The gasoline supply of the independent trade was about 0.027 DM/l cheaper than that from the large refinery companies. When the price difference between leaded and unleaded gasoline rose to more than 0.03 DM/l, the independent traders lost their price advantages. Moreover, until the end of 1986, no import market for unleaded gasoline existed, so the independent traders had to buy unleaded fuel from domestic refinery companies at petrol station sales prices. At that time, price competition between the two trading groups was impossible (Statistisches Bundesamt 1987).

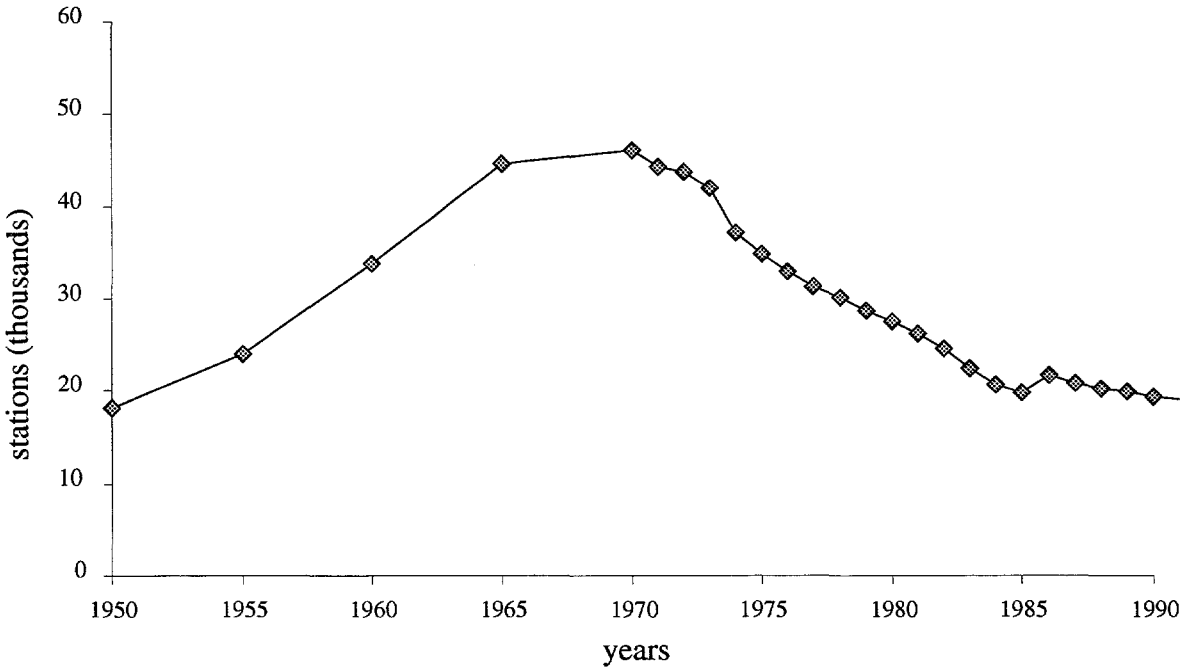
Westheide (1987) calculated that in the years 1987 and 1988 tax subsidies for unleaded gasoline amounting to DM 540 million were not passed on to the consumer. Despite this, the tax incentive

benefited not only the gasoline traders but also the consumers and pushed the sales of unleaded gasoline. Overall, the political target of stimulating the market for unleaded gasoline was achieved independently of the question of whether it was realized by minimal or maximal costs.

3.1.4 Distribution system

In the 1970s and 1980s, the wholesale of gasoline in Germany consisted of two groups. On the one hand, large mineral oil companies with a market share of about 90% distributed gasoline through their own petrol stations or authorized dealers. On the other hand, there were independent wholesalers who imported predominantly from spot operation markets like Rotterdam (Baum 1983).

Like the refinery market, the distribution system was an oligopolistic market. As a result of stronger competition, the number of petrol stations decreased after 1970 (Figure 8). The international companies in particular reconstructed their distribution systems in Germany. The number of petrol stations declined from 46,859 in 1950 to 19,231 in 1987 (Mineralölwirtschaftsverband 1998).



Data source: Mineralölwirtschaftsverband (1998).

Figure 8: Gasoline Stations in Germany, 1950-1990

In 1986, it was not only the refinery companies that established a network of unleaded petrol stations but the independent trade did the same. During the first months of the implementation of unleaded gasoline, the independent traders were able to keep their market share. After 1987,

however, the international mineral oil companies pushed back the independent petrol stations. The reconstruction of the stations was a much higher financial strain for the independent traders than for the large international companies. The traditionally smaller petrol stations had to build new gasoline pumps and containers, while the larger stations operated or franchised by companies often only had to rename a part of their pumps. Furthermore, the supply of unleaded gasoline was difficult for the independent trade. The traders could receive unleaded fuel only from domestic refineries at the same price level as it was sold at the petrol stations owned by the large companies. Therefore, the independent trade was not very interested in acting in that market segment, as they were unable to offer unleaded gasoline cheaper than the operated or franchised stations without incurring losses (Neu 1990).

Moreover, the independent trade was financially less sound. Although the German government implemented investment subsidies for these middle-class firms, from 1985 to 1988, 81% of middle-class gasoline traders received subsidies totalling about DM 22 million, the independent petrol stations lost their market share (Neu 1990). In 1986, the independent trade had a market share of 11% of leaded gasoline sales but only 7.5% of unleaded fuel sales (Mineralölwirtschaftsverband 1998).

In January 1989, some companies introduced unleaded gasoline with 98 octane ("Superplus"). The concept of four different pumps worsened the competitive strength of the independent trade because it was connected with high investment costs (Neu 1990).

3.2 Automobile market

Until the 1990s, seven companies dominated the automobile market in Germany, so it could also be described as an oligopolistic market. Nevertheless, car manufacturers in the same market segment competed strongly, as, for example, Daimler-Benz and BMW or Ford and Opel. Moreover, automobile imports guaranteed price competition, for example, in 1984, 27% of new cars registered were imported ones. While in the 1960s the imports came mostly from France and Italy, Japanese cars achieved a high market share in the 1970s (Berg 1984).

During the implementation process of unleaded gasoline in 1984 and 1985, the consumers hesitated to buy new cars. Therefore, the automobile producers had to broaden their array of catalyst-cars quickly. Due to exports to the USA, all German firms except the U.S.-subsidiary companies Ford-Deutschland and Opel-Deutschland had experience with the catalyst technology. However, in 1986, many car manufacturers had long delivery periods for catalyst-cars due to technical and logistical problems (Westheide 1987). In autumn of 1987, low-emission cars with a cubic capacity up to 2000 cm^3 were mostly offered by German and Japanese manufacturers. With regard to automobiles in the highest cubic-capacity class, more than 2000 cm^3, the Germans dominated the market (Neu 1990).

The calculated additional costs of equipping automobiles with catalysts varied widely. The Umweltbundesamt (1980a) computed incremental costs of about DM 750 per car on average,

whereas the Organisation for Economic Co-Operation and Development (OECD) estimated costs of about U.S. $ 250-750. The differences were mainly caused by different assumptions about the reconstruction of the motor and exhaust systems of the automobiles and the lifetime of the low-emission system.

The German automobile industry even calculated an increase in consumer prices by DM 1500-2500 per car (Westheide 1987), which was quite similar to the increase calculated by the Ifeu-Institut (1985) of about DM 2200.

Dependent upon the automobile and catalyst type, the car manufacturers specified diverse additional costs (see Table 3). BMW benefited from technically less difficult reconstructions and in 1986 was able to offer catalyst-cars for an extra charge of DM 950. Standard installation of catalysts by Daimler-Benz lowered the additional costs to DM 1000-1700.

Table 3: Additional Costs per Automobile Equipped with Catalysts, 1985/86

Car manufacturer	1985 (DM)	1986 (DM)	Car manufacturer	1985 (DM)	1986 (DM)
Audi	2500	2000	Porsche	*	1400-1600
BMW	1800-2000	950	Citroen	-	2000
Daimler-Benz	1800-5400	1000-1700	Fiat	2500	1000-1500
Ford	2300-3300	1600-2000	Peugeot	*	2200-2400
Opel	2000-5000	750-3000	Renault	2000	1600-1800
VW	2800-3200	950-1900	Volvo	2400	2100

-: no supply of automobiles with catalysts; *: no information about prices
Source: adapted from Westheide (1987).

The broad lowering of extra charges by both firms indicated a strong price competition between Daimler-Benz and BMW, who supplied in the same market segment. During the first years of the regulation of unleaded gasoline, Ford-Deutschland had large technical problems in equipping their models with catalysts. Therefore, they concentrated their activities in the market for cars with diesel engines. In 1985, Opel-Deutschland also had no experience with catalysts, but in 1986 they were able to offer catalyst-cars as standard. In 1984, Porsche was the first firm in Germany that produced all their models with catalysts, profiting from their knowledge from U.S.-exports. VW offered the largest array of catalyst-cars, but until 1987 the extra charges were much higher than for automobiles from BMW or Daimler-Benz. Unlike Peugeot and Citroen, Fiat and Renault had started with low-emission models early and quite sucessfully. Although catalysts had already been obligatory in Japan, the Japanese producers had large technical problems on the German car market because at high velocities their catalyst systems did not work properly (Westheide 1987).

During the first years of low-emission-car-regulation, among German car manufacturers Daimler-Benz and VW were the great winners from the introduction of the regulations. Daimler-Benz

produced motors easily compatible with catalysts, supplied a large number of diesel engines, and the customer demand was inelastic. So the market share of Daimler-Benz for low-emission cars rose to 20% in 1986, whereas their market share of the total sales was 10.7%. VW benefited because of its large array of catalyst-cars, establishing a market share that was 5-10% higher than their share of the total car sales. Market share losses were suffered especially by Renault, Opel-Deutschland and Ford-Deutschland (Westheide 1987).

Overall, favourable terms of competition were experienced by producers of cars with high technical standards, who had already gathered experience with catalyst systems on the U.S.-market and who offered a broad supply of cars with diesel engines. Over time, the additional costs of installing catalyst systems declined. This decline indicated the dropping unit costs due to increasing production of low-emission cars, an effect of economies of scale and strong price competition.

The share of total new automobile registrations held by low-emission cars increased steadily from 3.1% in July 1985 to 93.7% in 1988. Indeed, most of them were not catalyst-cars but automobiles with diesel engines, which were classified as low-emission cars as well. Obviously the consumers trusted more in the well-established diesel technology. Furthermore, in the middle of the 1980s, the network of petrol stations in foreign countries selling diesel gasoline was better developed than that for unleaded fuel. This sideways reaction had a negative effect on the changeover to unleaded gasoline (Bundesminister für Verkehr 1988).

During the first months of the introduction of catalyst-cars, the media comments were negative. They claimed that catalyst-cars would achieve less output and have a higher fuel consumption than automobiles without emission-reduction systems. Moreover, they criticized the short lifetime of catalysts and health dangers due to the platinum plates catalysts contained. It took time for these arguments to be proved wrong. The automobile traders also tried to convince the consumers not to buy a catalyst-car because they wanted to sell their stocks of conventional automobiles first.

The tax incentive for converting conventional cars to low-emission automobiles was only rarely taken advantage of by car owners, because the economic incentives were low and the people mistrusted the technology used to convert the car. The prices for second-hand cars evolved as was theoretically anticipated. Increasing acquisition and running costs led to the substitution of new cars with second-hand automobiles. In the middle of the 1980s, the demand and the price level for second-hand cars rose, as did the lifetime of these automobiles (Neu 1990).

Germany was a net exporter of automobiles. Therefore, it was very important for the German automobile industry that the regulations regarding low-emission cars did not restrict the free merchandise trade within the EU nations. As the German car industry was the first in the EU to change its production to low-emission automobiles, they could realize trade benefits in the following months, and in the middle term the export opportunities increased. But the classification of diesel engines as low-emission cars and their tax support acted in favour of foreign imports, because the car industries in other EU nations produced mostly diesel engines and no catalyst-cars. Even more important was the EU regulation regarding tax incentives for

automobiles with an engine of cubic-capacity less than 1400 cm^3 (cf. p. 7). This special regulation was forced by France and benefited particularly the French, Italian and English automobile imports to Germany. In 1986, in that cubic-capacity class, they achieved a market share of 31.4%, while only 13.1% in all cubic-capacity categories. The Japanese import of small cars benefited too. Moreover, the trend of international specialization to produce only automobiles in certain cubic-capacity classes was boosted (Westheide 1987).

4 EFFECTS OF GASOLINE LEAD CONTENT REDUCTIONS ON GERMAN NATIONAL ECONOMIC INDICATORS

In 1972, when the regulations on the lead content in gasoline were first implemented, not only did a political change take place from the "broad" coalition of the German parties SPD, FDP and CDU to a social-liberal coalition, but additionally the German budgetary and financial state was healthy. So everything seemed to be feasible. This also applied to environmental policies. In 1976, the situation was quite different. Germany was in a recession, and so the trade unions and employers offered resistance to environmental policies for fear of negative effects on economic growth and an assumption of resultant enormous costs. At that time, environmental protection was required to coincide with economic stabilization. Finally, the government amended the lead reduction regulations by implementing exemption paragraphs, which were interpreted as a concession to the affected industries (Schulz 1983) (cf. p. 4).

Meißner/Höhl (1977) calculated the costs of air pollution due to automobile traffic to be approximately 1% of the gross national product. They defined a damage function including the parameters increase of mortality rate, material damages, damage to plants and animals estimated as yield losses in agriculture, health damages and the loss of productivity of the factor labour. This result coincided with the analysis of Peters (1980), who estimated the damages of air pollution to be about DM 10 billion per year. Applying the methodology of willingness-to-pay health damages, damage to plants, animals, materials and costs due to dodge steps were contained.

At 1981 price levels, Schulz (1983) calculated the costs of the reduction of automobile emissions to be about DM 1.4 billion and the benefits to be DM 1.9 billion, much lower than the estimations of Peters (1980). The cost function of Schulz (1983) considered 2.7 million automobiles equipped with catalysts (DM 500 per low-emission system) and investment costs for the mineral oil industry of about DM 50 millions per year. The benefits were adopted from Peters (1980). The administration costs of the regulation were neglected because controls were limited to cases of strong suspicion.

According to Westheide (1987), the additional consumer costs caused by supplying unleaded gasoline and low-emission cars were about DM 1.6 billion in 1986. This, he concluded, had an order of macroeconomic magnitude. The compensation tax for producing or importing gasoline with a lead content higher than 0.15 g Pb/l was estimated to be about DM 30 million (cf. p. 4). This money was, however, used for government revenues, not public expenditure on environmental policies.

4.1 Economic indicators

The refinery industry had a high proportion of fixed capital costs, and low labour levels. Therefore, the regulations to reduce the lead content in gasoline had no effects on employment levels. Both Gabriel/Zimmermann (1978) and Schulz (1983) concluded that the regulation costs were too small to affect the target of economic growth. In fact, they assumed that the temporary declines of gasoline sales in the 1970s were caused by the two oil crises. Moreover, the stability of price levels was not affected by the regulations. Assuming additional gasoline production costs of about 0.02 DM/l, the financial burden on households was marginal, particularly as these costs were not passed on to the consumer. But that conclusion contradicts the results of Westheide (1987) (cf. p. 16).

The gasoline market was dominated by international trusts which were highly flexible. This guaranteed that the lead policy did not affect the foreign trade balance, due to the relatively small costs induced (Schulz 1983).

In general, oligopolistic sectors of industries preferred regulation policies because they complied with the limitation of entry into the market, which favoured firms already acting in this market segment (Buchanan/Tullock 1975). However, until 1977, no effects could be observed in the economic indicator of competition between gasoline suppliers, although the German regulations at times excluded foreign refineries because they were stricter than in other EU nations, and could have therefore in theory favoured domestic suppliers (Gabriel/ Zimmermann 1978).

Furthermore, environmental policies presented the possibility of new markets or production facilities opening up, and the establishment of new sales opportunities. Innovations were encouraged, and the competition was strengthened so that the tendency for collaboration in the gasoline and automobile markets was weakened. Both market segments had been oligopolistic markets in which the companies tended to collaborate and fix prices. However, Jarre/Zimmermann (1980) concluded that the lead regulation caused a distortion of competition. The independent gasoline importers and stations lost most of their market shares and their function as a price regulator.

4.2 Allocation effects

In the 1970s, the income elasticity for traffic expenditures was very high, and so as the income rose the share of these expenses in the net income increased overproportionally. Hence, increasing costs for automobiles and gasoline due to lead-reduction policies were thought to discriminate against people with a high income. As the costs of the emission policies were hardly passed on to fuel consumers, however, rich people were not overburdened. Overall, the additional costs would have been marginal (Heidtmann/Altkrüger 1974).

Schulz (1983) worried about discriminable effects of the lead regulations on rural areas. Increasing gasoline prices, fairer commuter routes and lower income levels would have weakened the rural in comparison to urban development potential. In fact, the tax subsidies for the mineral

oil and automobile industries as well as for motorists widely prevented the discrimination of rural areas.

5 SUMMARY

Environmental protection policies in the automobile market were not implemented until the motorisation of masses in the 1960s which caused an increasing environmental burden. The rising air pollution was considered a latent danger for humans, animals and plants. In the years up to 1985, the EU passed several regulations to limit the mass pollutants CO, CxHy and NOx.

Germany was the first EU-member nation which was also concerned with lead in gasoline, and in 1971 the "Gasoline Lead Content Regulation" was passed by the German parliament. Although the health risks were not objectively calculable, the population was thought to be protected by reducing the lead content of gasoline.

In the 1980s, the discussion about air pollution was dominated by the worry of widespread forest damage. Introducing the catalyst, which functioned properly only with unleaded gasoline, the automobile emissions, responsible for forest damage, were thought to be lowered significantly. Again, it was Germany which pushed the EU regulation regarding low-emission systems and unleaded gasoline. Finally, in 1987 the regulation passed the EU, dominated not by German interests but by those of Italian, French and English export industries.

The regulations were often criticised. It was argued that standards and thresholds averted innovations and technical advances. Despite the criticism, the lead policies were quite successful concerning the reduction of lead concentrations in the atmosphere and in human blood in Germany.

The regulations had several effects on the German mineral oil and automobile markets. Increases in gasoline production costs due to additives with high octane numbers came into force in 1976 and 1986 and were different subject to the type of refinery. In any case, none of the anticipated bottlenecks in gasoline supply occurred because large overcapacities had been built up in the German refinery sector. Several factors had a negative influence on the sales of unleaded gasoline. The price level higher than leaded gasoline, the execution of adaptation measures in the motor and negative comments from both the automobile traders and the media were all important. When unleaded gasoline became cheaper than leaded fuel its market share increased quickly. Overall, the price trend of unleaded fuel was heavily influenced by tax incentives which benefited not only the gasoline traders but also the consumers. With regard to the distribution system, the lead reduction policy weakened the market position particularly of the medium-sized traders and the independent importers despite the fact that investment subsidies had been implemented.

In the automobile market, favourable terms of competition were experienced by producers of cars with a high technical standard, who had already gathered experience with catalyst systems on the U.S.-market and who offered a broad supply of cars with diesel engines. Over time, the additional costs of installing catalyst systems declined. This indicated dropping unit costs due to increasing production of low-emission cars, an effect of economies of scale and strong price competition. The German car industry was the first in the EU to change its production to low-emission automobiles so that it could realise trade benefits. The EU classification of diesel engines as low-emission cars and tax incentives for automobiles with engines of low cubic-capacity benefited particularly the French, Italian, English and Japanese automobile imports to Germany.

The gasoline lead content regulations had no significant effects on economic indicators such as unemployment level, economic growth, price stability and foreign trade balance. Innovations were encouraged, and competition was strengthened so that the tendency for collaboration in the gasoline and automobile markets was weakened. Furthermore, no significant allocation effects occurred. As the costs of reducing lead in gasoline were hardly passed on to fuel consumers, people with high incomes were not burdened overproportionately and a discrimination against rural areas was prevented.

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