APPENDIX AVAILABLE ON REQUEST

Research Report 139

Effects of Long-Term Exposure to Traffic-Related Air Pollution on Respiratory and Cardiovascular Mortality in the Netherlands: The NLCS-AIR Study

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Appendix D. Assignment of Traffic Intensity Data

Note: Appendices Available on the Web appear in a different order than in the original Investigators' Report. HEI has not changed these documents. Appendices were relettered as follows:

Appendix C was originally Appendix 1
Appendix D was originally Appendix 2
Appendix E was originally Appendix 3
Appendix F was originally Appendix 4

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Appendix 2: Assignment of traffic intensity data

1. Introduction

This appendix provides more detailed information regarding

1. Conversions for traffic intensity data collected during workdays only or daytime hours only into average traffic intensities
2. Procedures for extrapolation of traffic intensity data to years for which no data are available.
3. Assignment of default value for roads with no data

2. Procedures for the calculation of average weekday traffic intensity data, and for the calculation of total truck traffic intensities on municipal roads

2.1 Introduction

We wanted to link *average weekday* traffic intensities to the digital road network. Average weekday traffic intensity is defined as the total traffic intensity on all seven days together divided by seven, and weekday traffic intensities include thus workday traffic intensities.

However, average weekday traffic intensities on *municipal* roads are not always available:

1. for approximately 7% of the municipalities *average workday* traffic intensities are available;
2. for approximately 3% of the municipalities *day* traffic intensities, i.e. traffic intensities that have been collected between 7.00 AM and 7.00 PM, are available;
   for one municipality (Zuidhorn) (of a total of 97 municipalities) traffic intensities collected between 14.00 PM and 18.00 PM are available;
3. furthermore, for approximately 30% of the municipalities only total traffic intensity data, but no information about total truck traffic intensity (i.e. sum of medium-duty and heavy-duty traffic intensity), is available.

In the following paragraphs in this chapter it is explained in detail which conversion factors were used to calculate average weekday traffic intensities, but in summary, the following conversion factors were used:

1. average *workday* traffic intensities was multiplied with a conversion factor of **0.94** to calculate an average *weekday* traffic intensity;
2. *day traffic intensities* was multiplied with a conversion factor of **1.29** to calculate an average *weekday* traffic intensity;
   and traffic intensities of the municipality of Zuidhorn which are collected *between 14.00 PM and 18.00 PM* were multiplied with a conversion factor of **3.86** to calculate average *weekday* traffic intensities;
3. for municipalities for which only total traffic intensity data were available, but no total truck traffic intensities are available, total truck traffic intensities were not calculated using total traffic intensity data, because there is a fairly wide range in the percentage total truck traffic on municipal roads between municipalities and on municipal roads within municipalities.

2.2 Conversion of average workday traffic intensities into weekday traffic intensities

For approximately 7% of the municipalities only traffic intensities on workdays (Monday-Friday) are available. There are no standards for the conversion of average workday intensities into average weekday intensities, however, for some municipalities both average workday and average weekday traffic intensities are available. These data can be used to develop conversion factors. In table 1, average ratios between weekday and workday intensities (i.e. weekday intensities divided by workday intensities) on municipal roads for five municipalities are shown for several years. There seems to be no trend over time. Furthermore, there seems to be no association between the size of the ratios and the population size of a municipality. The average ratios per year are also shown in table 1. The overall average ratio of the ratios in table 1 is *0.94*. In figure 1, the relation between workday traffic intensity and the ratio between weekday and workday intensities is shown. Data are from the municipality of Schiedam for the year 1992. No association between workday traffic intensity and the ratio between weekday and workday intensities could be shown (p=0.6). Data from Schiedam from other years and data from other municipalities showed similar results. The ratio between weekday and workday intensities seems therefore not related to the workday traffic intensity.

Furthermore, the correlations between weekday and workday traffic intensities on roads in these five municipalities were calculated. An average correlation per year was calculated, and all correlations were higher than 0.98. Workday and weekday traffic intensities are thus highly correlated, supporting the conversion for the few municipalities with workday traffic intensities.

For national roads, average weekday traffic intensities are already available for the period 1986-2000 and do not have to be converted, but also average workday traffic intensities are available. To

evaluate whether the ratio between weekday and workday traffic intensities is different on national roads or depends on the traffic intensity on a road, ratios for national roads are also calculated. In table 2, the ratios between weekday and workday intensities for national roads are shown.
The ratios between weekday and workday intensities for national and municipal roads are quite similar, which is also an indication that the ratio between weekday and workday traffic intensities is independent of the traffic intensity on a road.
For individual roads the road specific ratio can differ from the average ratio, for example depending on the function of the road; a road leading to a recreational area may have a higher weekday-workday ratio, and a road leading to an industrial area may have a lower weekday-workday ratio compared with the average ratio. In addition, a ratio may be season (or weather) dependent. However, such information is not available for individual roads. Therefore, average ratios were used for the conversion of workday traffic intensities into weekday traffic intensities. As described above, the average correlation between weekday and workday traffic intensities is very high.
In conclusion, we used a conversion factor of *0.94* with which workday traffic intensities were multiplied to get average weekday traffic intensities. We assume that these ratios did not change over time, and that the ratios are independent of the workday traffic intensity on a road.

2.3 Conversion of day traffic intensities or hour traffic intensities into weekday traffic intensities

For approximately 3% of the municipalities only day traffic intensities, i.e. traffic intensities that have been collected between 7.00 AM and 7.00 PM, are available; and for one municipality, only traffic intensities between 14.00 PM and 18.00 PM are available.

Day traffic intensities

Information about distributions of the traffic intensities over the different parts of the day has been obtained for several years. In tables 3, and 7, percentages of total daily traffic intensity during day hours on municipal roads are shown ranging from 77.8% till 84.0%, with no specification whether these percentages are for weekdays or workdays or both.(1981; Vermeulen and Wouters 1993; Dassen, Dolmans et al. 2000)
In tables 4 and 5, average day percentages that have been collected separately for light-duty, medium-duty and heavy-duty traffic *on workdays* are shown. However, the municipalities with day traffic intensities have only total traffic intensities, i.e. no separate data for light-duty, medium-duty and heavy-duty traffic. In the 1986 rapport “Bepaling van verkeersgegevens ten behoeve van de Wet Geluidhinder” (Assessment of traffic data for the Dutch Noise Law) the percentages light-duty,

medium-duty and heavy-duty traffic of the total traffic intensity on municipal main and non-main roads are given: light-duty: 86%; medium-duty: 10%; and heavy-duty: 4%.(Hofstra and Bergsma 1986) With these percentages, the percentage of the total daily traffic intensity that occurs during day hours can be calculated, i.e. for municipal main roads: 76.8*0.86 + 82.8*0.10 + 81.6*0.04 = 77.6%, and for municipal non-main roads 76.8*0.86 + 82.8*0.10 + 85.2*0.04 = 77.7%. These (workday) percentages are similar with the percentages in tables 3, 6 and 7, and therefore we used the assumption that there is no difference in the percentage of the total daily traffic intensity that occurs between 7.00AM and 7.00PM on weekdays and workdays.

In table 8, percentages of total traffic intensity that occurs during day hours on roads for three municipalities are shown for different years. The annual average percentages are similar with the described percentages in tables 3-7.

Although only limited data are available, the percentages of the total daily traffic intensity that occurs between 7.00AM and 7.00PM do not seem to change over time.

In table 3, there is a slight difference between the percentages for municipal main roads and municipal non-main roads, with the highest percentage for municipal non-main roads. A reason for this difference might be that on roads with a higher total daily traffic intensity, the distribution of traffic intensity might be more evenly distributed over the 24 hours, with a larger part of the total traffic intensity that occurs during the night compared with roads with a lower total daily traffic intensity. However, the percentages for municipal main roads and municipal non-main roads, based on tables 4 and 5, are 77.6% and 77.7%, respectively. Furthermore, in figure 2, the relation between the total daily traffic intensity and the percentage of the total daily traffic intensity that occurs between 7.00AM and 7.00PM is shown. Data are traffic intensity data from the municipality of Den Bosch for 2002. No association could be shown (p=0.2). Data from other years showed similar results. Therefore, the percentage of the total daily traffic intensity that occurs between 7.00AM and 7.00PM was assumed to be independent of the total traffic intensity on a road.

In conclusion, the described percentages are comparable and we used a percentage of *77.8%* (table 7) as the percentage of the total daily traffic intensity that occurs during day hours on municipal roads. We used the assumption that there is no difference in the percentage of the total daily traffic intensity that occurs between 7.00AM and 7.00PM on weekdays and workdays. There seems to be no clear trend over time, and we assumed that the percentage of the total traffic intensity that occurs between 7.00AM and 7.00PM is independent of the traffic intensity on road.

With this percentage day traffic intensities can be converted to weekday traffic intensities. Day traffic intensities were multiplied with 1/0.778 = *1.29* to calculate weekday traffic intensities.

If day traffic intensities may have been collected on workdays, first the traffic intensity for the full 24 hours on a workday can be calculated using the above conversion factor, and second, this 24-hour workday intensity can be calculated to a weekday traffic intensity using the conversion factor described in paragraph 2.

Hour intensities

For one municipality (Zuidhorn), only traffic intensities between 14.00 PM and 18.00 PM are available. In tables 3 and 6, average percentages of the total traffic intensity during one hour between 7.00 AM and 7.00 PM are shown. The percentages are 6.7% (municipal main roads, 1981), 7.0% (municipal non-main roads, 1981), and 6.6% (all municipal roads, 1993). The percentages are similar for 1981 and 1993, suggesting that these percentages have not changed over time. No information is available whether these percentages are for weekdays or workdays or both. But we used the assumption, as in the previous section, that there is no difference between weekdays and workdays. And further, we used the assumption that the percentage is independent on the total traffic intensity on that road.

For the municipal roads of Roermond both weekday traffic intensities and day traffic intensities are available, and the average percentage of the total traffic intensity during one hour between 7.00 AM and 7.00 PM was 6.6%.

We described above that we used a percentage of 77.8 as the percentage of the total daily traffic intensity that occurs during 7.00 AM and 7.00 PM on municipal roads. Using this percentage, the average percentage that occurs per hour in the period 7.00 AM – 7.00 PM is thus 77.8/12 = 6.5%, which is comparable to the percentages described above.

Thus, we used a percentage of *6.5%* to convert intensities per hour during day hours into average weekday intensities.

However, data for the municipality of Zuidhorn are available for the period 14.00 PM – 18.00 PM, which includes a part of the evening rush hour. The percentage of the total traffic intensity that occurs during the morning rush hour and evening rush hour were larger than 6.5%. The municipality of Den Haag uses 8.0% as the percentage of the total traffic intensity that occurs between 8.00 AM and 9.00 AM, and 8.1% as the percentage that occurs between 4.30 PM and 5.30 PM on municipal roads with total traffic intensity > 2,000. These percentages are for workdays. We assumed that these percentages are also applicable for weekdays. The municipality of Weert and the municipality of Pijnacker use percentages of 8.5% and 8.7% respectively, as the percentage of the total daily traffic intensity that occurs during 5.00 PM and 6.00 PM.

If we assume that the evening rush-hour starts at 5.00 PM, for the municipality of Zuidhorn three hours in the period 14.00 PM – 18.00 PM are not in the rush-hour period, and further Zuidhorn is a relatively small municipality (N ~ 20,000) were the rush-hour intensities was not so different from traffic intensities during other hours of the day, so we assumed that in this time-period 6.5% of the total daily traffic intensity will occur per hour. Therefore, in the period 14.00 PM – 18.00 PM, *26%* of the total daily traffic intensity will occur.
In conclusion, traffic intensities of the municipality of Zuidhorn were multiplied with 1/0.26 = *3.86* to calculate the weekday traffic intensity.

2.4 Calculation of total truck traffic intensities using total traffic intensities

For approximately 30% of the municipalities only total traffic intensity data, but no information about total truck traffic intensity data, are available. For the other municipalities total truck traffic intensities are available; however, for most of these municipalities total truck traffic data are only available for one (recent) year. We have evaluated whether it might be possible to calculate total truck traffic intensities using total traffic intensity data.
Total truck traffic intensity is defined as the sum of medium-duty and heavy-duty traffic intensities (variable “vracht”year”” in the dataset).
In tables 9 and 10, percentages light-duty, medium-duty, and heavy-duty traffic on municipal main and non-main roads are shown. The percentages are the same for both types of municipal roads.(Hofstra and Bergsma 1986) In tables 11 and 12, also percentages light-duty, medium-duty, and heavy-duty traffic on municipal main and non-main roads are shown during day-hours and night-hours.(1981) The percentages are almost the same for day-hours and night-hours. The percentages in tables 11 and 12 for municipal main and non-main roads are slightly different compared with the percentages in tables 9 and 10. The average percentages for light-, medium, and heavy-duty traffic on municipal main roads are 89%, 8.4%, and 2.6%, respectively; and the average percentages for light-, medium, and heavy-duty traffic on municipal non-main roads are 92%, 6.3%, and 1.7%, respectively. The percentages on municipal main and non-main roads differ somewhat, with slightly lower percentages total truck traffic on municipal non-main roads. The overall average percentages for light-, medium-, and heavy-duty traffic on municipal roads are 91%, 7.1%, and 1.9%.
In table 13, average percentages total truck intensity (i.e. sum of medium- and heavy-duty traffic) of the total traffic intensity for the municipality of Winterswijk for different years are shown

(Winterswijk is one of the few municipalities with total truck traffic data for several years). Percentages are comparable with the other data.

In table 14, the percentages light-, medium- and heavy-duty traffic of the total daily traffic intensity on municipal roads in 3 municipalities are shown. The percentages are comparable with the percentages in tables 9, 10, 13 and 14. However, the percentages heavy-duty traffic differ between the 3 municipalities.

In figure 5, the relation between percentages light-duty, medium-duty, and heavy-duty traffic and the total daily traffic intensity is shown. No clear association could be shown, but there might be some indication that the percentage light-duty traffic is slightly lower, i.e. that the percentage total truck traffic is slightly higher, on roads with higher total traffic intensities. This is comparable to the results in tables 11 and 12. This might indicate that total truck traffic intensities depend on the total traffic intensity on a road, with higher total truck traffic intensities on roads with higher total traffic intensities; this indication might be a reasonable one.

In tables 9-14 only average intensities are shown and no information about the range in percentages in the different types of traffic are shown. The data in table 14 suggest however, that there might be differences in the percentage of the different types of traffic between different municipalities, and possibly also between different roads within a municipality. Therefore, we calculated the correlations between total traffic intensity and total truck traffic intensity, and between light-duty and heavy-duty traffic intensities for the 3 municipalities in table 14 (Roermond (1999); Zeist (1994); Zoeterwoude (2001)). The correlations are shown in table 15. Further, we calculated in each of these 3 municipalities per road the percentage total truck traffic, and calculated per municipality the average percentage total truck traffic, the standard deviation, and minimum and maximum percentage. The results are shown in table 16. The average percentages total truck traffic on municipal roads differ between the 3 municipalities, and within each municipality the percentages total truck traffic can also vary on municipal roads. Further, a RIVM report evaluated also the percentage total truck traffic within municipalities, and concluded also that the average percentage total truck traffic could vary substantially between municipalities (4-18%).(Laan 1992)

Because of this fairly wide range in percentages total truck traffic on municipal roads between municipalities and on municipal roads within municipalities, we will not calculate total truck traffic intensities using total traffic intensities, because then we have to use an *average* percentage. Therefore, when we will evaluate the effects of total truck traffic intensities on health outcomes, we will only use the municipalities with total truck traffic data available. For these municipalities we assumed that the percentage total truck traffic has been stable over the period 1986-1996. Thus, to estimate total truck traffic intensities for years for which no total truck traffic intensities are

available, we used the same procedure as described in chapter 5.3 *"Procedure for the extrapolation of traffic intensity data on municipal roads to years for which no data are available"*, i.e. the same percentages as described for the different road types were applied to estimate total truck traffic intensities for years for which no total truck traffic data are available.

3. Assignment of a traffic intensity value to municipal roads for which no traffic intensity data are available

3.1 Introduction

The local scale exposure was characterized in different ways, but for all these different methods, it is needed that a traffic intensity is linked to every road in the digital road network to avoid underestimation of local scale exposure. Otherwise, traffic intensities on minor roads may not be taken into account. Traffic intensity data are available for all national and provincial roads, but are not available for all municipal roads.

Therefore, a (low) standard traffic intensity was assigned to municipal roads for which no traffic intensity data are available. We did this for roads in municipalities for which we have traffic intensity data for part of the municipal roads, and for roads in municipalities for which we have no traffic intensity data at all. Municipalities for which we have no traffic intensity data at all are mostly small towns or villages, with a small number of inhabitants. To the roads in municipalities for which no traffic data are available the same (low) standard traffic intensity were assigned under the assumption that in these (small) municipalities the only busy roads are provincial and/or national roads and for these road types traffic intensity data are available from other sources.

In the following paragraph, the decision about which standard traffic intensity value was assigned to roads for which no traffic data are available is further explained.

3.2 Traffic intensity value which were assigned to roads without traffic data

The traffic intensity data that have been collected from municipalities are mostly for major roads within a municipality, i.e. the roads with relatively high traffic intensities. The average traffic intensities per municipality (per year) are also shown in table 2 . The average overall intensity of these average intensities per municipality is 5,506 mvh/24h, with a minimum of 300 mvh/24h

(which was for a municipality with only data for one road) and a maximum of 17,977 mvh/24h. This also indicates that the collected traffic intensity data are mostly for major roads in a municipality.

Approximately for half of the municipalities for which traffic intensity data are available, data are available from Environmental Traffic Maps (VerkeersMilieuKaarten – VMK). VMKs are developed by municipalities with more than 40,000 inhabitants to assess exposure to air pollution and to assess noise levels in all roads with relevant traffic intensities. All roads with traffic intensities > 2,450 mvh/24h are assessed in the development of VMKs, although also some roads with traffic intensities < 2,450 mvh/24h are included in a VMK. This traffic intensity value is used in VMKs to distinguish between roads with relevant traffic intensities and non-relevant traffic intensities (to assess air pollution and noise levels).(Harms 2000)

We assumed that roads, for which no traffic intensity data are available, are no major roads or roads with relevant traffic intensities. Therefore, we will assign a traffic intensity value of half the traffic intensity which is used in VMKs to distinguish between municipal roads with relevant and non-relevant traffic intensities, i.e. a value of 0.5*2,450 mvh/24h = *1,225 mvh/24h* were assigned to municipal roads for which no traffic intensity data are available.

4. Procedure for the extrapolation of total traffic intensity data on municipal roads to years for which no data are available

4.1 Introduction

Total traffic intensity data for municipal roads for all years in the period 1986-1996 (= follow-up period of the NLCS-AIR study) were linked to a digital road network (Nationaal WegenBestand; NWB). However, for a large part of the municipalities only for one or a few years and/or only for recent years total traffic intensity data are available. Therefore, if total traffic intensity data for a road are missing for one or more years in the period 1986-1996, data were extrapolated to the years for which no traffic data are available, using the traffic intensity data of the year(s) for which intensity data are available.

Some municipalities have traffic intensity data for all or several years in the period 1986-2000 (Den Bosch; Heemskerk; Laren; Rotterdam; Schiedam; Winterswijk; Goes; Oisterwijk; Zandvoort; Zevenaar; Twenterand; Oud-Beijerland; and Lichtenvoorde; see table 1), and these data can be used

to evaluate trends in traffic intensity over time on municipal roads, and can be used to develop a procedure to extrapolate data for municipal roads.
As a first check whether traffic intensities can be used to estimate traffic intensities for previous years, correlations between 1996 traffic intensities and 1986, 1987, 1988, 1989 and 1990 traffic intensities were calculated in these municipalities. Pearson correlations were 0.95, 0.96, 0.92, 0.93, and 0.97 respectively, supporting the use of traffic intensities to extrapolate to other years. In figure 1, the correlation between 1996 and 1986 traffic intensities is shown.
The procedure to estimate total traffic intensity data for years for which no traffic intensity data are available, is described in chapter 5.3. The purpose of this procedure is to extrapolate total traffic intensity on municipal roads in a consistent way. In paragraph 5.2 it is described how this procedure was developed.

4.2 Trends in total traffic intensity on municipal roads

Information about trends in total traffic intensities on municipal roads is available from several sources, e.g. reports, but also from traffic intensity data from municipalities, which we have collected. A summary of the available information is described in the following paragraphs.

4.2.1 Trends in total traffic intensity on municipal roads available from reports

A RIVM (National Institute of Public Health and the Environment) report by Harms evaluated location of traffic flows on municipal roads in the period 1987-1997 and concluded that traffic has been more and more concentrated on main municipal roads. Data from Verkeersmilieukaarten (VMK – Environmental Traffic Map) of 8 municipalities (Amsterdam, Arnhem, Gouda, Hoorn, Maastricht, Purmerend, Den Bosch, Tilburg; cities of between 64,616 and 731,200 inhabitants (in 2000)) for the years 1987 and 1997 have been used.(Harms 2000)
In the period 1987-1997, the traffic intensity on main municipal roads (“stedelijke hoofdwegen” – major urban roads – roads with traffic intensities > 11,000 mvh/24h) increased. This is mainly caused by the implementation of traffic regulation measures. In the period 1987-1997, the traffic intensity that occurs on main municipal roads increased with 15%, while the traffic intensity that occurs on non-main roads, “wijkontsluitingswegen” (roads with traffic intensities 4,000 – 11,000 mvh/24h) and “buurtontsluitingswegen” (roads with traffic intensities < 4,000 mvh/24h) increased with 10% and 5%, respectively. In addition, traffic has been moved from the more central located areas in a municipality to areas at the borders of municipalities in this period. The reason for this is

that the accessibility of the centrally located areas has worsened, and that the development of employment facilities and other facilities at the borders of municipalities has increased. The traffic intensity that occurs in a city center decreased with 4% in the period 1987-1997, while the traffic intensity on ring roads within a municipality ("binnenringwegen") increased with 9% and with 22% on ring roads around a municipality ("buitenringwegen").(Harms 2000) Based on the data of these 8 municipalities, it was estimated that on average the traffic intensity on all municipal roads together increased with 12%.(Harms 2000) However, the Central Bureau of Statistics (CBS) has also evaluated traffic intensities within municipalities over time, and the CBS data indicated a decrease of traffic intensities on all municipal roads with 18% in the period 1987-1997. Possible explanations that in the RIVM-evaluation an increase in traffic intensities on municipal roads was found, may be that only a small number of cities was included in the RIVM-evaluation, and that the 8 included cities were relatively large cities. Further, in the used VMKs of the 8 municipalities the smallest roads, with the smallest traffic intensities, were not included (all roads with traffic intensities > 2450 mvh/24h are included, but no or only a small part of the roads with intensities < 2450 mvh/24h are included in VMKs). This may result in an overestimate of average traffic intensities on municipal roads. And in addition, the increase in traffic intensity on municipal roads may be overestimated, because the increase on roads with higher traffic intensities is larger than on roads with lower traffic intensities, which are not all included in the VMKs. The CBS calculated the total traffic intensity on all municipal roads by subtracting the estimated total traffic intensity on all roads outside municipalities from the estimated total traffic intensity on all roads in the Netherlands, and used these data to evaluate the trend on all municipal roads.(Harms 2000) The CBS used thus general overall data to estimate an average trend in traffic intensity on municipal roads. The estimated percentage decrease in traffic intensity on municipal roads by CBS is thus an average percentage for all municipal roads, but individual roads, possibly major main roads, may have percentages which deviate from this overall average percentage.

Another RIVM report by Geurs also described the development of traffic intensities on municipal roads using traffic data from 6 municipalities (Apeldoorn, Tilburg, Haarlem, Maastricht, Nijmegen, Enschede). Traffic intensities on major municipal roads have increased with 17% in the period 1984-1993, ranging from a 3% decrease to a 31% increase. Major municipal roads were defined as "autosnelwegen" (highways) and "doorgaande wegen" (through roads), with no specification of the (average) traffic intensity on these road types. It was not possible to evaluate the trend on non-main municipal roads based on the data of these municipalities, because of the small number of data for non-main roads, and because the non-main roads for which data were available are largely roads with still relatively high traffic intensities.(Geurs 1995) The data in the Geurs report also indicate

that traffic intensities on major municipal roads may have increased over time (in the period 1984-1993).

Furthermore, the RIVM uses data about the total number of kilometers driven by all traffic together on all municipal roads and data about the total length of all municipal roads (both CBS-data) to calculate an average traffic intensity on all municipal roads. Index-data, as calculated with CBS-data, for average traffic intensity on municipal roads with 1990 as baseline are: 1990: 1.000; 1995: 0.840; 1996: 0.776; 1997: 0.779; 1998: 0.780; 1999: 0.800; and 2000: 0.817. These data indicate an average decrease in traffic intensity on all municipal roads in the period 1990-2000. The decrease is similar to the estimated decrease by RIVM of 18% in the period 1987-1997. However, this average trend is also derived from general overall data for all municipal roads together, and no distinction is made for different types of municipal roads.

In conclusion, the RIVM-VMK data showed an increase in traffic intensity on municipal roads while the CBS-data showed a decrease in traffic intensity over time. However, these CBS-data are based on general overall data, and do not specify trends in traffic intensities for different road types. As described above, in VMKs all roads with traffic intensities > 2450 mvh/24h are included, but no or only a small part of the roads with intensities < 2450 mvh/24h are included in VMKs. The traffic intensity data that have been collected from municipalities are mostly for major roads within a municipality (especially for the municipalities for which we have collected VMK-data). Therefore, the estimates based on the VMKs are more relevant for us, because these are also based on mostly major roads within a municipality.

4.2.2 Trends in total traffic intensity on municipal roads using intensity data from municipalities

To further evaluate the trend in traffic intensities on municipal roads, we evaluated traffic intensity data that were collected for roads within municipalities that were included in the NLCS-AIR study. For 13 municipalities we have traffic intensity data for all or several years in the period 1986-2000 (Den Bosch; Heemskerk; Laren; Rotterdam; Schiedam; Winterswijk; Goes; Oisterwijk; Zandvoort; Zevenaar; Twenterand; Oud-Beijerland; and Lichtenvoorde) and for 4 municipalities we have only data for two years which largely cover the follow-up period of the NLCS-AIR study (1986-1996) (Arnhem, 1987&2000; Dordrecht, 1989&1997; Heerlen 1989&1995; Helmond 1989&1998). The traffic intensity data of these municipalities have also been evaluated.

For 13 municipalities data are available for several years with a wide range in intensities from 63 mvh/24h to 44,772 mvh/24h. Because of this wide range in total traffic intensities, with these data

trends in traffic intensity on all and different types of municipal roads can be evaluated.
Linear regression analyses were conducted per road for all municipalities together, using only data from roads with data for at least 3 years. The natural logarithm of the traffic intensities was used in the statistical analyses to provide percentages increase in traffic intensity per year.
Results of these analyses are shown in table 2. For each road the percentage change in traffic intensity per year was calculated, and then an average percentage change per year was calculated, using all percentages from all roads in all municipalities together: 0.6%, which was significantly different from zero. This indicates that there is on average an increasing trend in traffic intensity on municipal roads. In total, there were more roads with a significant increasing trend than a significant decreasing trend. These results indicate that there has been (on average) an increasing trend in traffic intensity on municipal roads.
Further, we did similar analyses separately for roads with an average intensity < 4,000 mvh/24h, for roads with an average intensity of 4,000 - 11,000 mvh/24h, and for roads with an average intensity > 11,000 mvh/24h, using the classification as used in the RIVM report by Harms (see above) to evaluate whether the trend may be different for different types of roads (table 2). For roads with a traffic intensity < 4,000 mvh/24h, the average percentage change per year (-0.2%) was not statistically significant different from zero, while the averages percentages increase for roads with an intensity of 4,000 – 11,000 and > 11,000 were significant different from zero and were 1.2% and 1.1% respectively (table 2). This may indicate that on roads with higher traffic intensities, which are more likely to be major municipal roads, traffic intensities may have (more) increased over time compared with roads with lower traffic intensities. This indication is comparable with the conclusion in the Harms report that traffic intensities on major municipal roads have increased more over time compared with non-major municipal roads.
We wanted to evaluate whether trends in traffic intensity are linear. However, there were only a small number of years with data to estimate a stable trend, and further the percentage change in total traffic intensity per year is modest (table 2). Therefore, we assumed that the trend in traffic intensity on municipal roads is linear.
In addition, we used mixed modeling (with a random slope and intercept) to evaluate whether the trend in traffic intensity per road is different from an estimated fixed trend. We did the analyses for all roads of the 13 municipalities together, using the natural logarithm of the total traffic intensities to calculate the percentage change in traffic intensity per year. The results are shown in table 3. There were 365 roads available for analyses and 20 roads had a percentage which was significantly different from the fixed percentage. The fixed percentage change in traffic intensity per year was

0.5%, and was significantly different from zero (which is comparable with the calculated average percentage change of 0.6% using linear regression for all 13 municipalities together).

Mixed modeling analyses were also conducted separately for roads with traffic intensity < 4,000 mvh/24h, for roads with traffic intensity between 4,000 – 11,000 mvh/24h, and for roads with traffic intensity > 11,000 mvh/24h to evaluate whether the trend in traffic intensity is different for roads within each road type (table 3). The results for the trend in traffic intensity are comparable with the results from the linear regression analyses, *i.e.* for roads with traffic intensity < 4,000 mvh/24h the fixed percentage change is not statistically significant different from zero, and the fixed percentages increase for roads with traffic intensities between 4,000 – 11,000 and > 11,000 are both significantly different from zero. For each road type a statistically significant number of roads deviates from the fixed percentage change. The number of roads per road type with a percentage change significantly different from the fixed percentage change is also shown in table 3. The results indicate that there might be some roads within each road type for which the trend in traffic intensity deviates from the average trend. However, for most roads the trend is not significantly different from the average fixed trend. Therefore, we assumed that the trend is the same for each road within each road type.

In conclusion, the results of the linear regression and mixed modeling using data from 13 municipalities indicate that there is on average a (slight) increase in traffic intensity on municipal roads. Separate analyses for roads with traffic intensity < 4,000 mvh/24h, 4,000 – 11,000 mvh/24h, and > 11,000 mvh/24h indicated that on roads with higher traffic intensities the traffic intensity may have increased more than on roads with lower traffic intensities. We also evaluated whether trends in traffic intensity were different from a fixed trend using mixed modeling; for a small part of the roads the trend was different from the fixed trend, however for most roads the trend was not significantly different from the fixed trend in traffic intensity.

Data for the 4 municipalities (Arnhem, 1987&2000; Dordrecht, 1989&1997; Heerlen, 1989&1995; Helmond, 1989&1998) with data for only two years are available from Verkeersmilieukaarten (VMK – Environmental Traffic Map (see also above about VMKs)).

Differences in traffic intensity between the two years for the four municipalities are graphically shown in figure 2. In figure 2, the difference in traffic intensity between the two years is shown per street for the four municipalities separately. Overall, there seems to be a slightly increasing trend, although for individual roads a decrease in traffic intensity may have occurred.

Although the data of these 4 municipalities provide useful information, a limitation is that there are only data available for two years; and therefore, it is not possible to evaluate the shape (linear/non-linear) of the trend in traffic intensity over time. And further, because the trend per road is only

based on two years/points, trends per road can be influenced by extreme values, for example when one year has extreme high or low traffic intensities for a road.

In addition, for every road in each municipality the coefficient of variation (CV) in traffic intensity has been calculated. For each municipality, the average coefficient of variation has been calculated (table 4). The CV has been calculated by first calculating for each road the standard deviation of the traffic intensity over different years, and the average traffic intensity over years for each road; and second the CV per road was calculated as: (standard deviation/average)*100%; and third, the average CV per municipality was calculated. Because only data for two years were available for the 4 municipalities Arnhem, Dordrecht, Heerlen, and Helmond, the standard deviation for each road is on average larger than for roads with data for more years, and therefore, the CV for roads with only data for 2 years is on average higher than for roads with data for more than 2 years.

Further, the difference in traffic intensity and the average traffic intensity is shown per municipality (only for municipalities with data for only two years) (figure 3). It is shown that the difference is larger when the average intensity is also larger; both positive (*i.e.* increased intensities over time) and negative differences (*i.e.* decreased intensities over time) (although this is less clear for Heerlen and Helmond because these municipalities have more positive differences). However, from figure 3 (especially for data from Arnhem and Dordrecht) it cannot be clearly shown that major urban roads (i.e. roads with higher traffic intensity) show a larger increasing trend than non-major urban roads, because the points are evenly scattered around the x-axis. For the municipalities Heerlen and Helmond there might be some indication that on roads with larger intensities the intensities may have more increased compared with roads with lower traffic intensities (see figure 3). The data from these 4 municipalities do however not provide a clear indication that on average the traffic intensity has more increased on roads with higher traffic intensities compared with roads with lower traffic intensities. However, these results are only based on data from two years, and can be influenced by a few extreme values.

The data of the 13 municipalities with data for all or several years in the period 1986-2000 give thus more information about the trend in traffic intensity on municipal roads, compared with the data of the 4 municipalities with only data for 2 years.

4.2.3 Conclusion

In conclusion, the traffic intensity data of the 13 municipalities show a similar trend over time compared with the RIVM-VMK-data. The high correlation between repeated counts for different years for the same roads show that classification of subjects with respect to traffic intensity can be

made with confidence.

The CBS used general overall data to estimate an average trend in traffic intensity on municipal roads, which was somewhat different from the trend estimated with traffic intensity data of the 13 municipalities with traffic data for all or several years in the period 1986-2000. Further, the traffic intensity data that have been collected from municipalities are mostly for major roads within a municipality (especially for the municipalities for which we have collected VMK-data), and the trends estimated based on the data of these 13 municipalities and the trends estimated based on the RIVM-VMKs are also especially for major roads. Therefore, we used the results of the (mixed modeling) analyses of the 13 municipalities with traffic intensity data for all or several years in the period 1986-2000, to develop a procedure for extrapolating total traffic intensities on municipal roads to years for which no data are available.

4.3 Procedure for extrapolating total traffic intensity data on municipal roads

- Traffic intensity data for all years in the period 1986-1996 for each road was linked to a digital road network;
- If traffic intensity data are available for one or more years in the period 1986-1996, but not for all years in this period, data were extrapolated to the years for which no intensity data are available;
- For the 3 types of municipal roads different trends in traffic intensity were applied:
  - average traffic intensity < 4,000 mvh/24h: percentage increase per year is 0.1%;
  - average traffic intensity 4,000 – 11,000 mvh/24h: percentage increase per year is 1.0%;
  - average traffic intensity > 11,000 mvh/24h: percentage increase per year is 1.1%;

  (these trends are based on the mixed modeling results per road type; table 3);
- It was assumed that there is a linear trend over the whole period;
- And it was assumed that each road within a road type has the same trend;
- For each road for which data have to be extrapolated, the average intensity over all years for which intensity data are available was calculated; the average intensity per road determines which linear trend was applied to estimate traffic intensities for years for which no data are available;
- For each road, if no total traffic intensities are available, total traffic intensities for all years in the period 1986-1996 were estimated; this was done by using the total traffic intensity of the last year in the period 1986-1996 for which a traffic intensity was available (or a year outside this period if no data are available for years within the period 1986-1996, e.g. after

1996); a linear trend (which depends on the average intensity of each road) was then applied starting from that year to estimate total traffic intensities for all years in the period 1986-1996, if not available;

- Both the estimated total traffic intensities and the "real" traffic intensities obtained from municipalities were linked to the digital road network NWB (using different variable names).
- For roads with total *truck* traffic intensity for one or more years, but not for all years in the period 1986-1996, the same percentages and procedure as described above for the different road types were applied to estimate total truck traffic intensities for years for which no total truck traffic data are available.

5. Procedure for the extrapolation of total traffic intensity data on national roads to years for which no data are available

5.1 Introduction

For national roads total traffic intensity data are available for the period 1986-2000 (available from the Central Bureau of Statistics (CBS)). Traffic intensity data are available for 978 points where traffic intensities on national roads have been counted. For each of these 978 points the year in which a road has been first used was available from information of the Transport Research Centre (Adviesdienst Verkeer en Vervoer – AVV) of the Ministry of Transport, Public Works, and Water Management. This start year for each point has been compared with the years for which traffic intensity data are available. Start year was defined as a year between 1986-2000. If the year in which a road was first used was before 1986, the start year was defined as 1986. 151 points had traffic intensity data available for years which did not start at the start year for that specific point, for example when counting of traffic intensities was not started from the first year a road has been used. For these points traffic intensity data were extrapolated to the start year for each point.

Total traffic intensity data for national roads for all years in the period 1986-1996 (= follow-up period of the NLCS-AIR study) were linked to a digital road network (NWB).

As a first check whether traffic intensities can be used to estimate traffic intensities for previous years, correlations between 1996 traffic intensities and 1986, 1987, 1988, 1989 and 1990 traffic intensities were calculated on national roads. Pearson correlations were 0.95, 0.96, 0.95, 0.95, and

0.97 respectively, supporting the use of traffic intensities to extrapolate to other years. In figure 1 in the correlation between 1996 and 1986 traffic intensities is shown.
In the following paragraphs it is described how we will estimate traffic intensity for years for which no traffic intensity data are available. The purpose of this procedure is to extrapolate total traffic intensity on national roads in a consistent way. The exact procedure is described in chapter 6.3.

5.2 Trends in total traffic intensity on national roads

Information about trends in traffic intensity on national roads is available from Central Bureau Statistics. In table 1, annual traffic intensities on national roads are shown as an index with 1986 as baseline-year. The index-data show a consistent increasing trend. The index-data are also shown in figure 2 and show a (fairly) linear trend.
We further evaluated the available total traffic intensity to investigate the trend in traffic intensity on national roads. Total traffic intensity data were available for 978 points along the national roads.
Linear regression analyses were conducted for all points along national roads together, using only data from points with traffic intensity available for 3 or more years. The natural logarithm of the traffic intensities was used in the statistical analyses to provide percentages increase in traffic intensity per year. For each point the percentage change in traffic intensity per year was calculated, and then an average percentage change per year was calculated, using all percentages from all points: 3.4%, which was significantly different from zero. This indicates that there is on average an increasing trend in traffic intensity on national roads. In total, most points (843 of a total of 967) had a significant increasing trend, while only 25 had a significant decreasing trend. These results indicate that there is (on average) an increasing trend in traffic intensity on national roads.
To evaluate whether the trend in traffic intensities may be different for different traffic intensities, separate analyses were conducted for points with average traffic intensities < 20,000 mvh/24h, with traffic intensities between 20,000 and 50,000 mvh/24h, and with traffic intensities > 50,000 mvh/24h (table 2). All three classes of average traffic intensity had significant percentages increase in traffic intensity; with percentages increase for points with average traffic intensities < 20,000 mvh/24h, with traffic intensities between 20,000 and 50,000 mvh/24h, and with traffic

intensities > 50,000 mvh/24h of 2.8%, 3.9%, and 3.6%, respectively. Points with average traffic intensities > 20,000 mvh/24h have a slightly higher percentage change in traffic intensity compared with points with average traffic intensities < 20,000 mvh/24h.

We also conducted mixed modeling analyses (with a random slope and intercept and using the natural logarithm of the total traffic intensities) to evaluate whether the trend in traffic intensity on national roads is different from an estimated fixed trend. The mixed modeling results are shown in table 3. There were 967 points available for analysis, and 393 points had a percentage change which was significantly different from the fixed percentage change. The fixed percentage change in traffic intensity on national roads was 3.4%, which was significantly different from zero, and which was similar compared with the percentage change calculated using linear regression.

The mixed modeling analyses were also conducted separately for points with average traffic intensities < 20,000 mvh/24h, with traffic intensities between 20,000 and 50,000 mvh/24h, and with traffic intensities > 50,000 mvh/24h (table 3). The results from the mixed modeling analyses were similar compared with the linear regression results. The number of points for which the percentage significantly differed from the fixed percentage change is also shown in table 3. This indicates that there are some points for which the trend deviates from the fixed trend. However, we assumed that each point within each traffic intensity class has the same percentage change.

In conclusion, the percentages change in traffic intensity for both the linear regression analyses and the mixed modeling analyses are comparable with the CBS index-data in table 1. We used the results of the mixed modeling analyses (which were similar as the linear regression results) to develop a procedure for extrapolating total traffic intensities on national roads to years for which no data are available. Because percentages increase are different for points with average traffic intensities < 20,000 mvh/24h, with traffic intensities between 20,000 and 50,000 mvh/24h, and with traffic intensities > 50,000 mvh/24h, separate extrapolations were conducted for these different traffic intensity classes and we assumed that the trend for each point within a traffic intensity class is the same. We assumed that the trend in traffic intensity is linear in the period 1986-1996.

5.3 Procedure for extrapolating total traffic intensity data on national roads

- Total traffic intensity data for all years in the period 1986-1996 for each national road were linked to a digital road network;

- For 151 of the total 978 points, for which total traffic intensity data have been counted on national roads in the period 1986-1996, for one or more years data have to be extrapolated to the start year, i.e. the year in which a road was first used (see paragraph 4.1), for these points;
- For the 3 different total traffic intensity classes different trends in traffic intensity were applied:
  - average traffic intensity < 20,000 mvh/24h: percentage increase per year is 2.7%;
  - average traffic intensity 20,000 – 50,000 mvh/24h: percentage increase per year is 3.9%;
  - average traffic intensity > 50,000 mvh/24h: percentage increase per year is 3.6%;

  (these trends are based on the mixed modeling results per total traffic intensity class; table 3)
- It was assumed that there is a linear trend over the whole period;
- It was assumed that each point within each total traffic intensity class has the same trend;
- For each point for which data have to be extrapolated, the average intensity over all years for which intensity data are available were calculated; the average intensity per point determines which linear trend was applied to estimate total traffic intensities for years for which no data are available;
- For each point for which data have to be extrapolated, total traffic intensities were extrapolated to the start year for each point; this was done by using the total traffic intensity of the last year in the period 1986-1996 for which a traffic intensity is available (or a year outside this period if no data are available for years within the period 1986-1996, e.g. after 1996); a linear trend (which depends on the average intensity of each road) will then be applied starting from that year to estimate total traffic intensities for all years in the period 1986-1996;
- Both the estimated total traffic intensities and the “observed” traffic intensities obtained from CBS were linked to the digital road network NWB (using different variable names).

6. Procedure for the extrapolation of total truck traffic intensity data on national roads to years for which no data are available

6.1 Introduction

For national roads the percentage total truck traffic intensity is available for the period 1992-2000. These percentages are also available for the points for which total traffic intensities on national roads are available. With these percentages and the total traffic intensity data, the total truck traffic intensity at each point can be calculated. However, total truck traffic intensities are thus only available for the period 1992-2000. The year in which a road has been first used (start year) is available (see chapter 6.1) and for most points this start year is earlier than 1992, therefore, for most points total truck traffic intensities have to be extrapolated.
Total truck traffic intensity data for national roads for all years in the period 1986-1996 (=follow-up period of the NLCS-AIR study) were linked to a digital road network (NWB).
The trend in total truck traffic intensities in the period 1992-2000 was evaluated. As a first check whether total truck traffic intensities can be used to estimate total truck traffic intensities for previous years, the correlation between 1996 traffic intensities and 1992 traffic intensities were calculated on national roads. The Pearson correlation was 0.94, supporting the use of traffic intensities to extrapolate to other years. In figure 1, the correlation between 1996 and 1992 total truck traffic intensities is shown.
The exact procedure how data were extrapolated is described in chapter 5.3.

6.2 Trends in total truck traffic intensity on national roads

No other information than the available total truck traffic intensity data for the period 1992-2000 is available about trends in total truck traffic intensities over time on national roads. We evaluated these data to investigate the trend in total truck traffic intensity on national roads.
Linear regression analyses were conducted for all points along national roads together, using only data from points with total truck traffic intensity available for 3 or more years. The natural logarithm of the total truck traffic intensities was used in the statistical analyses to provide percentages increase in total truck traffic intensity per year. For each point the percentage change in total truck traffic intensity per year was calculated, and then an average percentage change per

year was calculated, using all percentages from all points: 4.2%, which was significantly different from zero. This indicates that there is on average an increasing trend in total truck traffic intensity on national roads. In total, most points (665 of a total of 864) had a significant increasing trend, while only 21 had a significant decreasing trend. These results indicate that there is (on average) an increasing trend in total truck traffic intensity on national roads.

To evaluate whether the trend in traffic intensities may be different for different total truck traffic intensities, separate analyses were conducted for points with average total truck traffic intensities < 3,200 trucks/24h, with intensities between 3,200 and 8,500 trucks/24h, and with intensities > 8,500 trucks/24h (table 1). All three classes of average total truck traffic intensity had significant percentages increase in total truck traffic intensity; with percentages increase for points with average traffic intensities < 3,200 trucks/24h, with intensities between 3,200 and 8,500 trucks/24h, and with intensities > 8,500 trucks/24h of 3.1%, 4.5%, and 4.8%, respectively. Points with average total truck traffic intensities > 3,200 trucks/24h have a slightly higher percentage change in traffic intensity compared with points with average total truck traffic intensities < 3,200 trucks/24h.

We also conducted mixed modeling analyses (with a random slope and intercept and using the natural logarithm of the total truck traffic intensities) to evaluate whether the trend in total truck traffic intensity on national roads is different from an estimated fixed trend. The mixed modeling results are shown in table 3. There were 864 points available for analysis, and 272 points had a percentage change which was significantly different from the fixed percentage change. The fixed percentage change in traffic intensity on national roads was 4.2%, which was significantly different from zero, and which was similar compared with the percentage change calculated using linear regression.

The mixed modeling analyses were also conducted separately for points with average traffic intensities < 3,200 trucks/24h, with intensities between 3,200 and 8,500 trucks/24h, and with intensities > 8,500 trucks/24h (table 3). The results from the mixed modeling analyses were similar compared with the linear regression results. The number of points for which the percentage significantly differed from the fixed percentage change is also shown in table 3. This indicates that there are some points for which the trend deviates from the fixed trend. However, we assumed that each point within each total truck traffic intensity class has the same percentage change.

In conclusion, the percentages change in total truck traffic intensity for the linear regression analyses and the mixed modeling analyses are comparable, but are somewhat higher compared with the percentages increase in total traffic intensity on national roads (chapter 4). We used the

percentages as described in this paragraph to develop a procedure for extrapolating total truck traffic intensities on national roads to years for which no data are available. Because percentages increase are different for points with average traffic intensities < 3,200 trucks/24h, with intensities between 3,200 and 8,500 trucks/24h, and with intensities > 8,500 trucks/24h, separate extrapolations were conducted for these different total truck traffic intensity classes and we assumed that the trend for each point within a total truck traffic intensity class is the same. We assumed that the trend in traffic intensity is linear in the period 1986-1996.

6.3 Procedure for extrapolating total truck traffic intensity data on national roads

- Total truck traffic intensity data for all years in the period 1986-1996 for each national road were linked to a digital road network;
- First, for each point the total truck traffic intensity was calculated using the total traffic intensity and the percentage total truck traffic intensity, resulting in total truck traffic intensities for the years 1992-1996.
- Second, for *all* years in the period 1986-1996, if not already available, a total truck traffic intensity was extrapolated using the procedure described below.
  For all years in the period 1986-1996 total truck traffic intensities are then available. However, total traffic intensities are not available for all roads for the full period 1986-1996 (because the start year of a road can be after 1986; see chapter 4.1). Therefore, total truck traffic intensities were changed into a missing value when the total traffic intensity is missing. Using this method, total truck traffic intensities are only available when also total traffic intensities are available.
- For the 3 different total truck traffic intensity classes different trends in total truck traffic intensity were applied:
  - average traffic intensity < 3,200 trucks/24h: percentage increase per year is 3.2%;
  - average traffic intensity 3,200 – 8,500 trucks/24h: percentage increase per year is 4.6%;
  - average traffic intensity > 8,500 trucks/24h: percentage increase per year is 4.8%;

  (these trends are based on the mixed modeling results per intensity class; table 3)
- It was assumed that there is a linear trend over the whole period;
- It was assumed that each point within each intensity class has the same trend;
- For each point for which data have to be extrapolated, the average total truck traffic intensity over all years for which intensity data are available was calculated; the average

total truck traffic intensity per point determines which linear trend was applied to estimate total truck traffic intensities for years for which no data are available;

- Total truck traffic intensity data were extrapolated using the total truck traffic intensity of the last year in the period 1992-1996 for which a total truck traffic intensity is available (or a year outside this period if no data are available for years within the period 1992-1996, i.e. after 1996); a linear trend (which depends on the average intensity of each road) will then be applied starting from that year to estimate total truck traffic intensities for all years in the period 1986-1996;
- Both the estimated total truck traffic intensities and the "observed" total truck traffic intensities were linked to the digital road network NWB (using different variable names).

Tables and figures Appendix 2

Tables and figure chapter 2

Table 1: Average ratio between weekday and workday intensities on municipal roads for six municipalities for different years (i.e. weekday intensities divided by workday intensities).

Municipality*	***1971***	***1972***	***1973***	***1974***	***1975***	***1976***	***1977***	***1978***	***1979***	***1980***	***1981***	***1982***
Den Bosch							0.981	0.939	0.952	0.941	0.958	0.936
Laren	0.984						0.964	0.951				0.963
Schiedam												
Winterswijk												
Zevenaar												
Average	0.984						0.973	0.945	0.952	0.941	0.958	0.950

Municipality*	***1983***	***1984***	***1985***	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***	***1994***
Den Bosch	0.920	0.931	0.940	0.954	0.945	0.914		0.931	0.941	0.943	0.942	0.940
Laren	0.950	0.953	0.942	0.963	0.962	0.958	0.956	0.950	0.953	0.962	0.956	0.846
Schiedam		0.857		0.920	0.913	0.887	0.900	0.913	0.893	0.903	0.900	0.904
Winterswijk		0.972	0.957	0.966	0.970	0.958	0.969	0.946	0.950	0.966	0.957	0.947
Zevenaar									0.967	0.953	0.934	0.926
Average	0.935	0.928	0.946	0.951	0.948	0.929	0.942	0.935	0.934	0.944	0.939	0.909

Municipality*	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***
Den Bosch	0.937	0.929	0.928	0.923	0.920	0.927	0.918	0.921
Laren	0.934	0.937	0.930					
Schiedam	0.916	0.923	0.914	0.918	0.926	0.918	0.909	0.913
Winterswijk								
Zevenaar	0.917	0.937	0.929	0.924	0.964			
Average	0.929	0.930	0.024	0.921	0.923	0.923	0.914	0.917

* Population sizes (1990): Den Bosch: 91,113;Laren 11,529; Schiedam 69,417; Winterswijk 27,919; Zevenaar 26,955.

Table 2: Average ratio between weekday and workday intensities on national roads for different years.

Year	***1986***	***1987***	***1988***	***1989***	***1990***	***1991***	***1992***	***1993***
Ratio	0.945	0.945	0.943	0.942	0.943	0.939	0.939	0.940

Year	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***
Ratio	0.938	0.936	0.934	0.933	0.931	0.931	0.925	0.926

Table 3: Percentages of total daily traffic intensity on municipal main and non-main roads that occurs between 7.00AM – 7.00PM (1981).

Type of road	***Percentage between 7.00AM and 7.00 PM***
Municipal main roads	6.7% *12 = 80.4%
Municipal non-main roads	7.0% *12 = 84.0%

Table 4: Percentages of total daily traffic intensity for light-duty, medium-duty and heavy-duty traffic on *municipal main roads within municipal borders* that occurs between 7.00AM – 7.00PM ("Gemeentelijke hoofdwegen, binnen de bebouwde kom") (1986).

Category	***Percentage between 7.00AM and 7.00 PM***
Light-duty	6.4% *12 = 76.8%
Medium-duty	6.9% *12 = 82.8%
Heavy-duty	6.8% *12 = 81.6%

Table 5: Percentages of total daily traffic intensity for light-duty, medium-duty and heavy-duty traffic on *municipal non-main roads within municipal borders* that occurs between 7.00AM – 7.00PM ("Buurt/wijkontsluitingswegen, binnen de bebouwde kom") (1986).

Category	***Percentage between 7.00AM and 7.00 PM***
Light-duty	6.4% *12 = 76.8%
Medium-duty	6.9% *12 = 82.8%
Heavy-duty	7.1% *12 = 85.2%

Table 6: Distribution of total traffic intensity over the different parts of the day on municipal roads (1993).

Part of the day	***Percentage of total daily traffic intensity***
Day (7.00 AM – 7.00 PM)	79.2% (=6.6% * 12 hours)
Evening (7.00 PM – 11.00 PM)	13.6% (=3.4% * 4 hours)
Night (11.00 PM – 7.00 AM)	7.2% (=0.9% * 8 hours)

Table 7: Distribution of total traffic intensity over the different parts of the day for *municipal roads* (1995).

Part of the day	***Percentage of total daily traffic intensity***
Day (7.00 AM – 7.00 PM)	77.8%
Evening (7.00 PM – 11.00 PM)	14.9%
Night (11.00 PM – 7.00 AM)	7.3%

Table 8: Percentages of total daily traffic intensity that occurs between during day-hours (7.00AM – 7.00PM) on roads for 3 municipalities for different years.

Municipality*	***1977***	***1978***	***1979***	***1980***	***1981***	***1982***	***1983***	***1984***	***1985***	***1986***	***1987***	***1988***	***1989***
Den Bosch	77.9	78.1	76.7	78.6	78.4	78.3	77.8	77.3	77.1	77.2	77.7	77.7	76.6
Zeist													
Utrecht											80.4		

Municipality*	***1990***	***1991***	***1992***	***1993***	***1994***	***1995***	***1996***	***1997***	***1998***	***1999***	***2000***	***2001***	***2002***
Den Bosch	77.9	77.0	76.7	77.7	76.6	77.0	75.3	78.2	78.9	79.2	79.0	79.6	79.6
Zeist					80.4								
Utrecht			80.2										

* Population sizes (1990): Den Bosch 91,113; Zeist 59,469; Utrecht 230,358.

Table 9: Percentages light-duty, medium-duty and heavy-duty traffic of the total traffic intensity on *municipal main roads within municipal borders* ("Gemeentelijke hoofdwegen, binnen de bebouwde kom") (1986).

Category	**Percentage of the total traffic intensity**
Light-duty	86%
Medium-duty	10%
Heavy-duty	4%

Table 10: Percentages light-duty, medium-duty and heavy-duty traffic of the total traffic intensity on *municipal non-main roads within municipal borders* ("Buurt/wijkontsluitingswegen, binnen de bebouwde kom") (1986).

Category	**Percentage of the total traffic intensity**
Light-duty	86%
Medium-duty	10%
Heavy-duty	4%

Table 11: Percentages light-duty, medium-duty and heavy-duty traffic of the total traffic intensity on municipal main roads and municipal non-main roads *during day hours* (7.00AM – 7.00PM) (1981).

Type of road	***Light-duty***	***Medium-duty***	***Heavy-duty***
Municipal main roads	92%	6.8%	1.2%
Municipal non-main roads	94%	5.4%	0.6%

Table 12: Percentages light-duty, medium-duty and heavy-duty traffic of the total traffic intensity on municipal main roads and municipal non-main roads *during night hours* (23.00PM – 7.00AM) (1981).

Type of road	***Light-duty***	***Medium-duty***	***Heavy-duty***
Municipal main roads	92%	6.8%	1.2%
Municipal non-main roads	96%	3.6%	0.4%

Table 13: Average total truck intensity (i.e. sum of medium- and heavy-duty traffic) percentages of the total traffic intensity for the municipality of Winterswijk for different years.

Year	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**
Percentage	10.1	7.9	8.6	8.0	10.1	8.9	8.3	7.1	5.0

Table 14: Average light-duty, medium-duty and heavy-duty traffic percentages of the total traffic intensity on municipal roads in 3 municipalities.

Municipality	***Light-duty***	***Medium-duty***	***Heavy-duty***
Roermond (1999)	89.0%	5.3%	5.7%
Zeist (1994)	95.4%	3.9%	0.6%
Zoeterwoude (2001)	91.6%	6.0%	2.3%

Table 15: Correlations between total traffic intensities and total truck traffic intensities; and correlations between light-duty and heavy-duty traffic intensities on municipal roads in 3 municipalities.

Municipality	***Correlation between total and total truck traffic***	***Correlation between light-duty and heavy-duty traffic***
Roermond (1999)	0.94	0.63
Zeist (1994)	0.94	0.69
Zoeterwoude (2001)	0.93	0.82

Table 16: Number of roads, average percentage total truck traffic, standard deviation, and minimum and maximum percentage per municipality.

Municipality	***# roads***	***Average percentage***	***Standard deviation***	***Minimum percentage***	***Maximum percentage***
Roermond (1999)	20	10.8	4.0	5.0	20.0
Zeist (1994)	98	4.2	1.1	2.0	10.0
Zoeterwoude (2001)	16	8.4	3.6	4.2	17.3

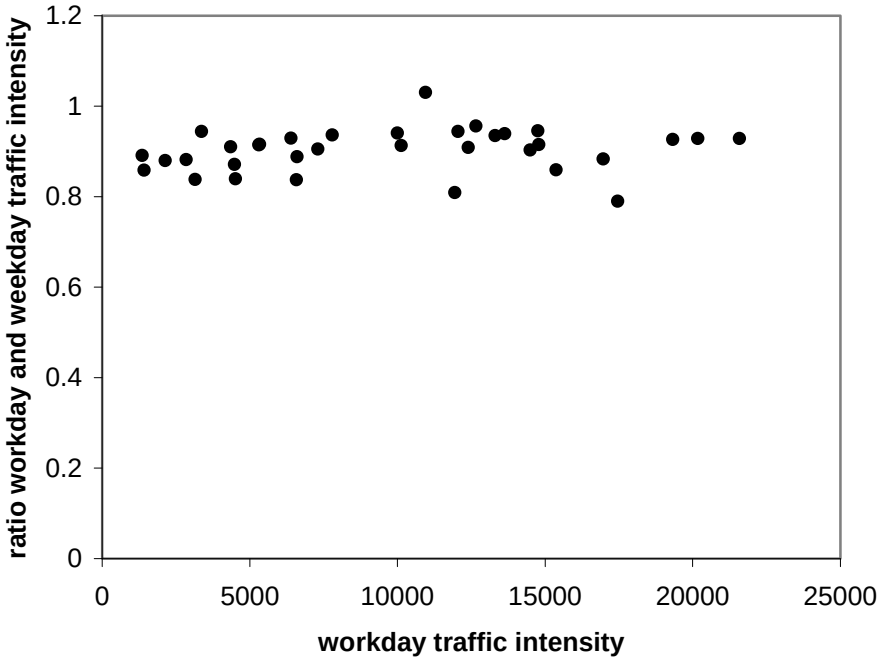


Figure 1: Association between workday traffic intensity and ratio between weekday and workday traffic intensity (data are from Schiedam for the year 1992).

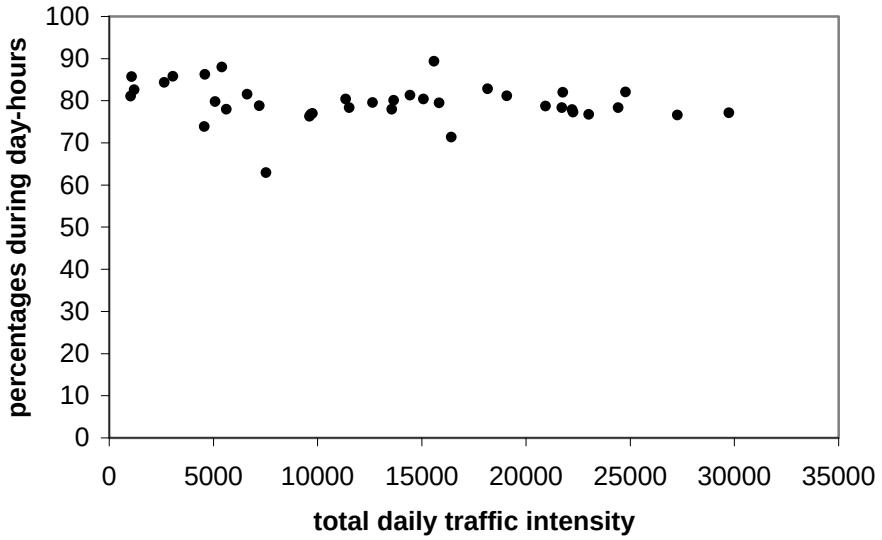


Figure 2: Association between total daily traffic intensity and percentages of the total daily traffic intensity that occurs between 7.00AM and 7.00PM (data are from the municipality of Den Bosch for the year 2002).

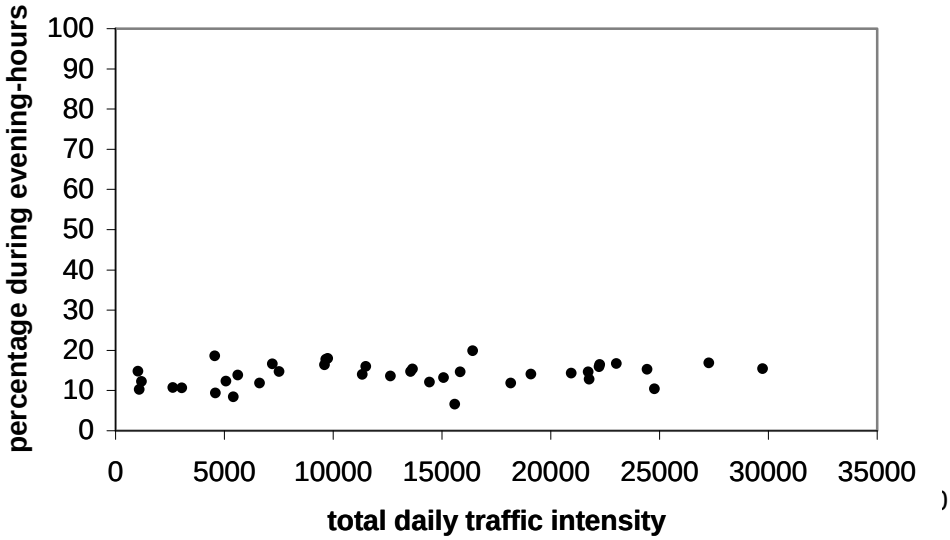


Figure 3: Association between total daily traffic intensity and percentages of the total daily traffic intensity that occurs between 7.00PM and 11.00PM (data are from the municipality of Den Bosch for the year 2002).

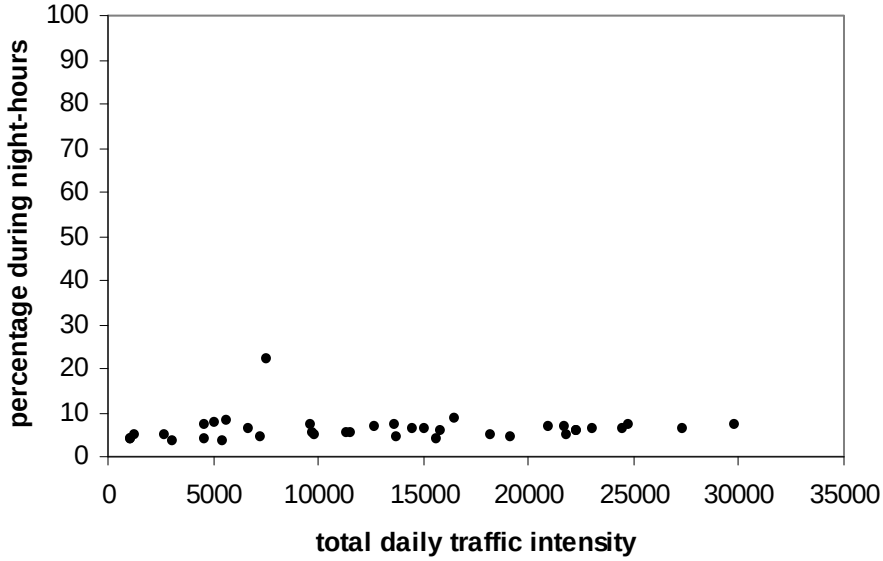


Figure 4: Association between total daily traffic intensity and percentages of the total daily traffic intensity that occurs between 11.00PM and 7.00AM (data are from the municipality of Den Bosch for the year 2002).

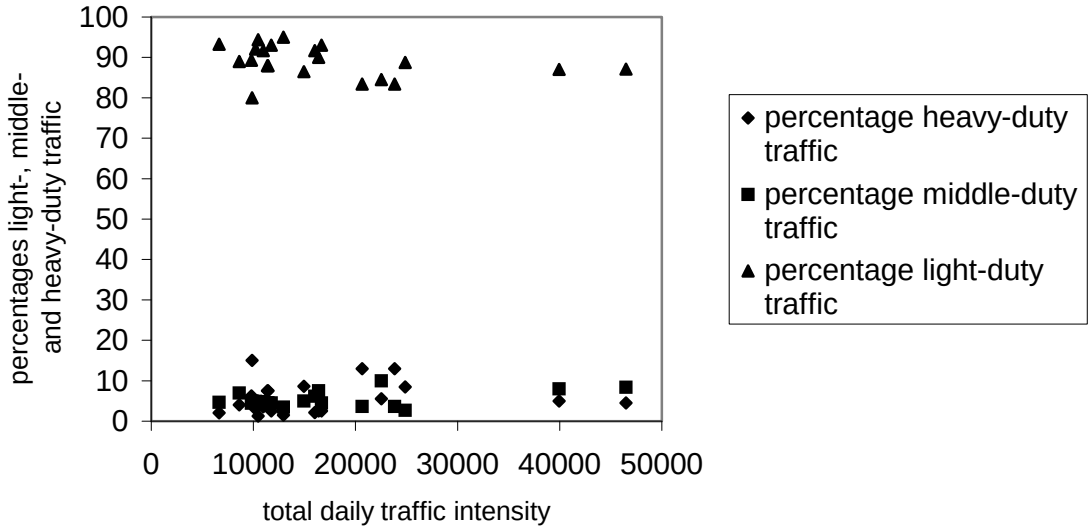


Figure 5: Association between percentages light-duty, medium-duty and heavy-duty traffic and total daily traffic intensity (data are from the municipality of Roermond for the year 1999).

Tables and figures of chapter 4.

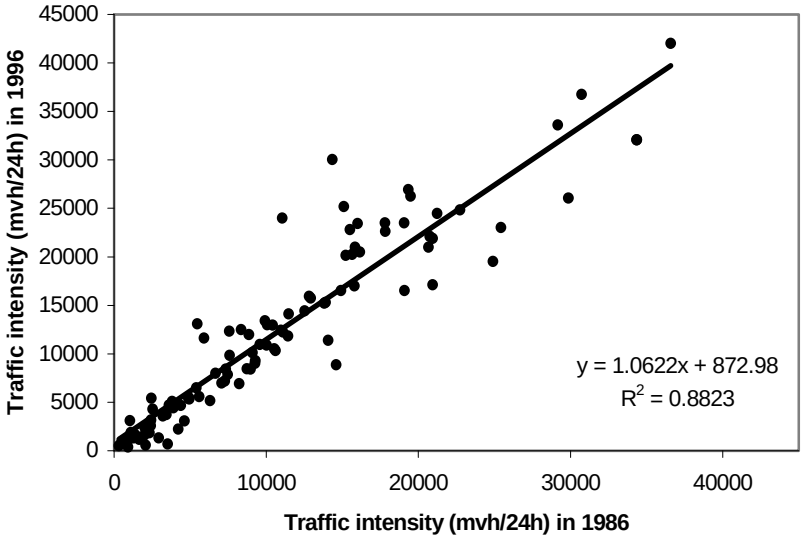


Figure 1: Correlation between 1996 traffic intensities (mvh/24h) and 1986 traffic intensities (mvh/24h) on municipal roads (using data of 13 municipalities with traffic data for all or several years in the period 1986-2000).

Table 2: Linear regression results for all 13 municipalities together: total number of roads with traffic data for at least 3 years; average percentage change in traffic intensity per year; number of roads with a significantly increasing traffic intensity; and number of roads with a significantly decreasing traffic intensity per municipality.

Roads	**Total number of roads**	**Average percentage ***	**Significant increase**	**Significant decrease**
All roads	377	0.6 *	78	17
Roads < 4,000 mvh/24h	166	-0.2%	20	7
Roads 4,000 – 11,000 mvh/24h	131	1.2% *	31	5
Roads > 11,000 mvh/24h	80	1.1 *	27	5

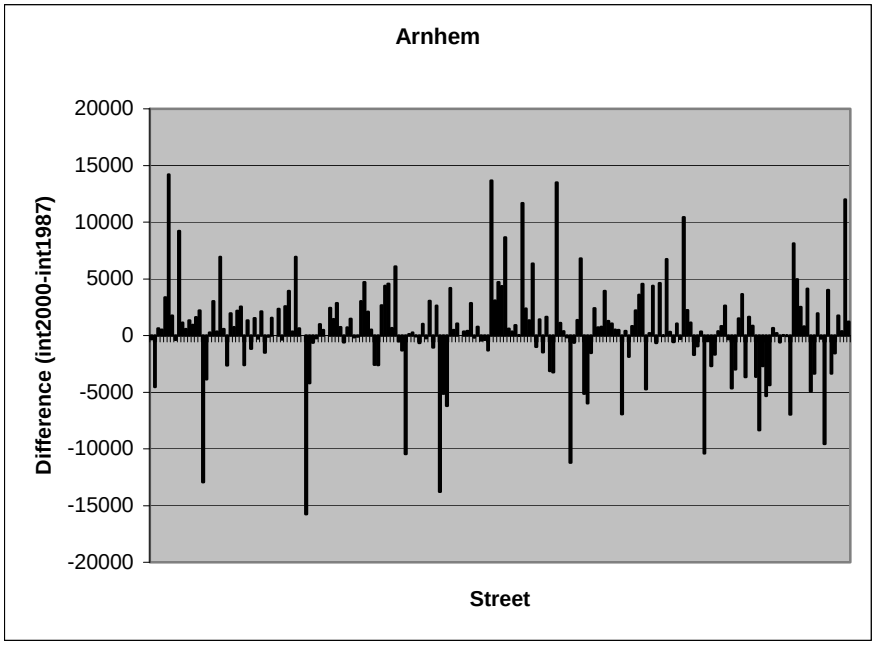
* Significant deviation from zero (i.e. deviation from horizontal slope).

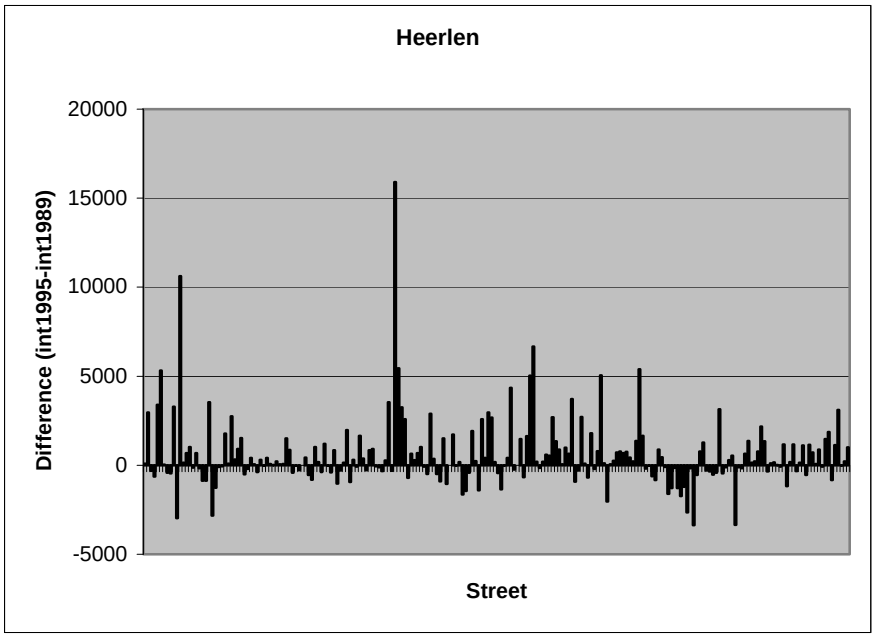
Table 3: Mixed modeling results for all 13 municipalities together: number of roads included in the analyses; fixed percentage change in traffic intensity per year; and number of roads with a percentage different from the fixed percentage.

Roads	**# roads for analysis**	**Fixed percentage ***	**# roads with percentage different from fixed percentage**
All	365	0.5% *	20
< 4,000 mvh/24h	161	0.1%	36
4,000 – 11,000 mvh/24h	131	1.0% *	2
> 11,000 mvh/24h	78	1.1% *	13

* Significant deviation from zero (i.e. deviation from horizontal slope).

Figure 2: Percentage difference in traffic intensity between two years for individual roads for four municipalities with data for only two years (Arnhem, Dordrecht, .




Heerlen
20000
15000
10000
5000
0
-5000
Difference (int1995-int1989)
Street

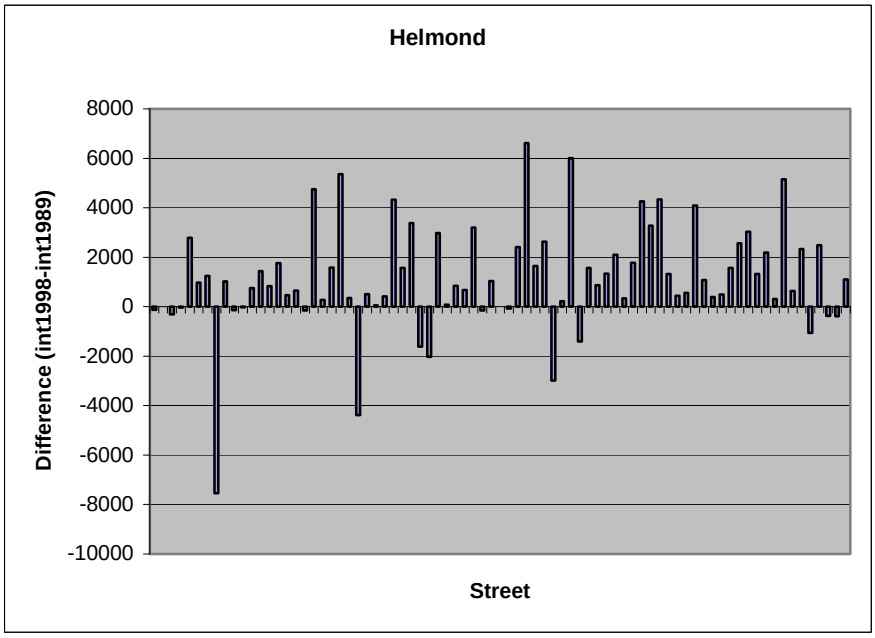
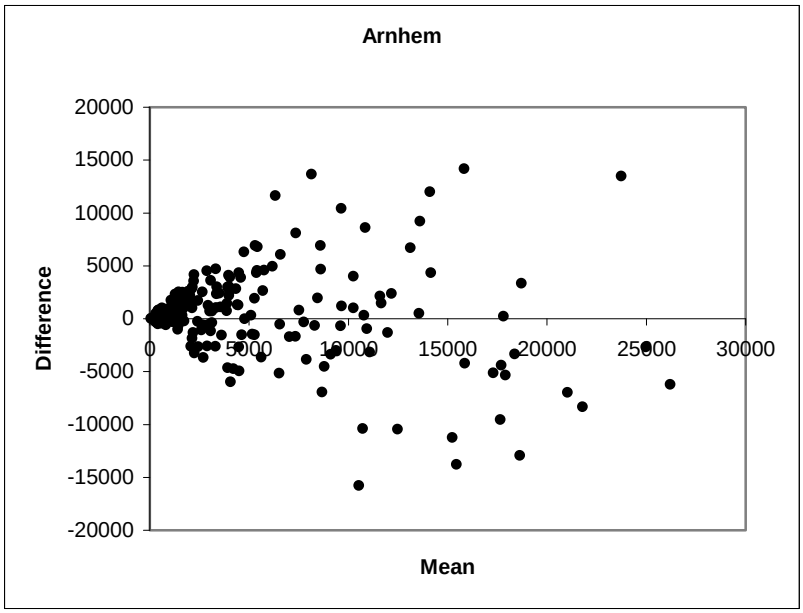
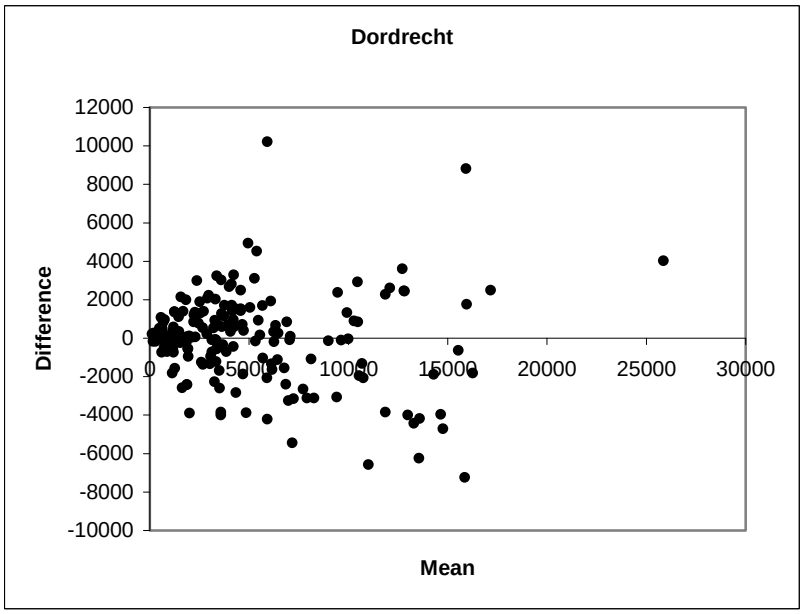

Helmond
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
Difference (int1998-int1989)
Street

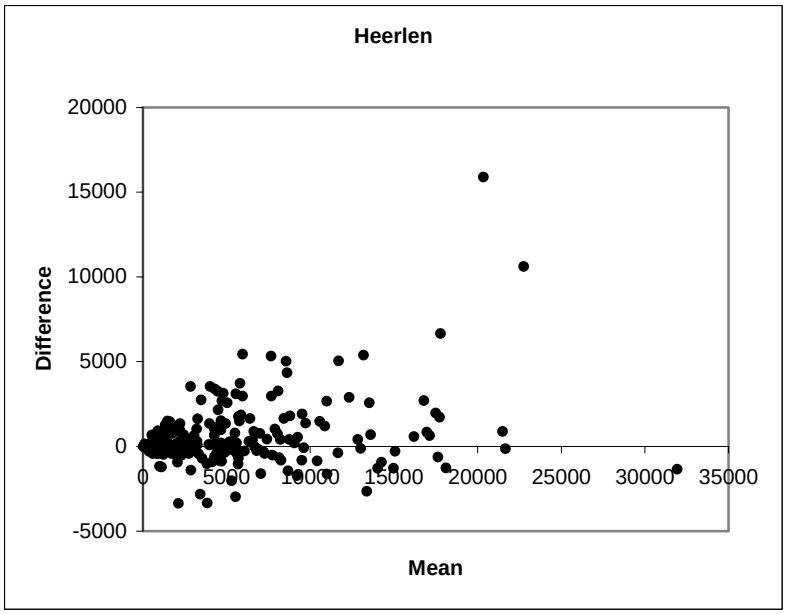
Table 4: Average coefficients of variation (CV) for traffic intensity data over several years in ten municipalities.

Municipality	**CV**	**Years for which data are available**
Arnhem	46.4%	1987; 2000
Dordrecht	32.9%	1989; 1997
Heerlen	20.5%	1989; 1995
Helmond	31.6%	1989; 1998
Twenterand	27.8%	1986; 1995 – 2000
Lichtenvoorde	19.9%	1996 – 2002
Winterwijk	18.0%	1984 – 1994
Zevenaar	31.8%	1991 – 2000
Heemskerk	16.3%	1995 – 1999; 2002
Laren	19.3%	1971; 1977; 1978; 1981 – 1998; 2002
Zandvoort	14.8%	1995 – 1998
Oud-Beijerland	26.5%	1994 – 2002
Rotterdam	25.9%	1986; 1990; 1995; 1996; 2000; 2001
Schiedam	24.5%	1984; 1986 – 2002
Goes	49.1%	1983; 1987 – 2002
Den Bosch	16.4%	1977 – 2002
Oisterwijk	19.8%	1990 – 2002

Figure 3: Plots of difference in traffic intensity between two years and the average traffic intensity for 4 municipalities with traffic intensity data for only two years.






Heerlen
20000
15000
10000
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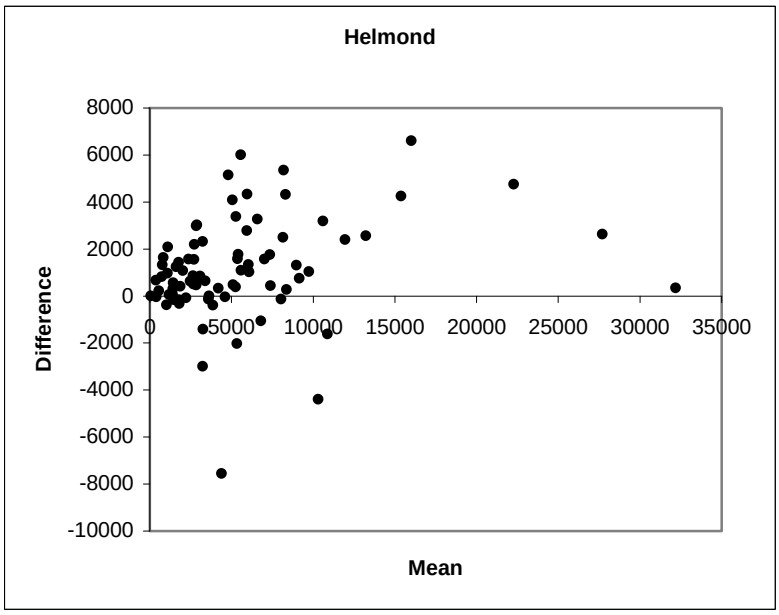
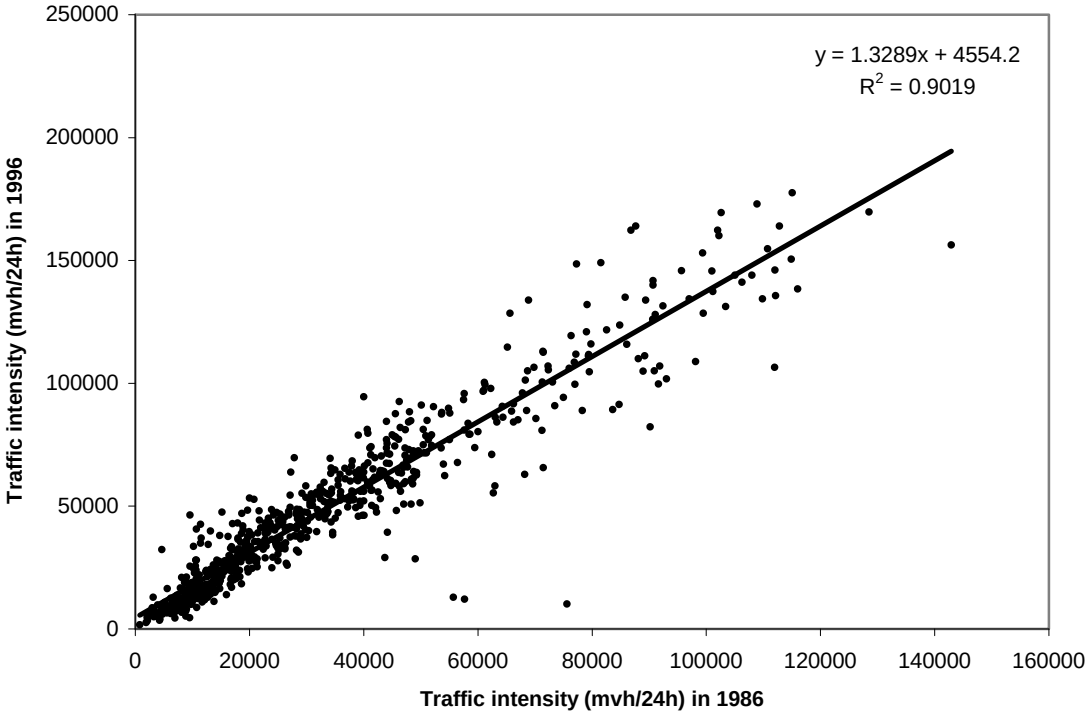
0
-5000
Difference
0
5000
10000
15000
20000
25000
30000
35000
Mean


Helmond
8000
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
Difference
0
5000
10000
15000
20000
25000
30000
35000
Mean

Tables and figures of chapter 5.



sities (mvh/24h) on national roads.

Table 1 and figure 2: Index for annual total traffic intensities on national roads (1986 = baseline).

Year	Index
1987	107
1988	114
1989	120
1990	129
1991	132
1992	138
1993	141
1994	146
1995	151
1996	155
1997	162

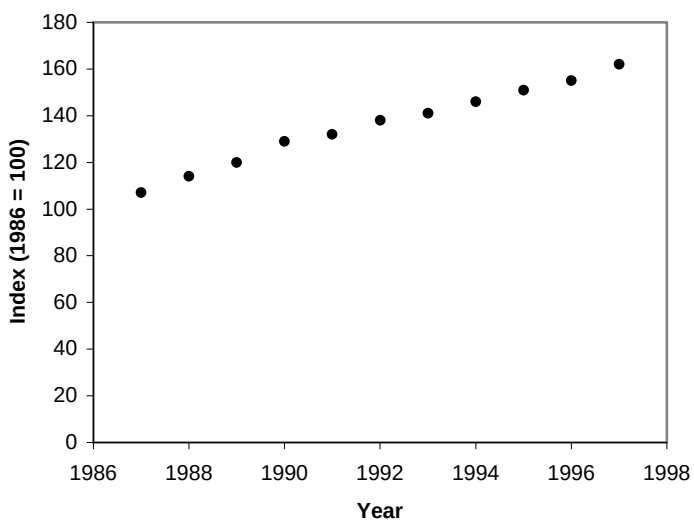


Table 2: Linear regression results for trend on national roads: total number of points with traffic data for at least 3 years; average percentage change in traffic intensity per year; number of points with a significantly increasing traffic intensity; and number of points with a significantly decreasing traffic intensity per municipality.

Points	**Total number of roads**	**Average percentage ***	**Significant increase**	**Significant decrease**
All points	967	3.4% *	843	25
Points < 20,000 mvh/24h	323	2.8% *	247	13
Points 20,000 – 50,000 mvh/24h	343	3.9% *	311	8
Points > 50,000 mvh/24h	301	3.6% *	285	4

* Significant deviation from zero (i.e. deviation from horizontal slope).

Table 3: Mixed modeling results for trend on national roads: number of points included in the analyses; fixed percentage change in traffic intensity per year; and number of points with a percentage different from the fixed percentage.

Points	**# points for analysis**	**Fixed percentage ***	**# points with percentage different from fixed percentage**
All roads	967	3.4% *	393
< 20,000 mvh/24h	323	2.7% *	127
20,000 – 50,000 mvh/24h	343	3.9% *	146
> 50,000 mvh/24h	301	3.6% *	67

* Significant deviation from zero (i.e. deviation from horizontal slope).

Figure and tables of chapter 6.

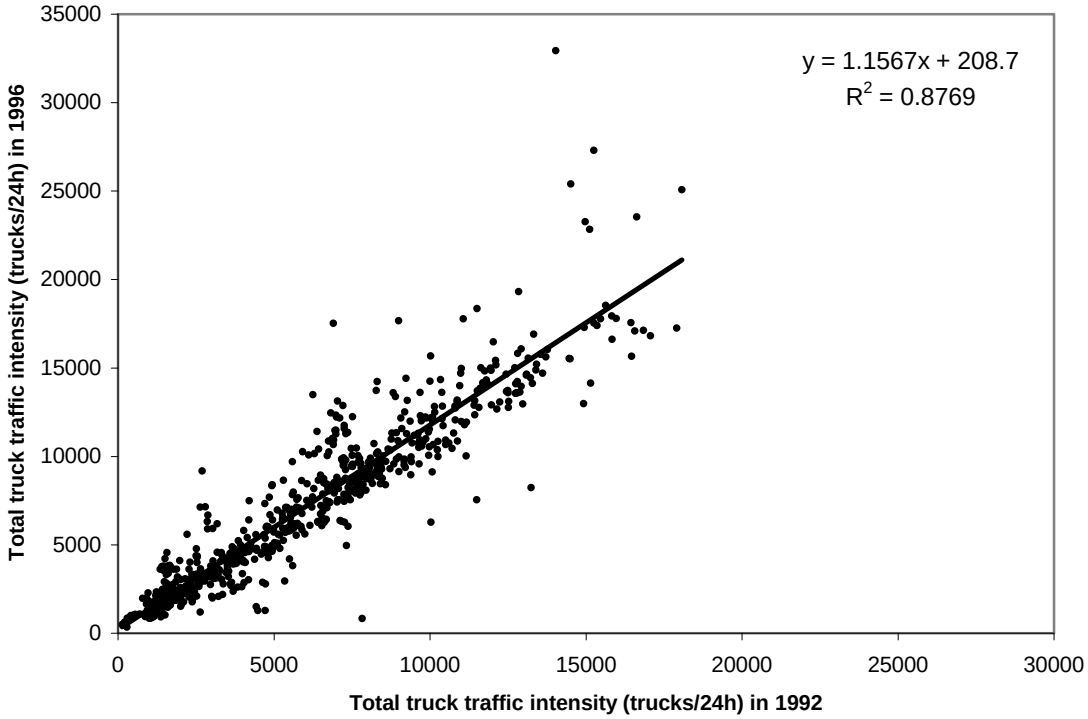


Figure 1: Correlation between 1996 total truck traffic intensities (trucks/24h) and 1992 total truck traffic intensities (trucks/24h) on national roads.

Table 1: Linear regression results for trend in total truck traffic on national roads: total number of points with traffic data for at least 3 years; average percentage change in traffic intensity per year; number of points with a significantly increasing total truck traffic intensity; and number of points with a significantly decreasing total truck traffic intensity.

Points	**Total number of roads**	**Average percentage ***	**Significant increase**	**Significant decrease**
All points	864	4.2% *	665	21
Points < 3,200 trucks/24h	283	3.1% *	161	12
Points 3,200 – 8,500 trucks/24h	289	4.5% *	232	8
Points > 8,500 trucks/24h	292	4.8% *	272	1

* Significant deviation from zero (i.e. deviation from horizontal slope).

Table 2: Mixed modeling results for trend in total truck traffic intensity on national roads: number of points included in the analyses; fixed percentage change in total truck traffic intensity per year; and number of points with a percentage different from the fixed percentage.

Points	**# points for analysis**	**Fixed percentage ***	**# points with percentage different from fixed percentage**
All roads	864	4.2% *	272
< 3,200 trucks/24h	283	3.2% *	104
3,200 – 8,500 trucks/24h	289	4.6% *	73
> 8,500 trucks/24h	292	4.8% *	56

* Significant deviation from zero (i.e. deviation from horizontal slope).

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