Indicators for waste prevention

Development of a methodology for, and testing of OECD-indicators

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This document presents an overview of the indicators for waste prevention. The methodology of pressure and response indicators of both enterprise and municipal waste is developed and the indicators are tested.

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13. *Other publications about the same subject*

De Groof, M., Smeets, K., Umans, L., Van Acoleyen, M. (2003). Preventie van bedrijfsafvalstoffen. Berekening en analyse van kwantitatieve en kwalitatieve indicatoren. OVAM, Mechelen. P. 112

De Baere, P. (2004). Resultaten bedrijfsenquête eco-efficiëntie 2004. OVAM, Mechelen. P. 21

Putseys, L., De Roover, G., (2003). Indicatoren voor de preventie van huishoudelijke afvalstoffen in Vlaanderen. OVAM, Mechelen. P. 47

** Price subject to change.*

Table of Contents

List of figures

List of Abbreviations

CI: Confidence Interval

EE: Eco-efficiency

EVA: Extrapolation of Waste (Extrapolation Software)

EVATREND: Extrapolation of Waste – Trend analysis (Trend analysis Software)

GAV: Gross Added Value

GDP: Gross Domestic Product

MFA: Material Flow Accounts

NIS: National Statistical Institute of Belgium

NOSS: National Office of Social Security

OECD: Organisation for Economic Co-operation and Development

OVAM: Public Waste Agency of Flanders

PI: Prediction Interval

VLAREA: Flemish waste legislation

Definitions

Decoupling: The term decoupling refers to the relative growth ratio of the environmental pressure vis-à-vis an economic or other relevant variable with which a causal connection may be assumed.

Positive decoupling: Occurs when the environmental pressure is increasing at a lesser rate than the economic parameter.

Negative decoupling: Occurs when the environmental pressure is increasing at a more rapid rate than the economic parameter.

Decoupling indicator: The decoupling indicator r(t) for a given year vis-à-vis a given reference year is in this document defined as follows:

$$r(t) = 1 - \frac{\frac{m(t)}{m(t_0)}}{\frac{a(t)}{a(t_0)}}$$

where m(t) is equal to the environmental pressure in year t and a(t) equal to the economic variable in year t. t_0 represents the reference year. (Positive) decoupling takes place when the decoupling indicator is greater than zero. There is no decoupling when the latter equals zero. When the decoupling indicator is below zero, there is negative decoupling.

Gross Added Value: The economic interest of a sector is calculated via the Gross Added Value of the enterprises that are part of that economic sector. This is the sum that the production factors that are applied in that sector, add at the value of the consumed goods and services. So the added value is the difference between the value of the produced goods and services on the one hand and the value of the in the production process consumed goods and services on the other hand.

Gross Domestic Product: The Gross Domestic Product is obtained by adding the GAV and the product related taxes on production and import and deducting the product related subsidies on production and import.

Confidence Interval: The confidence interval is the measurement of the certainty of the shape of the fitted regression line. A 95% confidence interval implies a 95% chance that the true regression line fits within the confidence intervals.

Prediction Interval: The prediction interval is the measurement of the certainty of the scatter about a certain regression line. A prediction interval bears the same relationship to a future observation that a confidence interval bears to an unobservable population parameter.

1 General introduction

During the meeting of the WGWPR on May 4 and 5, 2004 in Paris, Flanders engaged itself to test out the indicators for waste prevention from document ENV/EPOC/WGWPR/SE(2004)1/FINAL and to further develop the methodology.

The Public Waste Agency of Flanders (OVAM) possesses broad experience in the research and the development of pressure and response indicators for waste prevention, both in the areas of household waste and enterprise waste. Since many of the indicators already developed in Flanders correspond with the indicators proposed by the OECD in the document ENV/EPOC/WGWPR/SE(2004)1/FINAL, much of this experience could be usefully applied to the testing of the OECD indicators.

As the Flemish policy on waste products deals with enterprise and household wastes separately, this division is also retained in this document.

In the first paragraph of chapter 2, the indicators are introduced that were examined for the prevention of enterprise waste. In the first place, there are the direct pressure indicators for prevention of enterprise waste. The data regarding the waste generation are gained through the annual waste reporting procedure in a survey sampling of enterprises. On the basis of this sampling, the waste volume is extrapolated for the entire enterprise population. However, this extrapolation is only an estimate, which requires taking into account errors in the estimated data. A method was developed to calculate the confidence interval of the decoupling indicators by using a hypothesis test.

The purpose of the decoupling indicators is to check if there exists decoupling between the evolution of the waste generation and the evolution of an economic factor that maintains a causal connection with it. These decoupling indicators are considered as direct indicators for waste prevention, even though, strictly speaking, this is not correct. For, indeed, decoupling is an objective in prevention, and from the indicators it cannot be determined if the prevention of waste caused the decoupling.

The most relevant economic factors with indicators of the prevention of enterprise waste are the Gross Domestic Product (GDP) and the Gross Added Value (GAV).

Both parameters are used at constant prices, so that factors such as inflation do not influence their values.

In the second paragraph of chapter 2, the result is described of a survey that examined the mentality of enterprises versus Eco-Efficiency (EE). This survey did not only probe the enterprise mentality vis-à-vis waste prevention but also included other environmental aspects. The reason for this is that, when dealing with prevention policy, the various aspects of an environment-conscious operation need to be taken into account. When communicating with enterprises, the government uses the term EE to identify this integrated environmental policy. The direct response indicator that is obtained in this way classifies the organisations in phases based on their mentality towards EE. Since waste prevention is itself a major aspect of EE, it is assumed that the classification in phases applies to EE and waste prevention in like measure.

Chapter 3 introduces the indicators examined for the prevention of household waste. Developed since 2002 and adapted in 2003, these indicators were thus not specifically established for this OECD test programme. Nonetheless, they display strong similarities with the indicators proposed by the OECD for the prevention of household waste.

The same classification was retained here as with the indicators for the prevention of enterprise waste. The first paragraph of chapter 3 introduces the direct pressure indicators. These represent the indicators ‘household waste per unit of population’ and ‘household waste per consumption unit’. The second paragraph of chapter 3 describes a number of direct response indicators that monitor the behaviour of the population in the area of prevention of household waste.

Indicators for waste prevention based on Material Flow Accounts (MFA) were not examined. The OVAM currently lacks experience in MFA but intends to conduct further research into these indicators in the future.

2 Indicators for the prevention of enterprise waste

2.1 Direct pressure indicators

(De Groof, M., Smeets, K., Umans, L., Van Acoleyen, M. (2003). Preventie van bedrijfsafvalstoffen. Berekening en analyse van kwantitatieve en kwalitatieve indicatoren. OVAM, Mechelen. P. 112)

(OECD (2004).Towards Waste Prevention Performance Indicators (ENV/EPOC/WGWPR/SE(2004)/FINAL). P. 197)

2.1.1 Introduction

2.1.1.1 Estimating annual waste generation in Flanders

Proper management of the waste streams requires the most accurate knowledge possible of the volume of waste produced. This knowledge is required in function of the type and the processing method of the waste and in function of the size of the enterprises based on the number of its employees, together with the economic sector wherein the waste is being generated. To that end, the Flemish legislation imposed a reporting requirement on enterprises to annually provide the OVAM with the count of the volume and the type of the waste they generated, together with the treatment methods used. However, to enforce this reporting on every business proved an impossible task. For that reason, the decision was taken to select a broad sampling from the reporting files and to enter only the data from those particular reports into the databank. This sampling has been classified by economic sector and dimension (sector/dimension), a stratification in accordance with the number of employees. The number of enterprises is entered per stratum (sector/dimension), with the aim of achieving a variation coefficient of maximum 25 % per stratum. This working method has since 30 April, 2004 been imbedded into the Flemish waste legislation. *(VLAREA Art. 6.3.1.1. §1.)*

In order to arrive at an idea of the total waste generation in Flanders, software (Extrapolation of Waste Product - EVA) has been developed that per sector/dimension extrapolates the volume of waste for the total number of enterprises within that stratum according to the reference databank of the National Office of Social Security (NOSS). Beside the extrapolation, EVA carries out a statistical analysis that is used to determine the reliability of the estimated waste quantities. The extrapolation method is described in attachment 1.

2.1.1.2 Defining the trend

Aside from the estimate of the volume of enterprise waste produced annually, a thorough knowledge of the evolution of the waste streams in time is of crucial importance. But by having to work with estimations, one is rather severely limited in the ability to accurately define the evolution of waste streams in time. The accuracy of the trend analysis can be improved by considering the evolution in time for those enterprises whose waste generation is known for a number of successive years. This concept is known as an analysis of 'paired observations'. It premises that the variation in the waste generation, the factor that complicates the estimate, is due primarily to the variations between different enterprises. When the same enterprise is studied over successive years, the variation is smaller. In this way, a better estimate of the increase or decrease in waste streams becomes possible. The principle of the paired observations is processed through specific software, EVATREND (Extrapolation of Waste – TREND analysis), that was developed in order to carry out a trend analysis based on the estimations of the annual waste generation.

2.1.1.3 Research on decoupling

In general, mention is made of positive decoupling of the environmental pressure and a parameter that is causally linked to it when the environmental pressure increases less rapidly than the parameter in question. Research is being conducted to determine whether in Flanders there exists positive decoupling in the production of enterprise waste vis-à-vis the economic factors of Gross Domestic Product (GDP) and Gross Added Value (GAV), in each case at constant prices. By working with constant prices, the inflationary impact on these factors is excluded. Both the GDP and the GAV are available as separate figures for the Flemish Region.

The GDP and GAV are known quantities for the whole of the economy. In addition, the GAV is also available separately for a number of economic sectors. These sectors, however, do not always coincide with the classification used by the OVAM in its waste statistics, which makes monitoring impossible if decoupling is occurring for every sector. There are further a number of sectors for which the annual estimate renders too low a quality and for which it thus becomes impossible to calculate reliable time series. Furthermore, the waste generation of a number of sectors has only been calculated since 2000, so that time series figures over a more extended period are not yet feasible.

2.1.1.4 The use of hypothesis tests

In order to take into account the uncertainty factor in the estimations, a hypothesis test is needed when trying to determine whether or not there is decoupling. The uncertainty for the individual production years is relatively high, which complicates the estimate of decoupling. For that reason, the waste volumes are determined by a weighted regression line, which offers greater reliability than the estimate of each separate year. The regression is calculated on the basis of the reliability of the waste estimate in each production year and by application of paired observations.

A study has been carried out to determine if the hypothesis test can contribute to the determination of decoupling. This study is discussed in its entirety in attachment 2. The aim of the study is to determine the extent of the 95 % confidence interval for the decoupling indicator when calculated by using the results of the trend analysis.

2.1.2 Generation of enterprise waste versus Gross Domestic Product

2.1.2.1 Trend analysis

Figure 2.1: Trend analysis of total enterprise waste generation per year in Flanders, for the period of 1995-2002

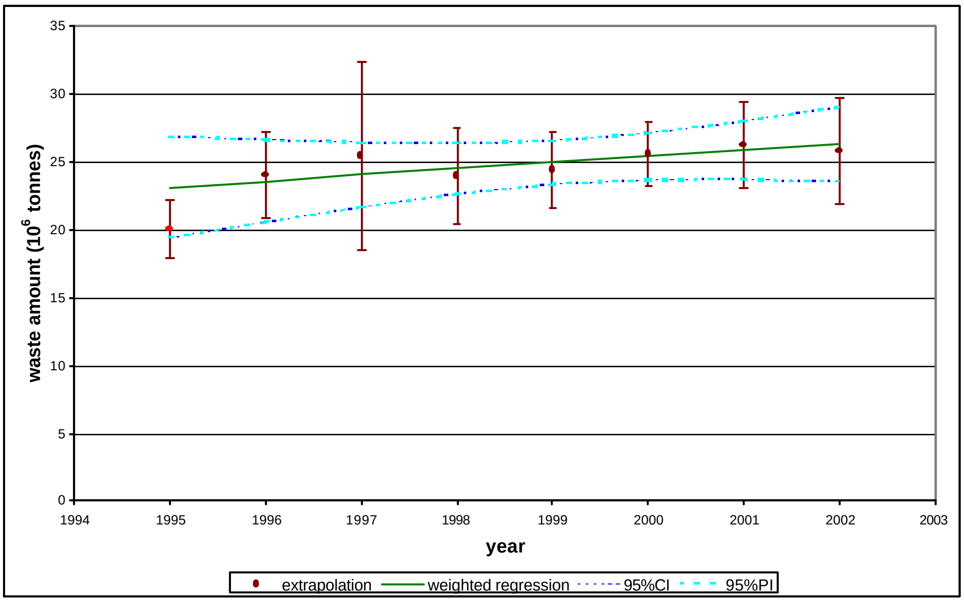


Figure 2.1 shows the weighted trend analysis of the total amounts of enterprise waste estimated annually:

- the annually estimated (extrapolated) volumes of enterprise waste from 1995 to and including 2002 with the 95 % confidence interval, represented as error bars;
- the weighted regression of the extrapolated amounts of waste taking into account the reliability of the annual waste estimations and the evolution of the waste generation of one and the same organisation in successive years;
- the 95 % confidence interval (CI) and 95 % prediction interval (PI) of the weighted regression.

In the regression analysis, no account was taken of the figures for the year 1995. The volume of waste generated during that year lies significantly lower than in the following years.

2.1.2.2 Regression of GDP and Total Enterprise Waste Amount

Figure 2.2: Simple Regression of GDP and Simple Regression of the Total Enterprise Waste Amount, relative to 1996

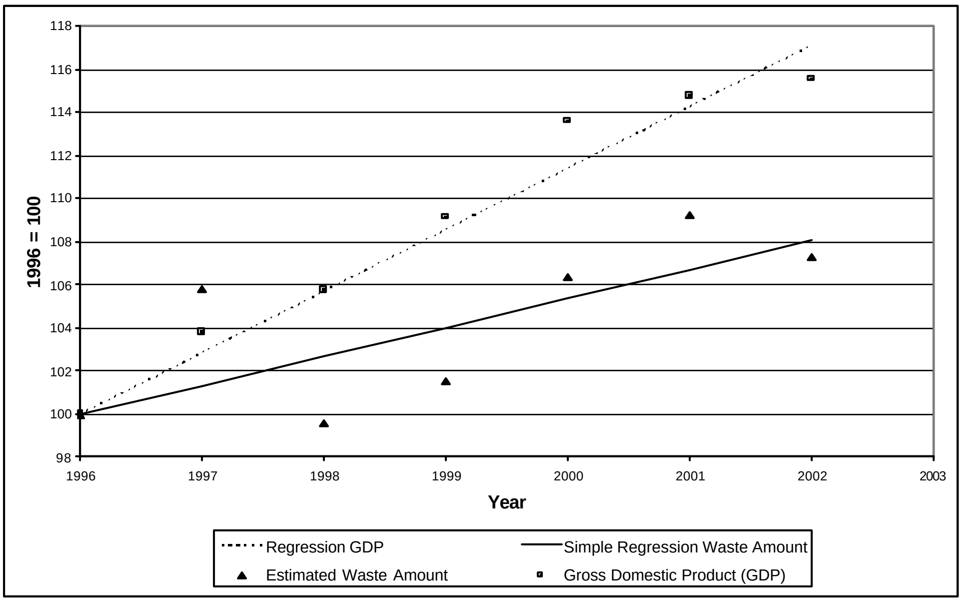


Figure 2.3: Simple Regression of GDP and Weighted Regression of the Total Enterprise Waste Amount, Relative to 1996

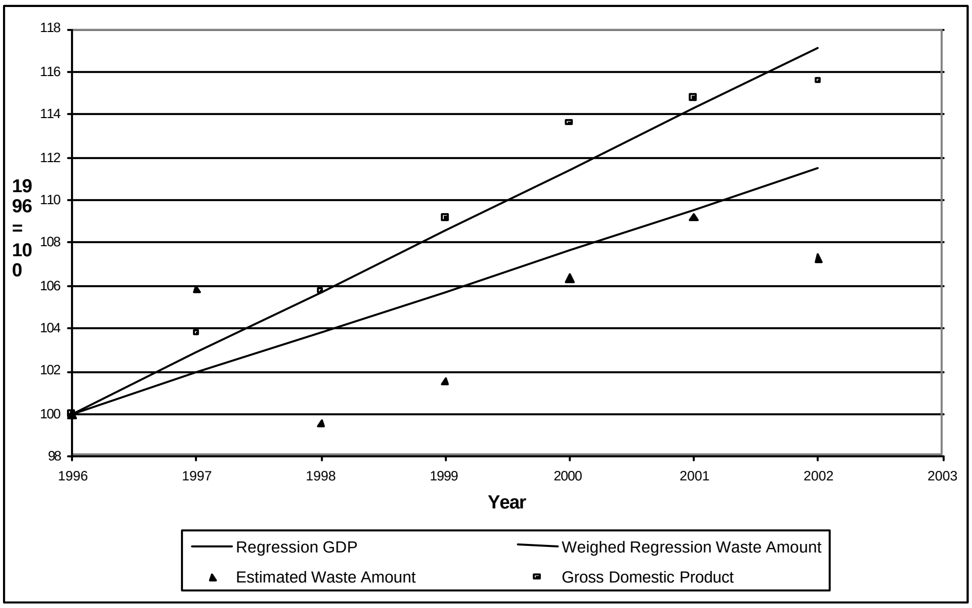


Figure 2.2 and figure 2.3 show the Gross Domestic Product (GDP), the annually estimates of waste volume and its regression relative to 1996. The reference year

1996 is fixed at 100. These figures show that the GDP over the period 1996-2002 manifests a stronger increase than the total generation of enterprise waste. The standardized weighted regression (figure 2.3) in this case rises somewhat more rapidly than the simple regression of the standardized waste generation (figure 2.2). One might possibly use these figures as evidence of a weak, relative positive decoupling: the economic parameter GDP appears to increase at a more rapid rate than the total waste generation, thus pointing to a positive decoupling. As the amount of waste is not diminishing, the decoupling is only relative.

Figure 2.3 shows a weighted regression of the extrapolation estimates of the waste generation. This means that in the calculation of the regression, account is taken of the reliability factors of the estimates in the different years. In addition, the paired observations are also taken into account. Since the statistically most reliable trend for waste generation is calculated by using the weighted regressions, the decision was taken to use the annual point values of this weighted regression when calculating the indicators.

A detailed description of how one arrived at the methodology that uses the results of the weighted regression analysis and by which the decoupling indicators are determined with a shifting reference year is given in attachment 2.

2.1.2.3 Decoupling indicator

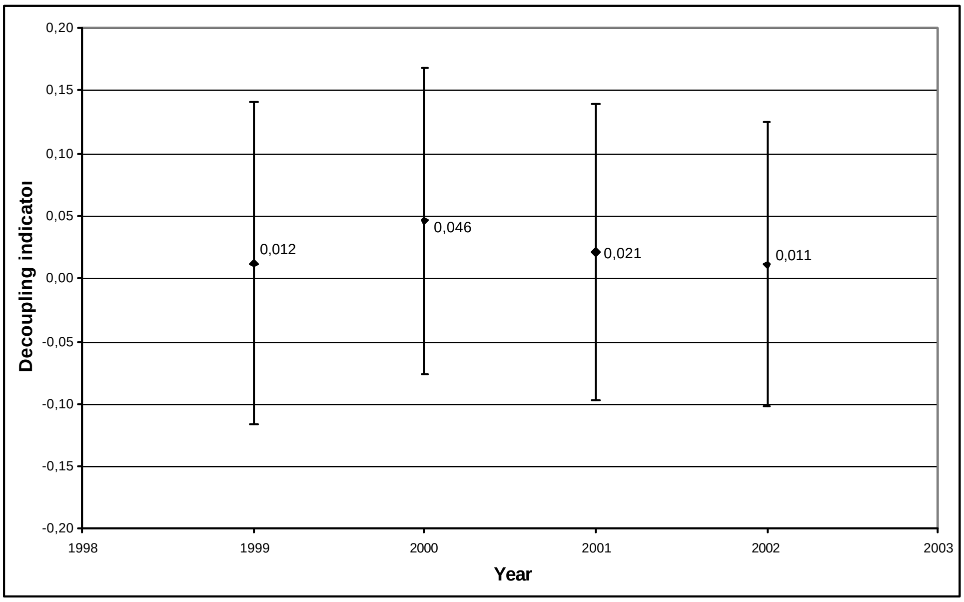
The reliability of the decoupling indicators that is determined on the basis of a hypothesis test depends on the time interval considered. The greater this interval, the greater the uncertainty for the decoupling indicator and the greater also the confidence interval.

By using the shifting reference years and by studying each time a 5-year period, the extent of the confidence interval becomes independent of the time interval. The following indicators are calculated by that method:

- 1999 with reference year 1995;
- 2000 with reference year 1996;
- 2001 with reference year 1997;
- 2002 with reference year 1998.

These decoupling indicators are shown together with their 95 % confidence intervals.

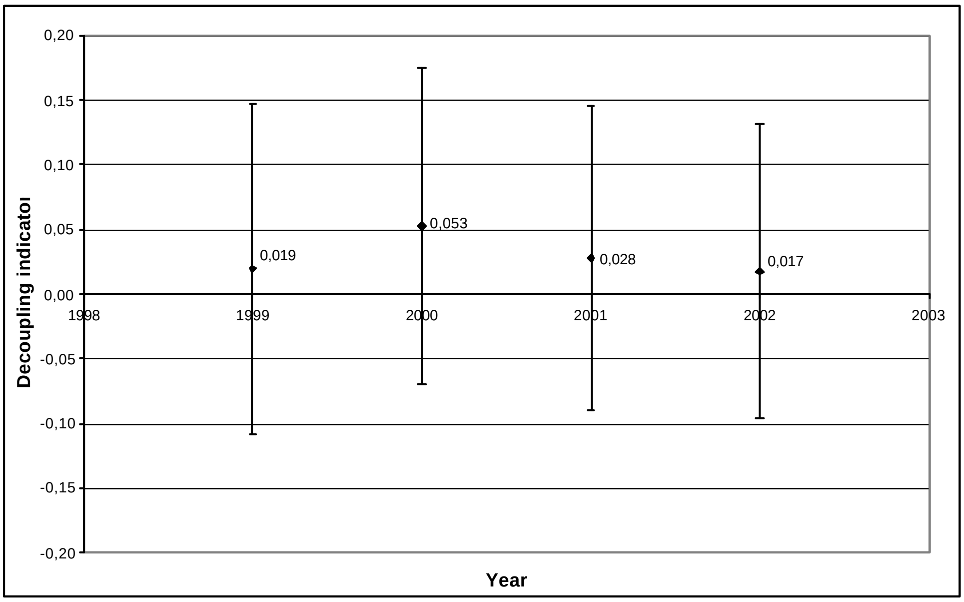
Figure 2.4: Decoupling indicator: total enterprise waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002, with separate weighted regression time intervals



The trends over the different intervals on which the indicators in Figure 2.4 are based have been calculated separately. This offers the advantage that previous years do not continue to be used in the calculation and thus cease to influence the calculation of the decoupling indicator over more recent time intervals. However, the disadvantage is that the reliability of the regression declines when the weighted regressions are being calculated over shorter periods of time. For that reason, the decision was taken to only calculate the weighted regression over the longest possible period for which reliable figures are available. In addition, it was decided not to include 1995 and the previous years into the calculation as this would give a distorted picture. The decoupling indicators calculated on the basis of the weighted regression over the period 1996-2002 are shown in Figure 2.5.

In the following paragraphs, the decoupling indicators are each time calculated on the basis of the weighted regression over the period 1996-2002. In a number of cases, where 1995 does not give a distorted picture, this year too was included into the calculation.

Figure 2.5: Decoupling indicator: total enterprise waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002, with weighted regression interval 1996-2002



The indicator is slightly positive, which may indicate a positive decoupling of the waste generation vis-à-vis the GDP. The decoupling is rather weak and because of estimation errors, it is not possible to show the decoupling with 95 % certainty. The 95 % confidence interval encompasses the value zero, which makes a statistically significant conclusion about the decoupling impossible.

For the weighted trend analysis, data for the period 1996-2002 are used, even though the waste statistics have been available since 1992. As figure 2.6 shows, the waste figures of the years 1992 to and including 1995 are significantly below those recorded as of 1996.

Figure 2.6: Simple Regression of GDP and Weighted Regression of the Total Enterprise Waste Amount since 1992, Relative to 1995

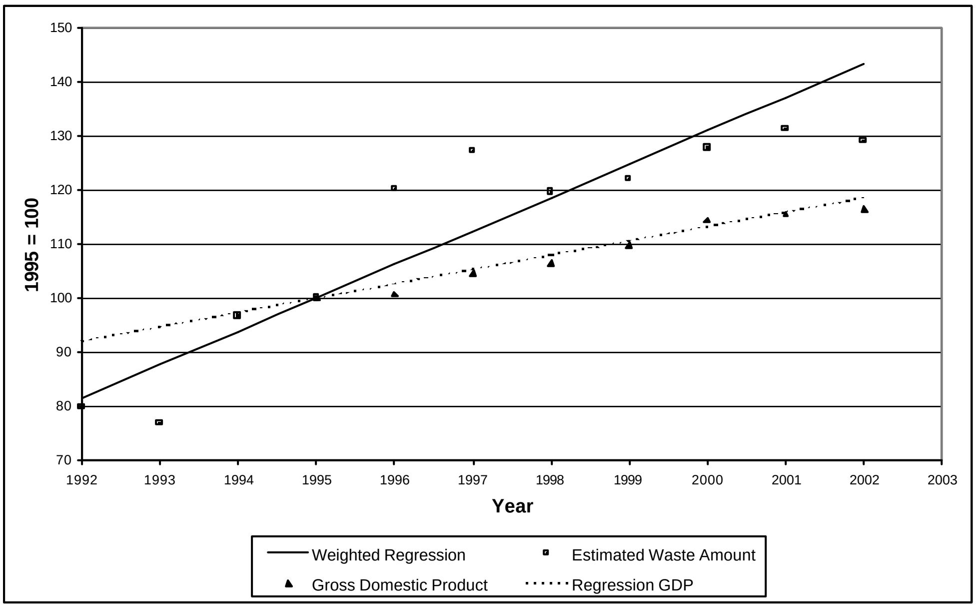


Figure 2.6 shows a weighted regression of the total waste amount, based on the years 1992-2002. Because of the lower estimated waste amounts in the years 1992 until 1995, this weighted regression is very different from the weighted regression based on the years 1996-2002 in figure 2.3.

This marked increase from 1992 to 1996 can be explained by two factors:

1. because of the gradual increase in the number of large-size enterprises reporting during this period, sectors/dimensions for which in past years reports were not available have been submitting data during the more recent years. When this includes enterprises of substantial size, the extrapolation may increase sharply as the volume of waste within such a sector/dimension can be substantial;

2. the waste generators are submitting more extensive reports on their amounts of waste, which leads to a rise in the average volume of waste per organisation in a given sector/dimension and thus also in the total waste estimate.

As of 1996, this sharp rise has stabilized. So, on the one hand, one becomes the most accurate trend when as much years as possible are taken into account. On the other hand, the data from 1992 to and including 1995 are much lower than those of the following years and may give a distorted image of the trend of the waste generation. Therefore, in this document one has chosen to calculate the weighted regression based on only the years 1996-2002, unless otherwise indicated.

Furthermore, the GDP and the GAV is being calculated differently from 1995 onwards, which makes these economic factors relevant only for time series as of 1995. Also for this reason, it was decided to take account of the waste data only as of 1996.

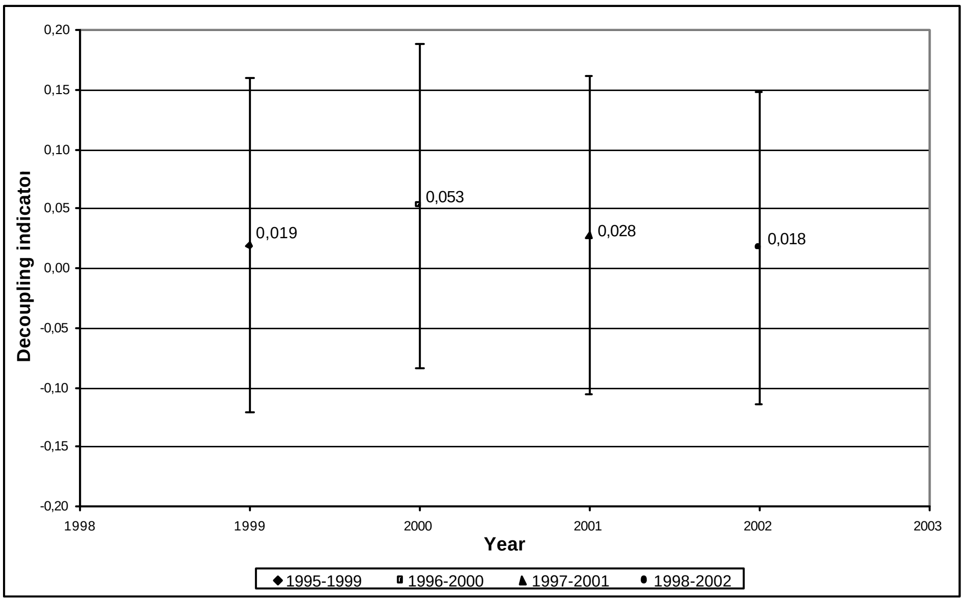
2.1.3 Generation of enterprise waste versus Gross Added Value

2.1.3.1 Trend analysis

(see 2.1.2.1)

2.1.3.2 Decoupling indicator

Figure 2.7: Decoupling indicator: total enterprise waste generation versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002

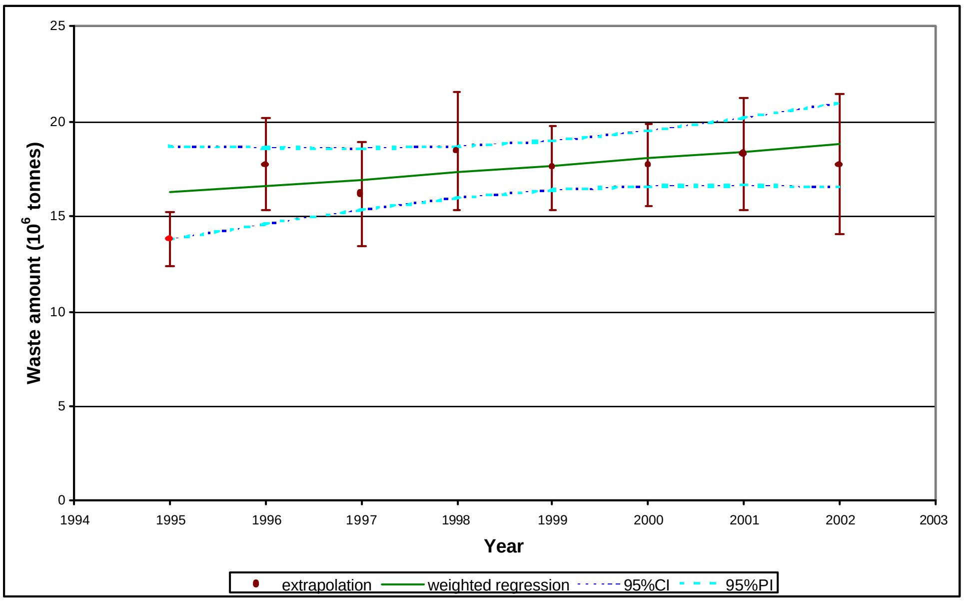


The evolution of the GDP and the GAV runs largely parallel, which explains the absence of major differences between the decoupling indicators. After all, the GDP is obtained by adding the GAV and the product related taxes on production and import and deducting the product related subsidies on production and import. Consequently, the evolution of both factors is largely the same.

2.1.4 Generation of primary enterprise waste versus Gross Domestic Product

2.1.4.1 Trend analysis

Figure 2.8: Trend analysis of primary enterprise waste generation per year in Flanders, for the period of 1995-2002



Primary enterprise waste is the enterprise waste that is produced for the first time. Secondary waste refers to waste resulting from waste processing, in other words, waste whose nature and composition can been altered by some kind of pre-processing. Secondary waste thus is produced by the waste processing sector; primary waste by the other sectors. The waste processing sector consists of the NACE-codes 90, 37.1, 37.2 and 51.57. The waste from the waste water treatment sector is not included in the secondary waste.

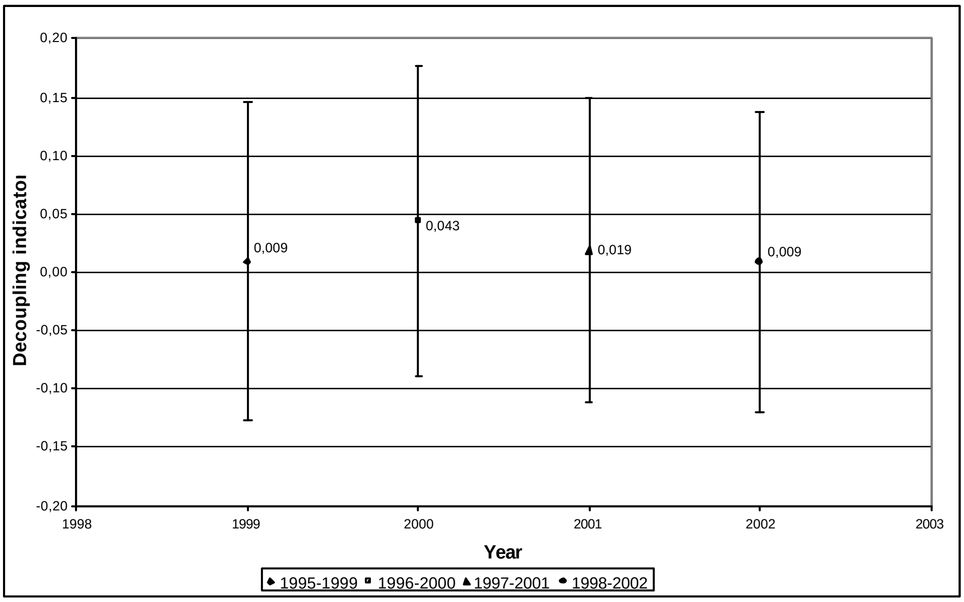
By including the secondary waste the trend of the waste amount is distorted, since in recent years the secondary waste has increased significantly, because the waste is treated in more steps. The waste generated in each of these steps is included in the secondary waste, although it originates from the same (primary) waste. Secondary waste cannot be reduced by prevention measures. So, the indicator for the primary enterprise waste renders a better picture of the waste prevention then the indicator for the total enterprise waste..

So this sector not only consists of waste treatment enterprises, but also of the waste collection, waste recuperation and the scrap merchants. The reason is that the enterprises often have several activities (treatment and recuperation) so the distinction can not be made.

Also the range of primary enterprise waste in 1995 deviates sharply from the following years. Here also, 1995 has not been included in the calculation.

2.1.4.2 Decoupling indicator

Figure 2.9: Decoupling indicator: primary enterprise waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



The best estimate for the decoupling indicator shows a positive decoupling over all time intervals. The 95 % confidence intervals do indicate, however, that the positive decoupling is not significant.

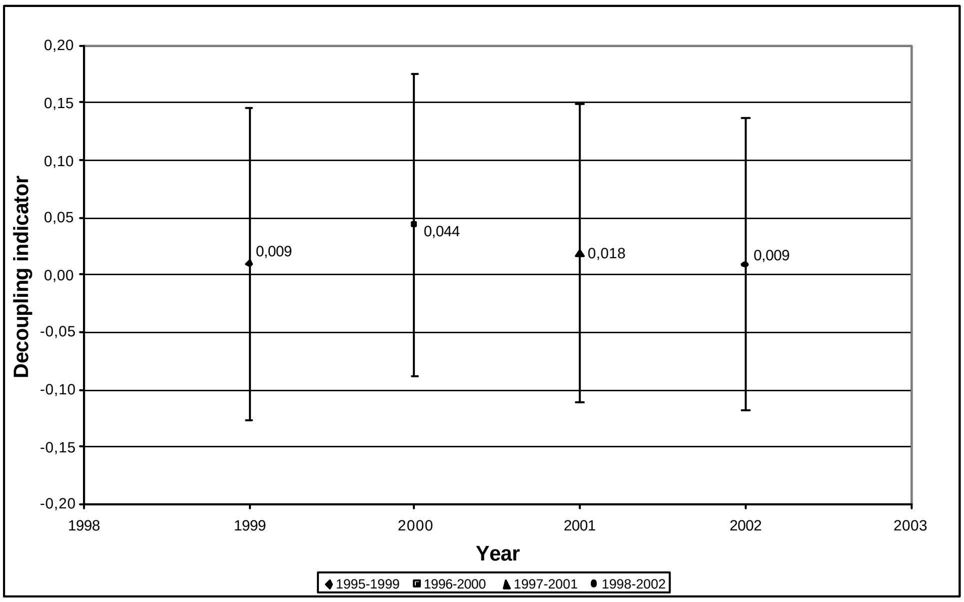
2.1.5 Generation of primary enterprise waste versus Gross Added Value

2.1.5.1 Trend analysis

(see 2.1.4.1)

2.1.5.2 Decoupling indicator

Figure 2.10: Decoupling indicator: primary enterprise waste generation versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



When GAV is selected as the economic factor, this largely renders the identical result as for the GDP selection. In this case also, there is a trend towards a positive decoupling, again not significant.

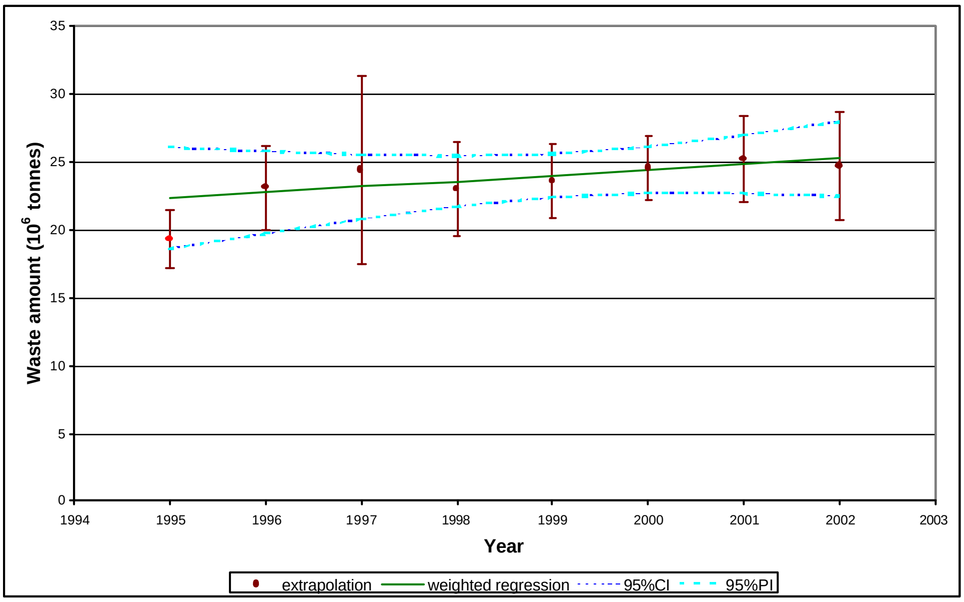
2.1.6 Generation of non-hazardous enterprise waste versus Gross Domestic Product

As defined in the Flemish waste legislation (VLAREA), hazardous waste is a waste product that presents or could present a specific hazard to human health and to the environment or that must be processed by specialized enterprises. VLAREA provides a list of hazardous properties. A hazardous waste product is supposed to possess at least one of the properties mentioned in this list. *(VLAREA, Art. 2.4.1*

§2) All substances that fall outside this definition are thus classified as non-hazardous waste products.

2.1.6.1 Trend analysis

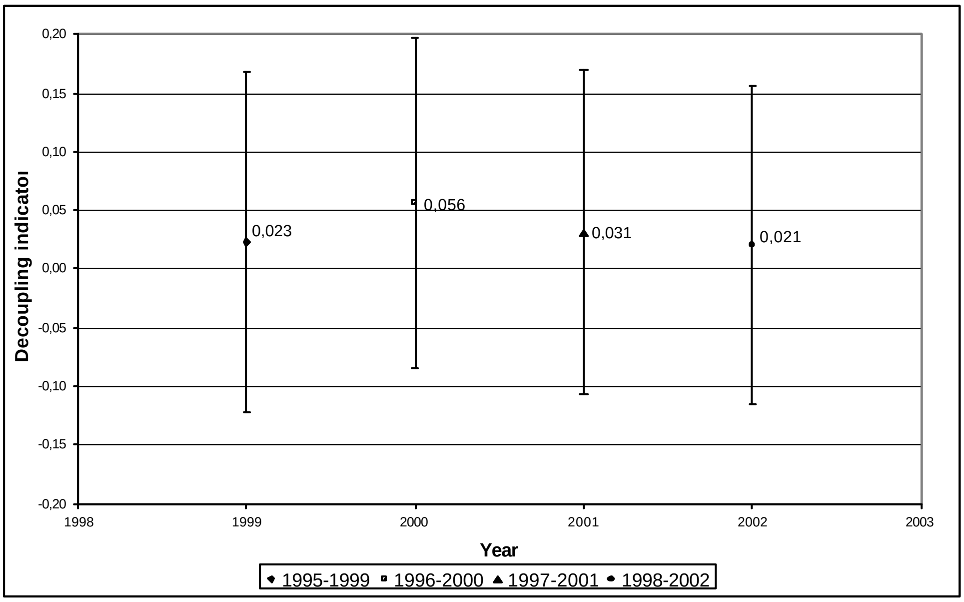
Figure 2.11: Trend analysis of non-hazardous enterprise waste generation per year in Flanders, for the period of 1995-2002



Also for the trend of non-hazardous waste volume, the inclusion of the year 1995 would distort the picture. For that reason, the 1995-2002 trends have been based on the data collected as of 1996 to and including 2002.

2.1.6.2 Decoupling indicator

Figure 2.12: Decoupling indicator: non-hazardous enterprise waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



The decoupling indicator for non-hazardous enterprise waste versus the GDP more or less equals the one for the total enterprise waste volume. The non-hazardous portion accounts for the major share of the total enterprise waste volume.

This does not apply to the decoupling indicator for hazardous enterprise waste, as discussed in paragraph 2.1.8.

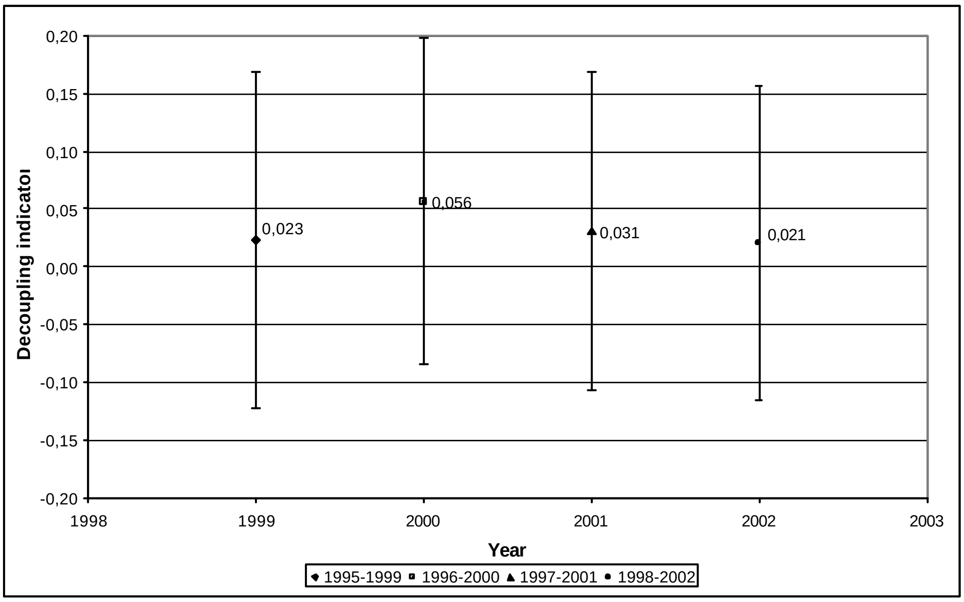
2.1.7 Generation of non-hazardous enterprise waste versus Gross Added Value

2.1.7.1 Trend analysis

(see 2.1.6.1)

2.1.7.2 Decoupling indicator

Figure 2.13: Decoupling indicator: non-hazardous enterprise waste generation versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002

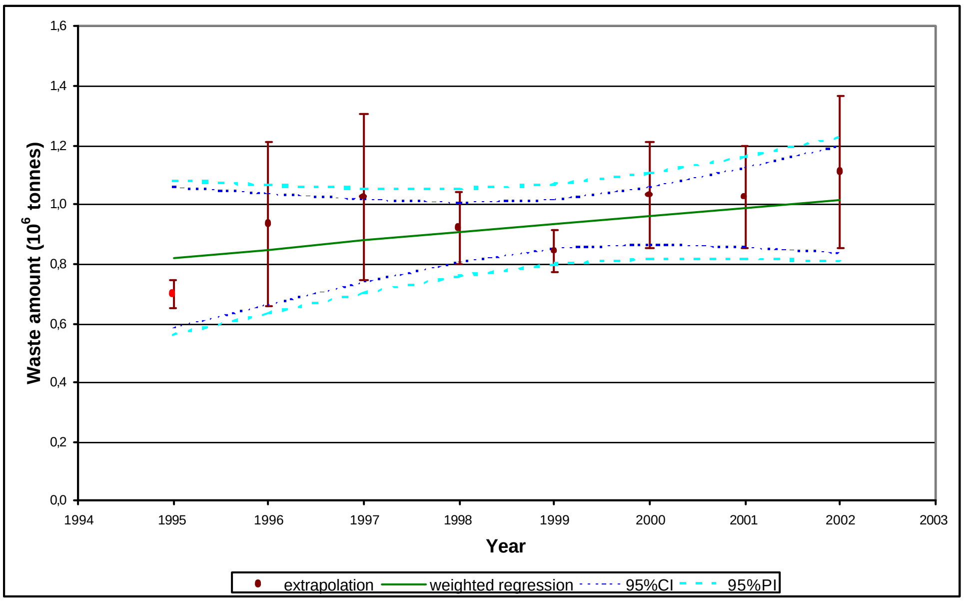


The decoupling indicators and the accompanying 95 % confidence intervals show the same picture for the GAV as for the GDP (paragraph 2.1.6.2).

2.1.8 Generation of hazardous enterprise waste versus Gross Domestic Product

2.1.8.1 Trend analysis

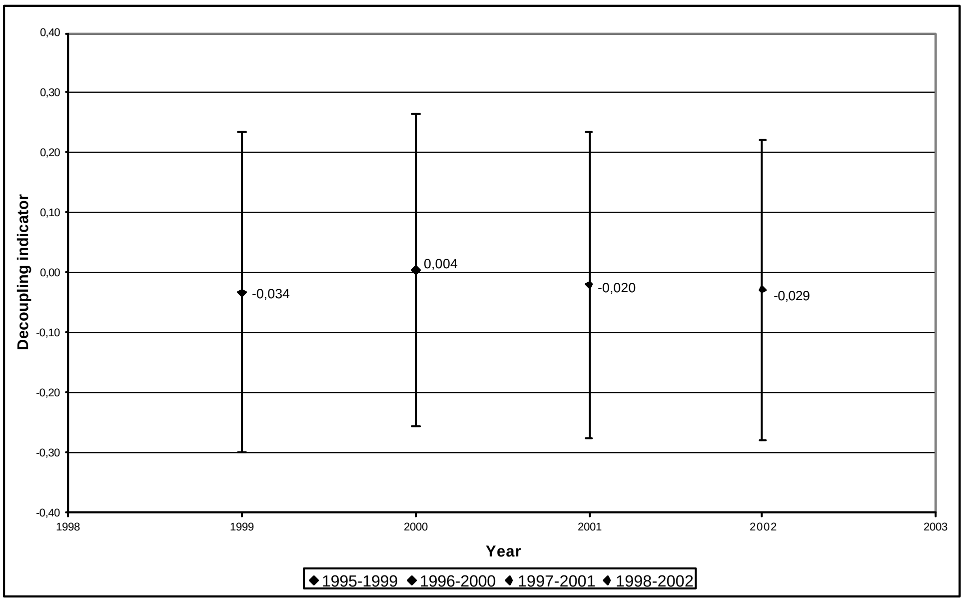
Figure 2.14: Trend analysis of hazardous enterprise waste generation per year in Flanders, for the period of 1995-2002



Also for hazardous waste, 1995 would present a distorted picture for the trend from 1995 to and including 2002. For that reason, the year 1995 has been excluded from the calculation.

2.1.8.2 Decoupling indicator

Figure 2.15: Decoupling indicator: hazardous enterprise waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



The decoupling indicator is negative for all time intervals, except for 1996-2000. This points to a negative decoupling that is, however, not significant.

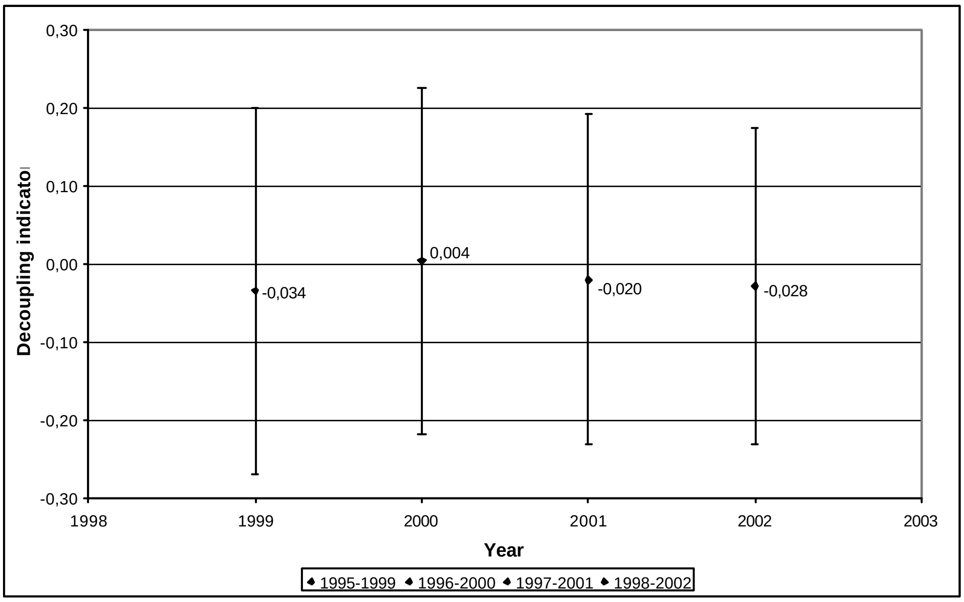
2.1.9 Generation of hazardous enterprise waste versus Gross Added Value

2.1.9.1 Trend analysis

(see 2.1.8.1)

2.1.9.2 Decoupling indicator

Figure 2.16: Decoupling indicator: hazardous enterprise waste generation versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



The decoupling indicators 'hazardous waste/GDP' and 'hazardous waste/GAV' do not show a trend towards a positive decoupling. The best estimated value for the decoupling indicators is negative, with the exception of those for 1996-2000, which makes the decoupling indicator approximately equal to zero.

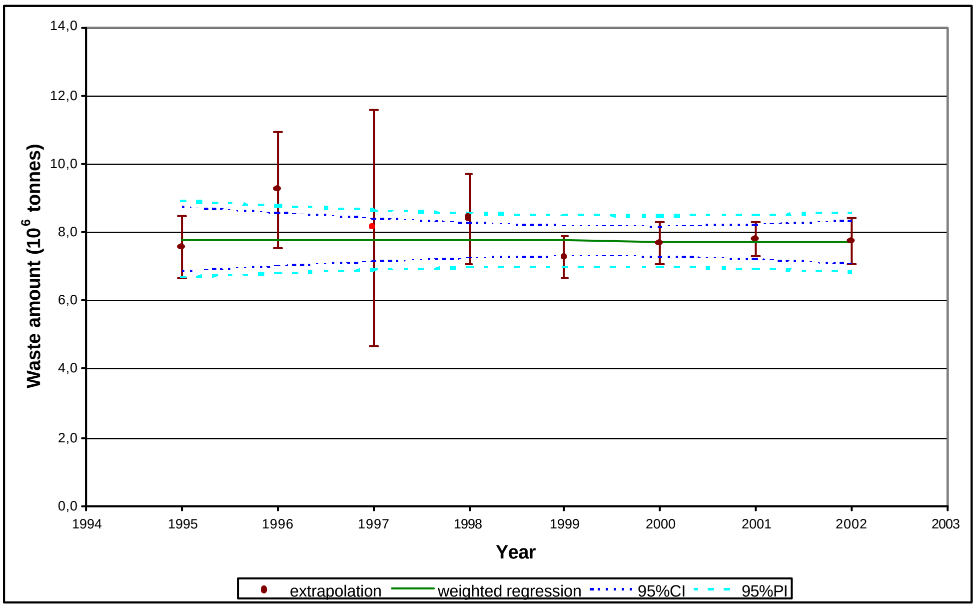
The hazardous enterprise waste displays a statistically non-demonstrable trend towards a sharper increase vis-à-vis the GDP or GAV than is the case for non-hazardous enterprise waste or the total volume of enterprise waste.

2.1.10 Generation of industrial waste versus Gross Added Value (NACE 10 to and including 37)

The OVAM defines industrial waste as the waste produced by all the enterprises with NACE-code 10 to and including 37, except for the waste treatment industry (secondary waste). Consequently, the definition the OVAM uses, deviates from the OECD-definiton as mentioned in the OECD-Eurostat Joint Questionnaire (NACE 15-37, including the secondary waste).

2.1.10.1 Trend analysis

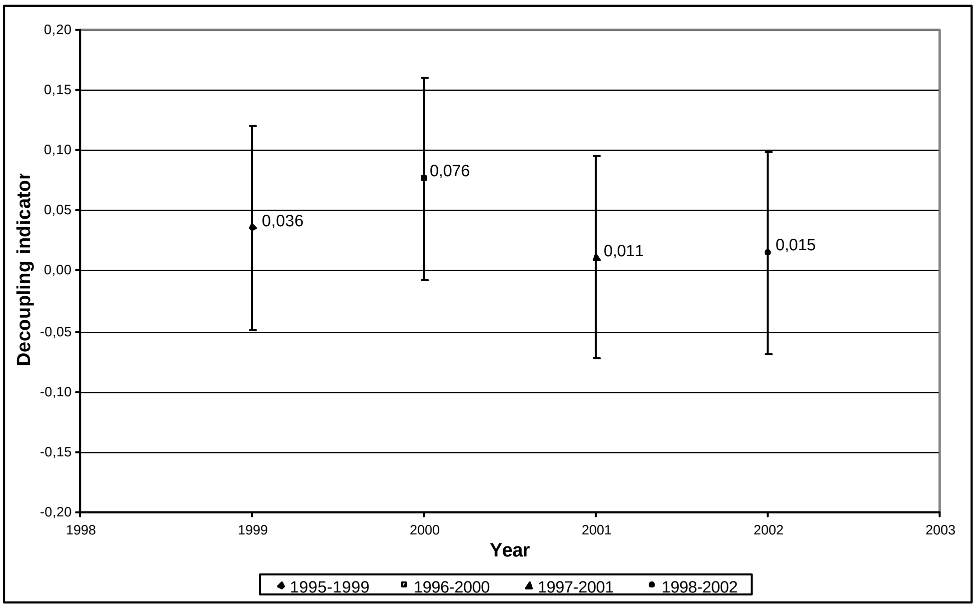
Figure 2.17: Trend analysis of the industrial waste generation per year in Flanders, for the period of 1995-2002



The year 1995 does not give a distorted picture of the trend from 1995 to and including 2002. For that reason, the year 1995 has been included in the calculation. The estimation of the waste generation in 1997 has got a too low quality. Therefore this year is excluded from the calculation of the weighted regression.

2.1.10.2 Decoupling indicator

Figure 2.18: Decoupling indicator: industrial waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002

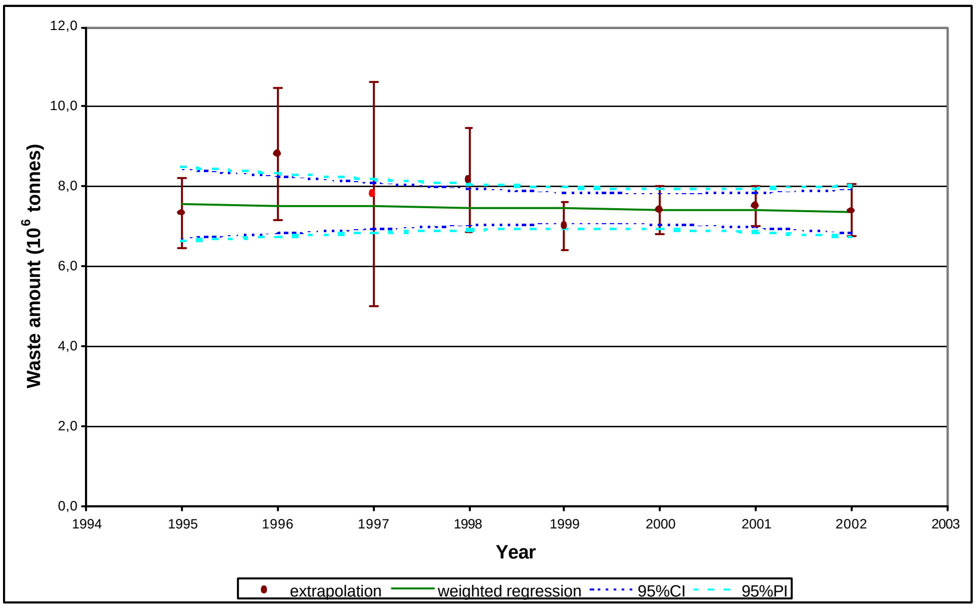


The decoupling indicator ‘industrial waste generation/GAV’ shows a trend towards a positive decoupling. The best estimated value for the decoupling indicators is positive. This points to a positive decoupling, but the decoupling is not significantly demonstrable.

2.1.11 Generation of non-hazardous industrial waste versus Gross Added Value (NACE 10 to and including 37)

2.1.11.1 Trend analysis

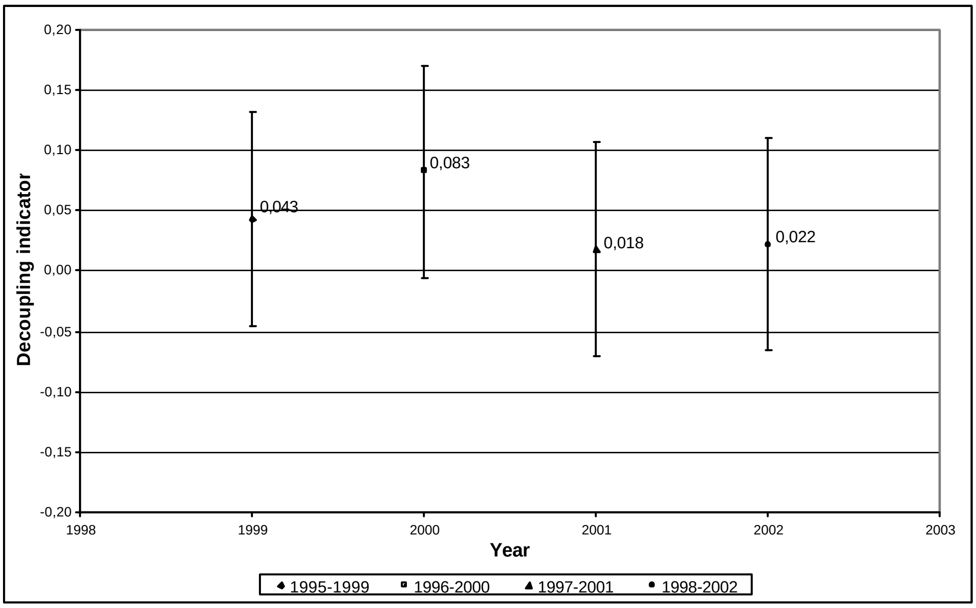
Figure 2.19: Trend analysis of the non-hazardous industrial waste generation per year in Flanders, for the period of 1995-2002



The non-hazardous industrial waste presents the same picture as the total industrial waste. Again, the year 1995 has been included in the calculation and the year 1997 is excluded from the calculation of the weighted regression.

2.1.11.2 Decoupling indicator

Figure 2.20: Decoupling indicator: non-hazardous industrial waste generation versus GDP in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



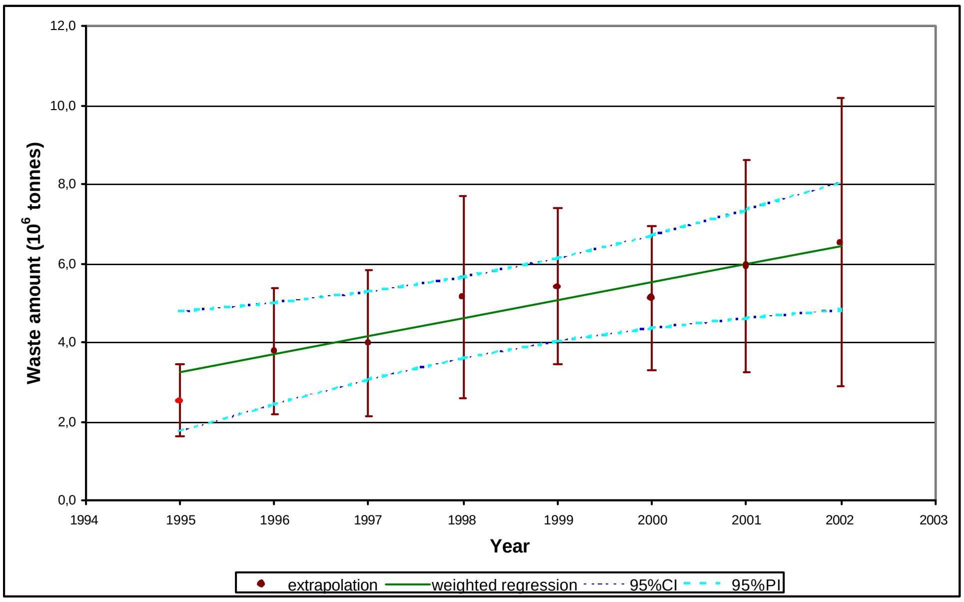
The decoupling indicator for non-hazardous industrial waste versus the GAV more or less equals the one for the total industrial waste volume. The non-hazardous portion accounts for the major share of the total industrial waste volume. Again, the decoupling indicator shows a trend towards a positive decoulping.

2.1.12 Generation of waste in the construction sector versus Gross Added Value (NACE 45.1 and 45.2)

The OECD proposes as indicator the ‘generation of construction and demolition waste/gross domestic product’. *(OECD (2004). Towards Waste Prevention Perfomance Indicators (ENV/EOPC/WGWPR/SE(2004)/FINAL). OECD. P.197)* In this document the decoupling indicator of all the waste generated by the construction sector is calculated, instead of only the construction and demolition waste. In 2002, the waste in the construction sector consisted for 75 % of the category construction and demolition waste product.

2.1.12.1 Trend analysis

Figure 2.21: Trend analysis waste generation in the construction sector per year in Flanders, for the period of 1995-2002



Here again, the year 1995 has not been included in the calculation of the trend, as it deviates sharply from the following years.

2.1.12.2 Graph relative to 1996

Figure 2.22: Simple Regression of GDP and Weighted Regression of the waste generation in the construction sector, Relative to 1996

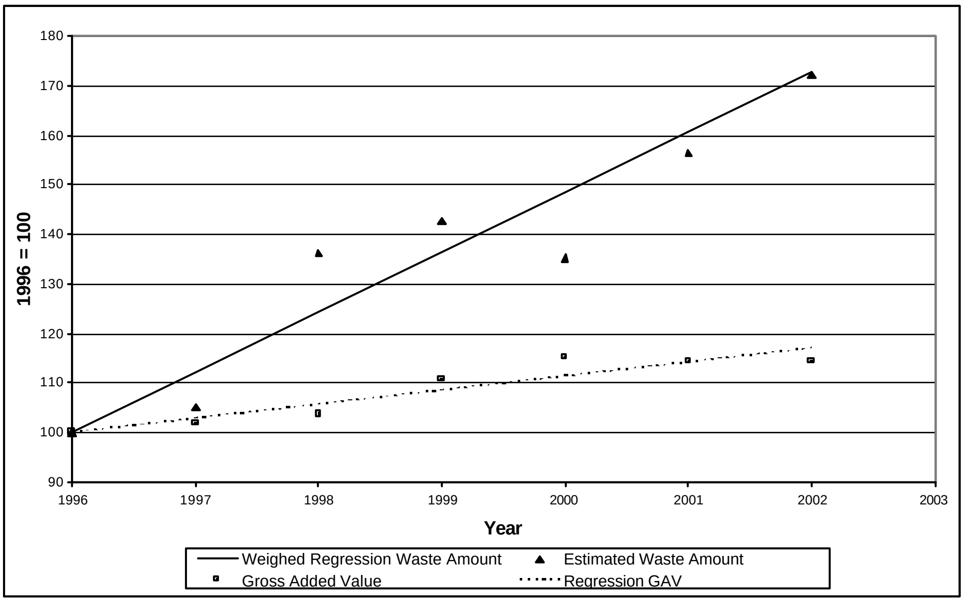
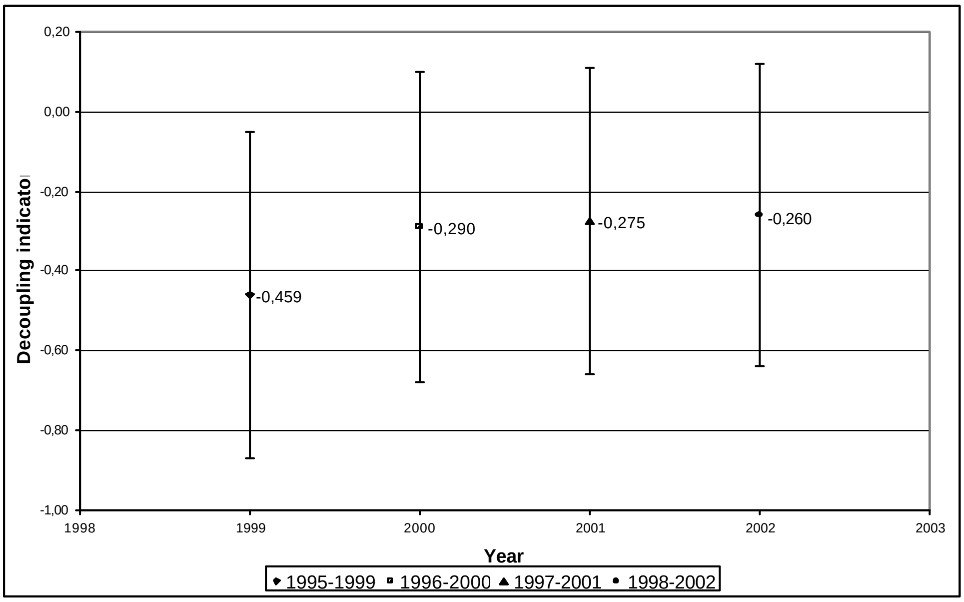


Figure 2.22 demonstrates that there is rather a trend towards negative decoupling: the weighted regression of the waste volume shows a much greater increase during the 1996-2002 period than the Gross Added Value.

2.1.12.3 Decoupling indicator

Figure 2.23: Decoupling indicator: waste generation in the construction sector versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



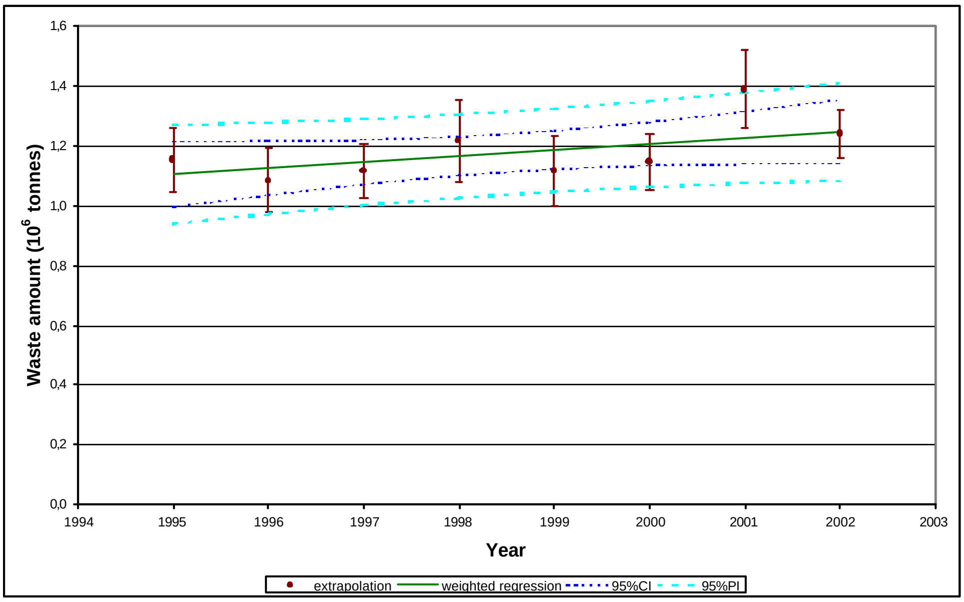
Also from the best estimate of the decoupling indicator it appears that there is rather a trend towards a negative decoupling, as this best estimate of the decoupling indicator is negative and the 95 % confidence interval lies largely in the negative zone. The 95 % confidence interval of the decoupling indicator in 1999 vis-à-vis the year 1995 is even completely negative, which makes the negative decoupling statistically significant. It is thus possible to state with 95 % certainty that the increase in construction and demolition waste (which, according to the OECD definition, corresponds to all of the waste from the construction sector) in 1999 is larger vis-à-vis 1995 than the growth of the GAV generated by this sector over the same time interval.

The size of the decoupling indicator increases, which points out that the difference in growth in the GAV and the waste generation in the construction sector is declining. The size of the negative decoupling evolves to a value closer to zero.

2.1.13 Generation of waste in the chemical sector versus Gross Added Value

2.1.13.1 Trend analysis

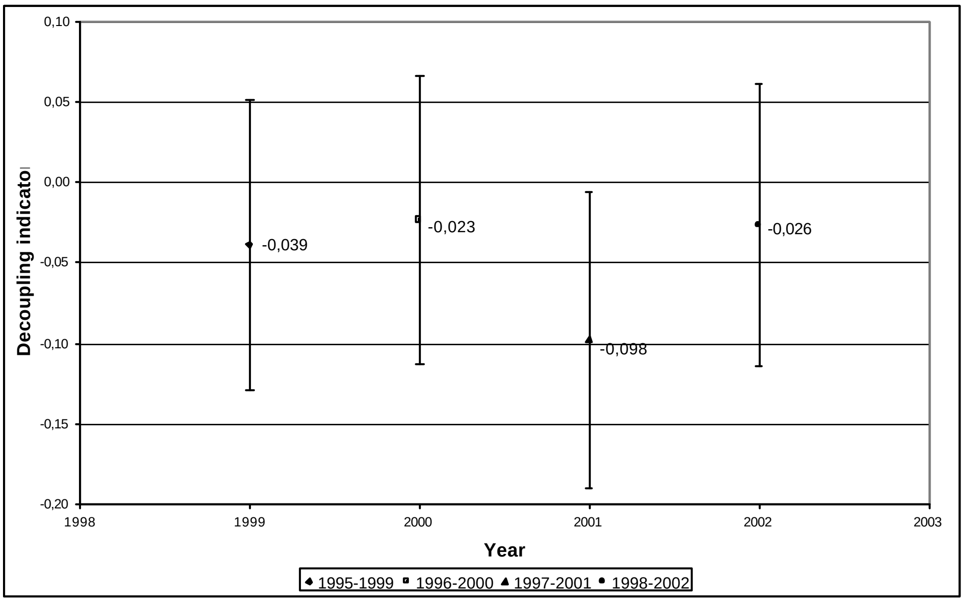
Figure 2.24: Trend analysis of waste generation in the chemical sector, per year in Flanders, for the period of 1995-2002



The waste estimate for the year 1995 in the chemical sector does not give a distorted picture of the trend from 1995 to and including 2002. For that reason, the year 1995 was included here in the calculation of the trend.

2.1.13.2 Decoupling indicator

Figure 2.25: Decoupling indicator: waste generation in the chemical sector versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002

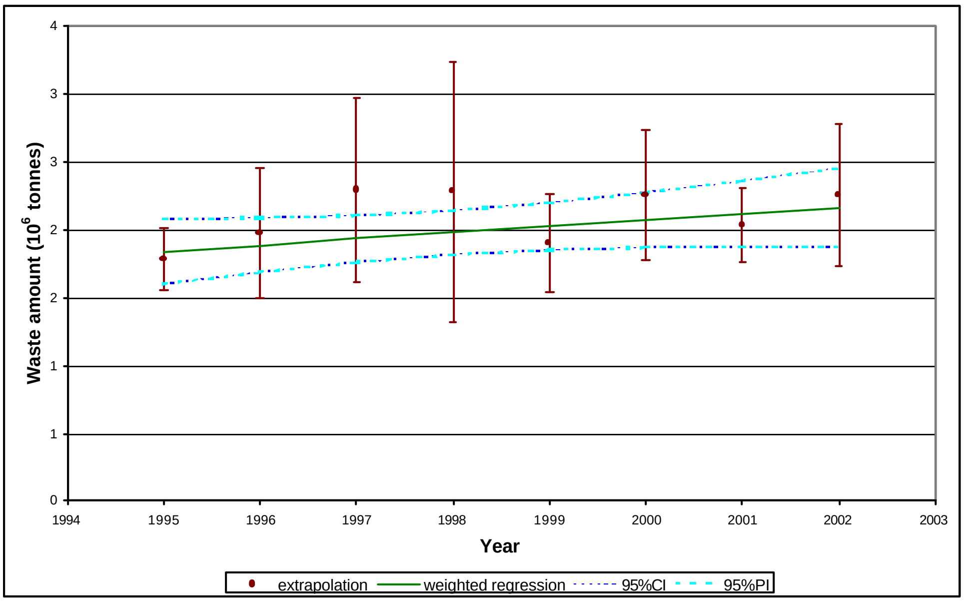


Notwithstanding the prevention efforts by the chemical industry, this sector shows no decoupling vis-à-vis the GAV it generates. According to the 2001 indicator for the period 1997-2001, there is 95 % reliability of a negative decoupling. The indicators for the other time intervals show the same picture but produce no exception. There is thus rather a trend towards a negative decoupling, meaning that the waste generation in this sector is increasing more sharply than the GAV.

2.1.14 Generation of waste in the food industry versus Gross Added Value

2.1.14.1 Trend analysis

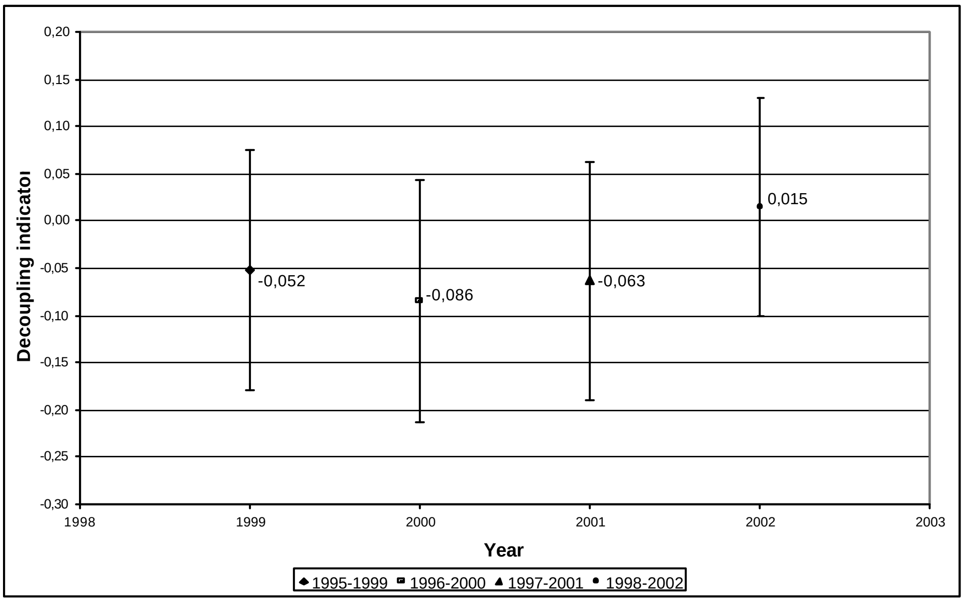
Figure 2.26: Trend analysis of waste generation in the food industry, per year in Flanders, for the period of 1995-2002



The waste generation in the food sector in 1995 is in line with the waste generation during the years following and is thus included in the calculation.

2.1.14.2 Decoupling indicator

Figure 2.27: Decoupling indicator: waste generation in the food industry versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002

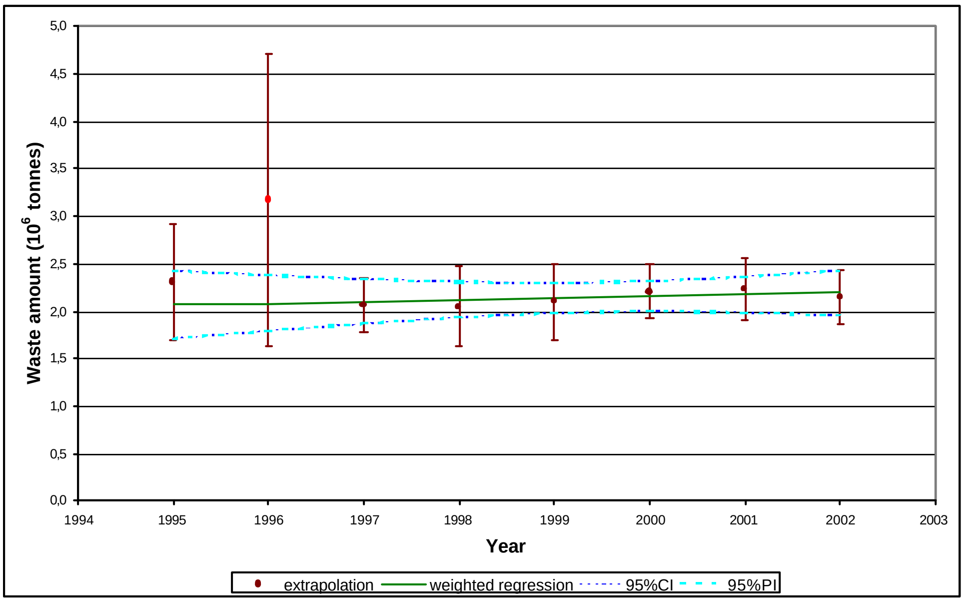


The negative decoupling is not significant, but there is nonetheless a stable and consistent picture over the time periods, except in 2002. Further analysis is needed to demonstrate whether there is a shifting towards positive decoupling in this sector.

2.1.15 Generation of waste in the metal industry versus Gross Added Value

2.1.15.1 Trend analysis

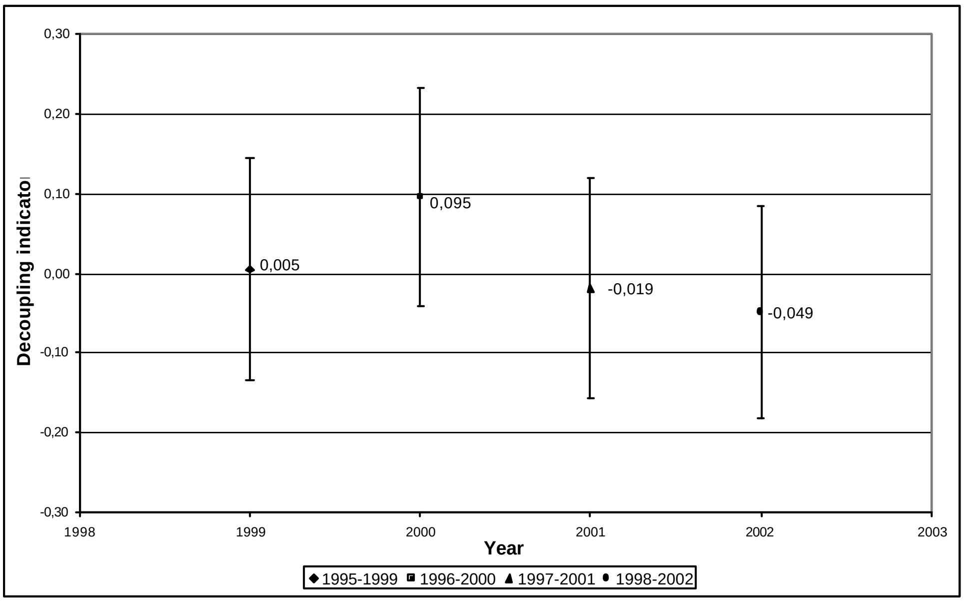
Figure 2.28: Trend analysis of waste generation in the metal industry, per year in Flanders, for the period of 1995-2002



The year 1996 is not at all reliable. For that reason, the waste generation for that year has not been included in the calculation of the trend. In contrast, the year 1995 has been included here, as for the metal industry this year does not give a distorted picture of the trend over the period 1995-2002.

2.1.15.2 Decoupling indicator

Figure 2.29: Decoupling indicator: waste generation in the metal industry versus GAV in Flanders, for the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002



The decoupling indicator for 2000 vis-à-vis the reference year 1996 displays a strong trend towards positive decoupling, even though the decoupling cannot be demonstrated with 95 % certainty. The other indicators are approximately equal to zero (1995-1999), which means that the GAV and the waste generation keep an even pace in their increase over the period 1995-1999 or tend rather towards negative decoupling.

2.1.16 General conclusion direct pressure indicators

Often it is statistically impossible to determine with any degree of certainty whether there is a decoupling between the waste generation and the economic factors GDP and GAV. The reasons for this are many:

- the estimates of the waste generation figures are not accurate enough and the confidence intervals are too broad to be able to render a defined picture. When carrying out the sample survey, one strives for a coefficient of variation of 25 % per stratum. This is sufficient to generate reliable statistics for the most relevant questions concerning the waste policy. Apparently, a coefficient of variation of 25 % is not sufficient to show a significant decoupling versus the

GDP or GAV. A higher reliability, e.g. by striving for a coefficient of variation of 10 %, is only possible provided that serious financial efforts are taken.

- the trends are calculated over a short period of seven years, but longer time series are not yet available at this moment. Longer time series will become available in the future and it will be possible then to more often demonstrate positive or negative decoupling with statistical certainty.

A weighted regression is calculated on the basis of the annually estimated waste generation, taking into account the reliability of the annual estimates and paired observations. The quantities of waste determined through this regression line are used for estimating the decoupling indicator. The confidence intervals of this weighted regression line form the basis for the calculation of the decoupling indicators and the accompanying confidence intervals. Per trend line, four indicators are being calculated, over the periods 1995-1999, 1996-2000, 1997-2001 and 1998-2002.

Because of the limited reliability of the trend lines, the confidence intervals of the decoupling indicators will also be extensive. In addition, it is so that the best estimate of the decoupling indicator is often of very low negative or positive value. To be able to state with certainty that there exists a decoupling, the evolutions of the waste generation, on the one hand, and of the GDP and the GAV, on the other, will have to be separated more in the future.

Nonetheless, it is notable how the calculated estimations for the decoupling indicators offer a consistent picture about the different time series considered. Often, they are all negative, which points to a negative decoupling, or all positive, which shows a positive decoupling.

The frequency of negative decoupling is a striking fact. The purpose of prevention is to reduce the mountain of waste in absolute values. To calculate this, the growth of this mountain must be slowed to relative positive decoupling, subsequently to be turned into absolute positive decoupling. In this regard, it may be accepted in general that a lot of work remains in this area and that the current efforts are not yet producing demonstrable decoupling. The non-statistically significant demonstration of relative decoupling is a strong indicator of the need for concerted prevention measures.

2.2 Direct response indicators

(De Baere, P. (2004). Resultaten bedrijfsenquête eco-efficiëntie 2004. OVAM, Mechelen. P. 21)

(De Groof, M., Smeets, K., Umans, K., Van Acoleyen, M. (2003). Preventie van bedrijfsafvalstoffen. Berekening en analyse van kwantitatieve en kwalitatieve indicatoren. OVAM, Mechelen. P. 112)

2.2.1 Introduction

An indicator was developed to monitor the mentality of Flemish enterprises vis-à-vis Eco-Efficiency (EE). This indicator is based on the indicator that was used in the Netherlands to evaluate the project 'Producing Cleaner'. In the communication with the enterprises, the OVAM uses the term Eco-Efficiency to bundle prevention measures of various natures in effect within the organisation. EE means rendering processes and products more environment-friendly, reusing waste products and, in general, steering the economy (both supply and demand) in an environment-friendly direction. EE offers both economic and ecological benefits for the organisations.

In the spring of 2004, the OVAM via its website launched a survey directed towards all enterprises in Flanders for the purpose of gathering information on their attitude versus EE. This survey was meant to elaborate further on a qualitative EE indicator that would answer the question ‘How efficiently is the public administration dealing with Eco-Efficiency?’. The OVAM wants to measure the efficiency of her EE policy by taking into account possible changes in the mentality enterprises vis-à-vis EE.

Since the enterprises had to fill in the survey via the website, only the enterprises that have access to the internet were able to answer it. This can give a distorted picture of the results.

Based on the responses, the enterprises were categorised in phases: the Non-interest, the Interest, the Implementation, and the Routinizing phase. This categorisation used a phase-classification key. The scores obtained on a number of key questions from the survey were added up. Per key question, each organisation was placed in one of the phases. Ultimately, the organisation was classified in the phase where it obtained the highest score, based on the sum of the scores per phase. The classification in phases is an arbitrary one and in itself is without value. The indicator has meaning only when follow-up measurements are carried out that give a picture of the evolution of the indicator.

Aside from the key questions, the survey further asked about attitude, behaviour, and interest enterprises towards and in EE.

2.2.2 Theoretical background of the classification in phases

The EE phase model starts from the premise that enterprises pass through four phases to reach the point where the environment becomes an integral segment of the operation. The four phases are based on the principle taken from behavioural sciences, which holds we are first unconsciously-incapable (one commits an error but is unaware of it), then consciously-incapable (one is aware of making a mistake but the erroneous action is continued nonetheless), next consciously competent (one is aware of how to do something and does it well), and, finally, unconsciously-competent (one acts correctly without thinking about it).

The four phases in the EE model are defined as follows:

- Non-interest
  - The enterprise is not interested in EE and does not consider it important;
  - There is little understanding of the impact of environmental problems on the enterprise;
  - There is little or no knowledge of government environmental policy and measures and the organisation is not geared to becoming engaged in that area;
  - There is little insight into the measures that are needed to participate in EE;
  - The enterprise has taken few or no concrete measures with respect to EE and is practically without any plans for the future;
  - The enterprise does not see concrete benefits in EE.

- Interest
    - The organisation is interested in EE and considers it important to a degree;
    - It possesses a global insight into its own environmental problems;
    - It is investigating possibilities for participating in EE (measures, information sources, financial instruments);
    - The enterprise has taken few or no measures and drawn up only a limited number of concrete plans for the future;
    - The organisation understands that EE can bring a number of benefits.
- Implementation
    - The enterprise is interested in EE and considers it important;
    - It has gained insight into its own environmental problem;
    - It has gained knowledge about EE and intends to proceed farther in this direction;
    - A number of concrete measures have already been implemented;
    - The enterprise intends to implement (more) measures of technical and organisational nature in the future;
    - The enterprise expects EE to render benefits.
- Routinizing
    - The enterprise is interested in EE, considers it important, and looks upon it as a permanent and integral part of its operations;
    - It has awareness of what is happening within the organisation in matters of the environment;
    - It possesses good insight into the possibilities of elaborating EE within the organisation;

- A great number of concrete measures have already been taken and there exist concrete plans for further measures in the future;
- The organisation has already experienced the benefits delivered by EE.

This phase model offers a theoretical representation of the practical aspects. However, the reality is that an organisation does not display only characteristics of one given phase. Many enterprises range across the characteristics of the different phases.

2.2.3 Organisation of the survey

The announcement of the enterprise survey Eco-Efficiency occurred parallel with the communication regarding the waste reporting of 2004. The brochure that accompanied the waste reporting form made reference to the website and contained a request for every enterprise to participate in the survey. This reporting form was sent to every enterprise known to the OVAM. The brochure was mailed at the end of 2003.

The response to the EE was disappointingly low. At the beginning of February 2004, only 100 organisations (out of a total of 30 000) had completed the survey via the website. In consequence, in the course of March 2004, a reminder was sent out to all enterprises with 100 or more employees. This involved reminding some 2000 enterprises.

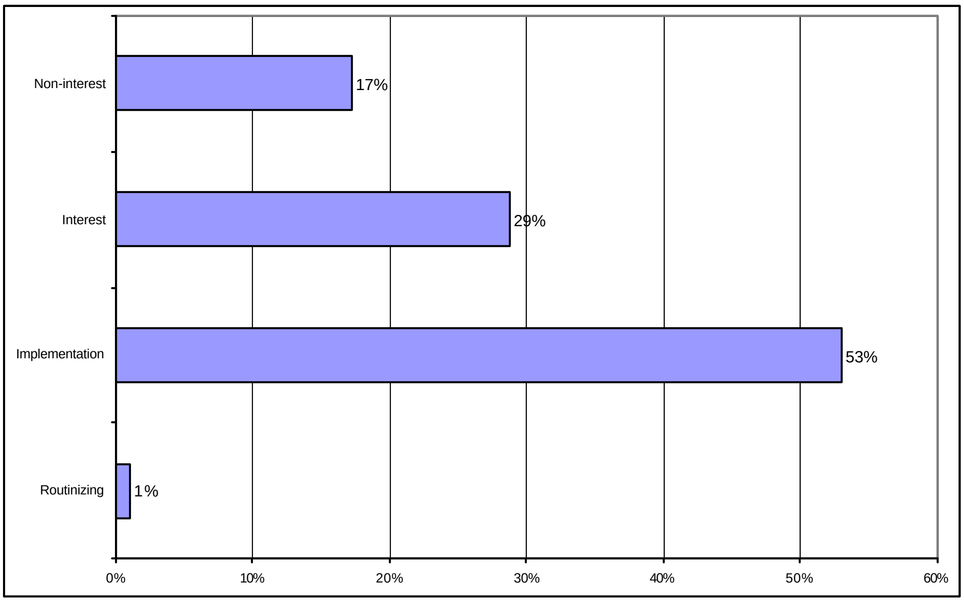
The survey was closed at the beginning of May 2004 and removed from the website. At that moment, 918 enterprises had completed the survey form. Of these, 725 organisations belonged to the group of 100 employees or more. When processing the results, only the responses from these 725 enterprises employing 100 or more workers will be counted because of the higher response.

When evaluating the results, one has to take into account that only the answers of the enterprises with 100 or more employees are used, since these enterprises are more likely to implement EE than the smaller ones.

2.2.4 Classification in phases based on the mentality vis-à-vis eco-efficiency

2.2.4.1 Entire economy

Figure 2.30: Direct response indicator: classification in phases (eco-efficiency)



From the classification in phases it appears that 53 % of the enterprises are found in the Implementation or in the Routinizing phase. These are active organisations that on their own initiative go searching for information and are taking concrete environmental measures. 1 % in this group of organisations have already firmly integrated EE in their operations. A minority of the enterprises (17 %) is not interested in EE. At this point, it should be noted that non-interested enterprises are generally less inclined to respond to the survey. In reality, the number of organisations in the non-interest phase thus lies higher.

2.2.4.2 Chemical sector and food sector

Figure 2.31: Classification in phases: chemical sector (NACE 24)

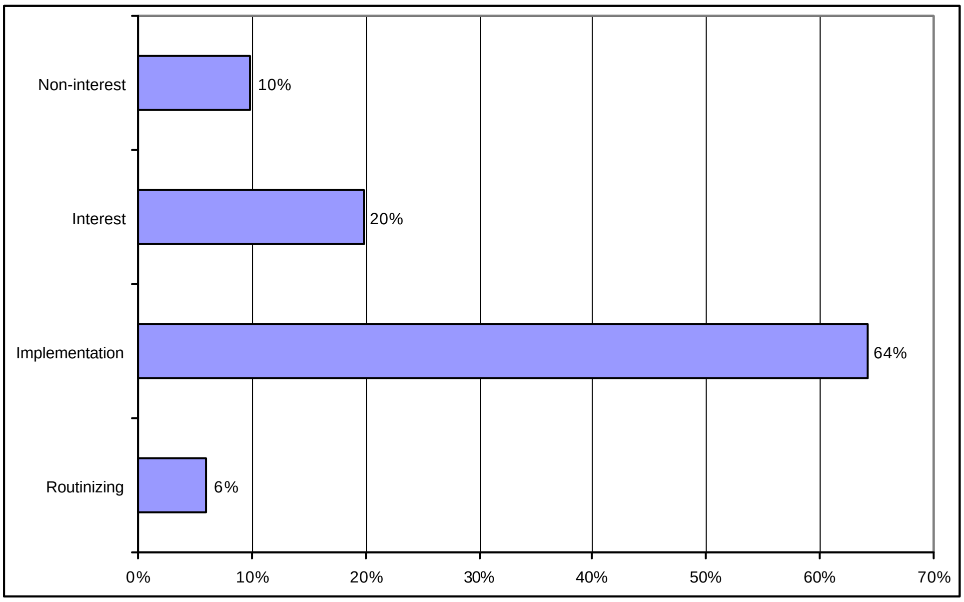
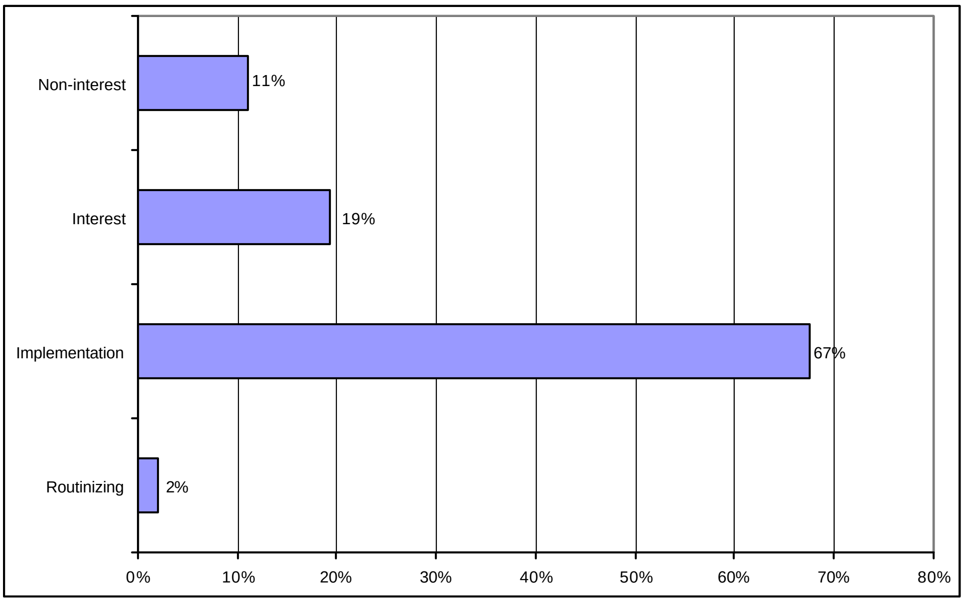


Figure 2.32: Classification in phases: food industry (NACE 14)



Based on the results of the survey, the food sector and the chemical sector were examined separately. The reason for this is the high response rate to the survey by these sectors. In addition, the decoupling indicators for these sectors are being examined in paragraph 2.1.

The differences in classification in phases between the surveyed sectors and the whole of the economy are small. Because of the low response to the survey and these minimal distinctions, no conclusions can be drawn regarding differences in the mentality versus EE amongst the various sectors.

2.2.5 General conclusion direct response indicators

The classification in phases is purely arbitrary in the sense that not many conclusions can be drawn from this stratification and that the demarcation between the various phases is not a rigid one. The classification in phases will only fully prove its usefulness if in the future follow-up surveys should be organized. That way, it will become possible to measure the effect of the current prevention policy on the interest, the attitude, and the behaviour of the enterprises. A positive effect will be achieved when more enterprises come to be situated in the Implementation and the Routinizing phases and fewer in the Non-interest and Interest phases.

3 Indicators for the prevention of municipal waste

(Putseys, L., De Roover, G. (2003). Indicatoren voor de preventie van huishoudelijke afvalstoffen in Vlaanderen. OVAM, Mechelen. P. 47)

3.1 Introduction

Already in 2002, a set of indicators was drawn up for the prevention of municipal waste, subsequently to be adapted in 2003. This chapter describes the general approach and the problems that emerged in the search for suitable indicators. Finally, the selected indicators are introduced. Thus, this set of indicators has not specifically been examined with the OECD test program in mind, but it does nevertheless correspond well with the indicators for municipal waste as proposed by the OECD.

3.2 Justification of the choice of indicators

A list of possible indicators, based on an understanding of factors, events and actions, was tested against the following criteria:

- Do the data exist for the calculation?
- Can time series be created and is continuation guaranteed?
- Is the indicator ‘valid’, in other words is the relationship between what we measure and the preventive effect aimed for sufficiently stable and are possible errors acceptable?
- Are the possible ‘interfering factors’ known so that the interpretation can be adjusted?

The result is a set which consists of two component parts:

1. A series of ‘pressure indicators’ which indicates how waste production progressed and from which it is possible to deduce how this waste production is influenced by waste prevention.
2. A series of ‘response indicators’ which indicates how consumers, distributors and producers take particular actions.

The **pressure indicators** are based on data on the collection of municipal waste. A first indicator gives the total quantity of municipal waste per head of population. This indicator takes account of the external factor of demographics, but not of economic factors (economic climate, income growth and so on). A second indicator has therefore been developed: waste production is linked to the spending of families. A view of the progression of this must allow an assumption to be made as to whether more or less waste arises over the years per unit of consumed product (by families). This indicator allows it to be examined whether there is a 'disconnection' between economic growth and the growth of the waste mountain.

The series of **response indicators** can provide a picture of the actions of the local councils, consumers, distributors or producers as a result of the policy. These indicators are:

- Paper waste: number of no-advertising stickers in use (consumer side);
- Paper waste: print run of printed advertising material (producer side);
- Re-use: purchasing in used-goods depots (consumer side);
- Home composting: number of compost bins in use (consumer side);
- Percentage of reusable municipal packaging (consumer side);
- Packaging: packaging per consumption unit (producer side).

It is clear that an indicator cannot be separately developed for all municipal waste fractions (e.g. metal waste, textiles etc.). The set of indicators for this reason is certainly not to be regarded as a reflection of the composition of municipal wastes. Certain fractions have two indicators (paper, containers), while others as yet do not have any. This does not pose a problem provided it is borne in mind that these are indications, and not a representation of the actual total waste prevention attained.

The set consists of dependent variables. All the 'response indicators' are in a certain relationship to the 'pressure indicators'. The degree to which no-advertising stickers, for example, are used affects the eventual quantity of waste per head of Flemish population.

3.3 Direct pressure indicators

3.3.1 Municipal waste generation/head of population

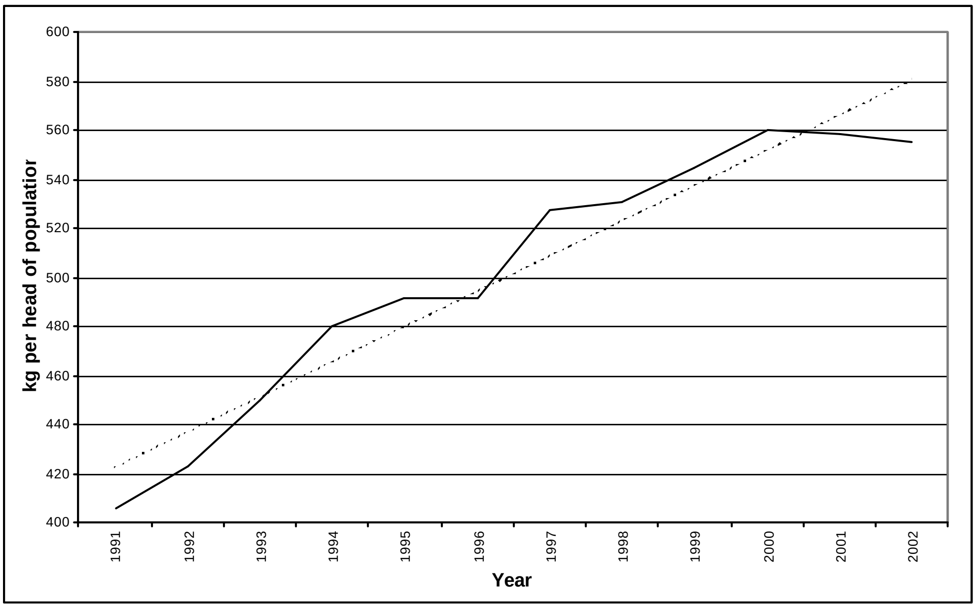
Since 1991, the OVAM has been systematically collecting inventoried quantities of collected municipal waste per head of population in the Flemish Region.

The municipalities and intermunicipal bodies have to make the data available to the OVAM annually. Thanks to correct fulfilment of this obligation by the 308 Flemish municipalities, the OVAM has very complete data on the total amount of municipal waste collected by or on behalf of the municipalities.

The data are divided into the various fractions. The four large groups are: selectively collected municipal waste, domestic refuse, bulky refuse and municipal refuse. Within the selectively collected wastes there are the various sub-fractions (including glass, metal, paper and cardboard, construction and demolition waste, green waste etc.).

This indicator provides the following picture.

Figure 3.1: Progression in quantity of municipal waste per head of Flemish population



A clear rising trend has been noticeable since 1991. As of 2000, stagnation occurs

and there is even a slight decline in the total volume of municipal waste per resident, although this latter development is not pronounced.
In interpreting, account must be taken of the characteristic features of the data. Firstly fluctuations may be attributable to tightened municipal policy which no longer allows waste from retailing, the services sector and hotels, restaurants and catering to enter the municipal collection circuit from a certain time. Such a fluctuation has nothing to do with any preventive actions. A correction is possible if it becomes clear what proportion these fractions account for in the total. Unfortunately this correction factor is not available for past years.

Another significant factor which causes fluctuations in the data is the improved registration by municipalities over time. For this reason too, great care must be taken with fluctuations in this indicator for waste prevention.

3.3.2 Municipal waste generation/private final consumption

The total quantity of municipal waste is an indicator to represent the effect of waste prevention. However, this quantity includes a few waste fractions for which no specific prevention policy has been conducted, or which are influenced by external factors which have a greater impact. One example of an external factor is obviously economic growth.

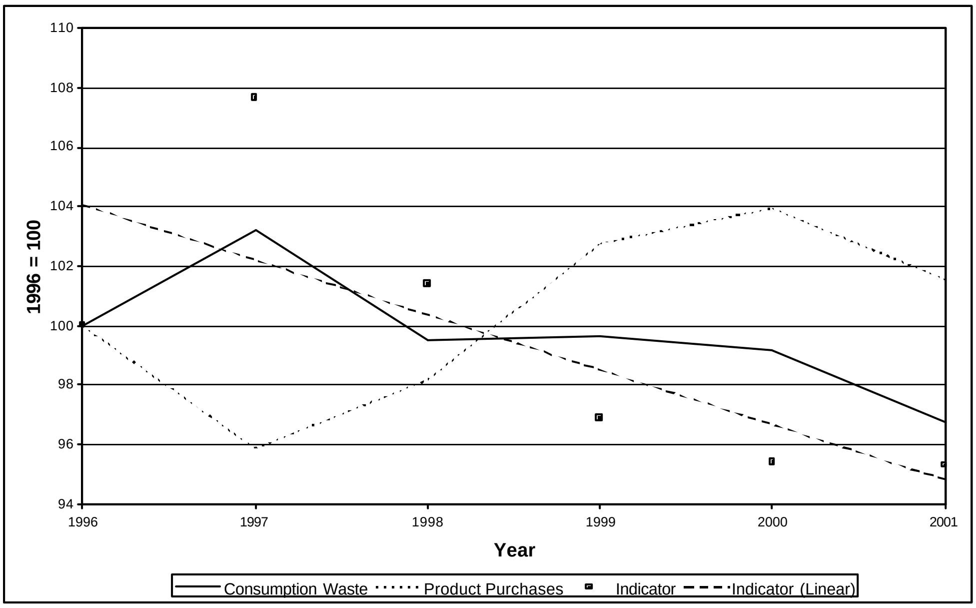
In order to eliminate the latter, the waste generation per head of Flemish population is related to a unit of economic activity. The GDP is usually used for this purpose. The drawback, however, is that GDP is not just an indicator of the level of family spending but also takes into account the expenditure of government and businesses.

It is recommended that an indicator should be used which demonstrates family spending even more correctly. In the National Accounts, GDP is split and the category of ‘private consumption spending’ can be used separately if appropriate. The drawback is that all spending is included, including spending on activities which engender waste at the consumer (for instance purchasing of services, non-profit association activities). The National Statistical Institute of Belgium (NIS) collects such data through the municipal budget surveys. In this way it is possible to take account only of those product categories which will actually have an effect on waste production in families. All the services are consequently filtered out. What remains are products which the consumer acquires and through waste logically arises at home.

The numerator in our approach (quantities of waste) has also been filtered out. Only those waste fractions which are normally associated with regular consumption have thus been taken into account. The intention is to eliminate these fractions when there is a high likelihood that the extent of the fraction is mainly determined by factors other than the pattern of consumption of the consumer (e.g. green waste, construction and demolition waste).

The economic statistics are usable from 1996. The indicator shows the following progression:

Figure 3.2: Progression of the indicator for waste per consumption unit



In contrast to the indicator of ‘waste per head of population’, the general trend for this selection of trends is downward.

There is an upward trend with regard to consumption itself (‘product purchases’). This is not surprising in view of economic developments in general. Relating the quantities to spending provides an indicator which indicates how much waste arises per unit of consumption. As the denominator (‘product purchases’) shows an upward trend, and the numerator (‘consumption waste’) a downward trend, the result sharply downward, with a distinct dip for 1997.

This appears, however, to be an indication of a certain degree of waste prevention: with similar spending over several years (unit of consumption) less waste also arises. This does not say anything about the causes: these may be both on the consumption side (people note the waste in purchases) and on the production side (less input of materials per unit of packaging, more in return …).

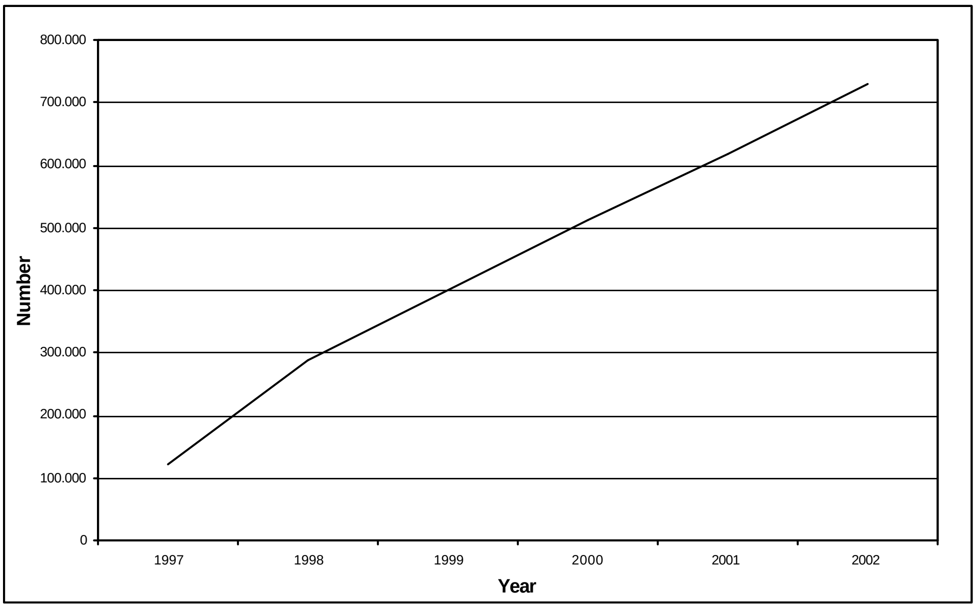
3.4 Direct response indicators

3.4.1 Number of no-advertising stickers handed out

The municipalities have been offering their population no-advertising stickers since the mid-nineties. This has the result that publishers can reduce their print run for unaddressed advertising and/or regional newspapers on the basis of the number of stickers. As a result, less paper waste is eventually produced.

The total numbers of stickers handed out in Flanders provides the following picture for the period 1997-2001.

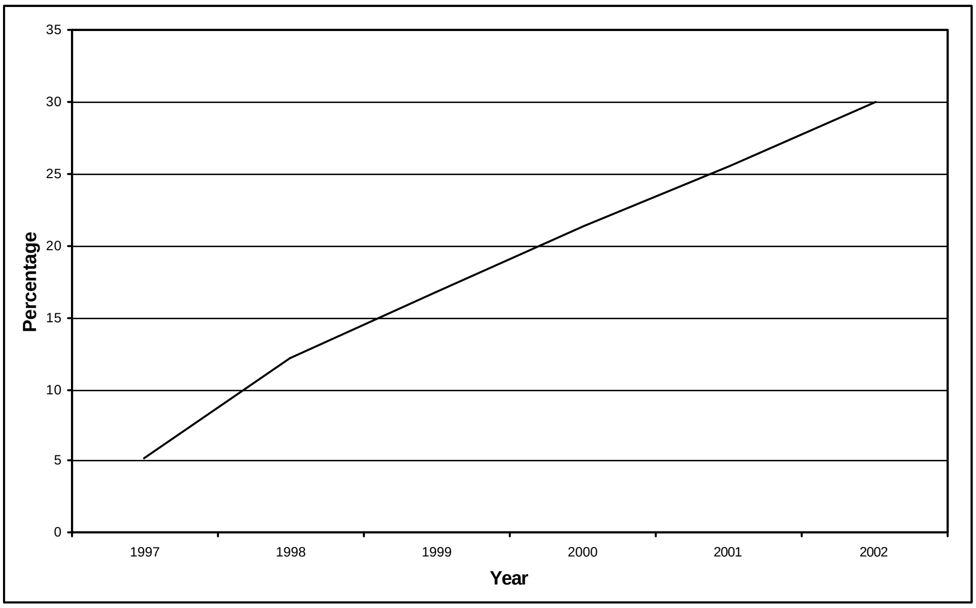
Figure 3.3: Number of no-advertising stickers distributed in Flanders (cumulative)



The number of stickers handed out rises from 1997 to 2002, and this trend appears to be continuing into the future.

The indicator of ‘number of families with a no-advertising sticker in relation to the total number of families in Flanders’ (expressed in %) provides the following picture.

Figure 3.4: Estimated number of Flemish families with a no-advertising sticker



It can be seen from this graph that in 2002 a maximum of 29,9 % of Flemish families already received a no-advertising sticker. The difference between the stickers handed out and stickers actually used is very important. Stickers may no longer be in use after a certain time, and stickers are not only acquired through the local authority. The two differences (over-estimate and under-estimate) will probably not cancel each other out. An estimate of necessary corrections is not possible at present on the basis of available data.

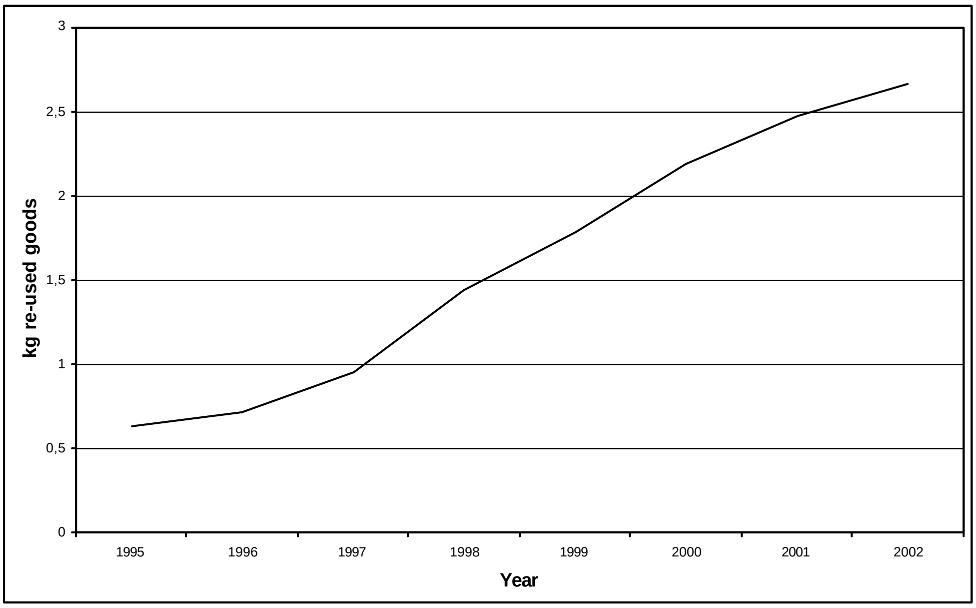
3.4.2 Amount of re-used goods sold

Re-use activities, more specifically the re-use of goods by offering them for sale and buying them at used-goods depots, prevent waste. Since 1994, the used-goods depots have themselves kept a record of the ‘number of kilograms of goods sold per head of population served’.

This indicator consequently provides a very good picture of the extent to which more or less waste prevention is done in the Flemish Region by re-using goods through used-goods depots.

The progression is as follows.

Figure 3.5: Progression of re-used goods sold per head of population served in Flanders



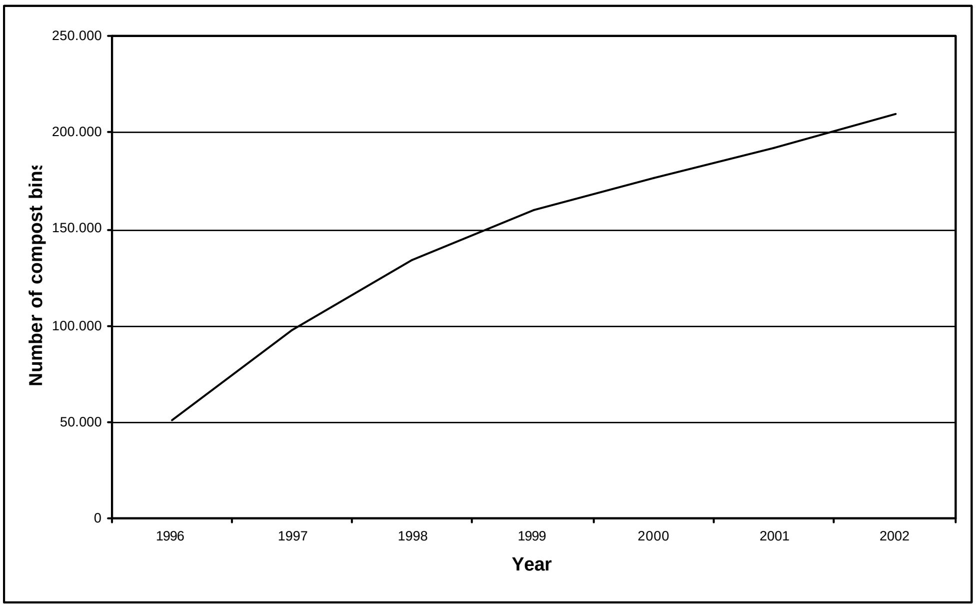
The indicator provides a fine upward trend. The annual rise is decreasing in relative terms, which according to the experts was to be expected.

3.4.3 Number of compost bins in use

Public awareness creation among the Flemish population on the home composting of biowaste was started in the early nineties. This resulted in the purchase of compost bins being subsidised by the Flemish Government. The municipalities and intermunicipal bodies have notified the OVAM of the number of compost bins sold since the mid-nineties through a questionnaire-based survey.

The total numbers of compost bins sold in Flanders provide the following picture for the period 1997-2002.

Figure 3.6: Progression of the number of compost bins in use by Flemish families (estimate)

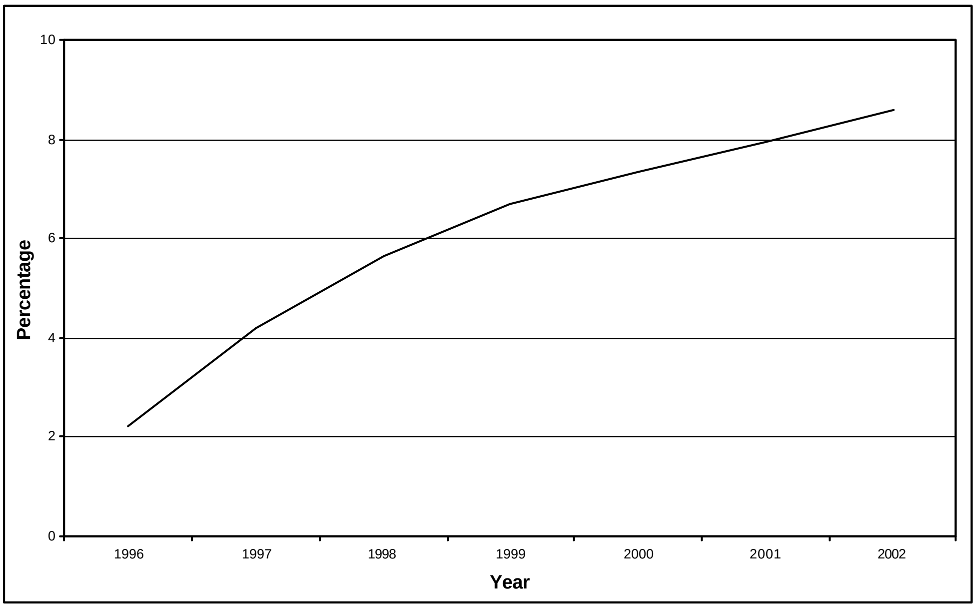


The numbers of compost bins sold were corrected for ‘dropouts’. Research shows that on average 10 % of home composters drop out, but that at least 10 % are also thinking about starting. The numbers of compost bins were therefore reduced by 10 % to take account of the dropouts.

It can be seen from the graph that the rapid rise since 1996 has eased off slightly in recent years. It can be concluded from this that the potential of home composters with a compost bin is gradually being reached. The population can meanwhile use other means of composting, such as wormeries, compost containers, compost heaps and so on.

The indicator of ‘proportion of Flemish families with a compost bin’ provides the following picture.

Figure 3.7: Progression in the proportion of Flemish families (%) who use a compost bin



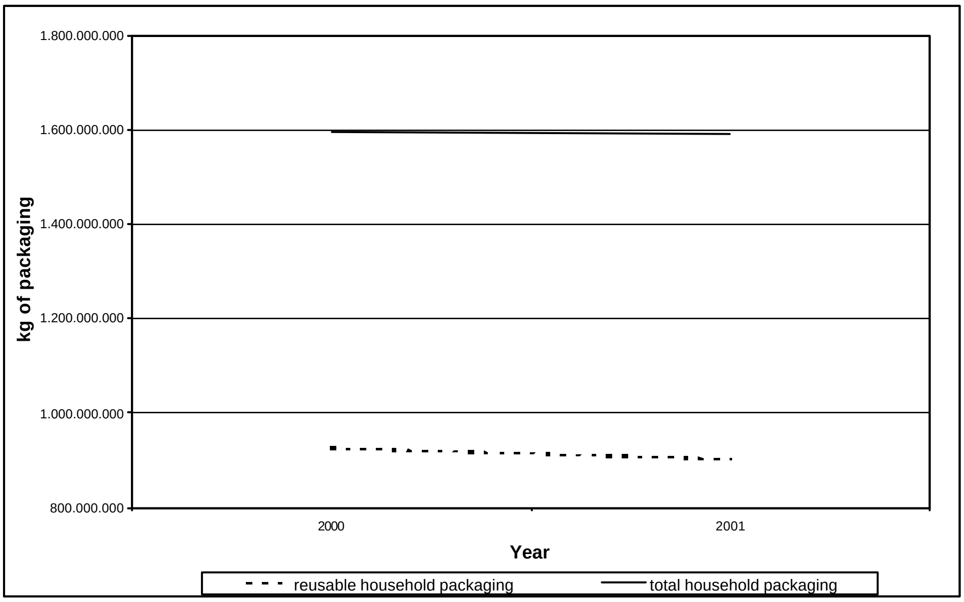
It can be deduced from this graph that at the end of 2002 approximately 8,6 % of Flemish families had a compost bin and presumably were also using it (in view of the fact that the figures were corrected for the number of dropouts).

3.4.4 Portion of reusable household packaging

This indicator offers a picture of the weight of reusable household packaging that is being introduced into the Belgian market versus the total amount of household packaging. A decline in this indicator points to a lower portion of reusable packaging and an increase in the use of one-time packaging.

The data employed relate to the household packaging (reusable and one-time). No account was taken of secondary and tertiary packaging. The data pertain to Belgium but the evolution in the household packaging is likely to prove of application for the Flemish Region as well.

Figure 3.8: Evolution of the quantity of reusable household packaging and of the total quantity of household packaging.



The above table shows but a bare change in the total quantity of household packaging, which in a context of ever-growing quantities of smaller packaging demonstrates that serious efforts are made to check the amount of household packaging. In contrast, there occurs a slight decline in the amount of reusable household packaging. Because of this, the ‘portion of reusable household packaging’ indicator shows a slightly declining trend.

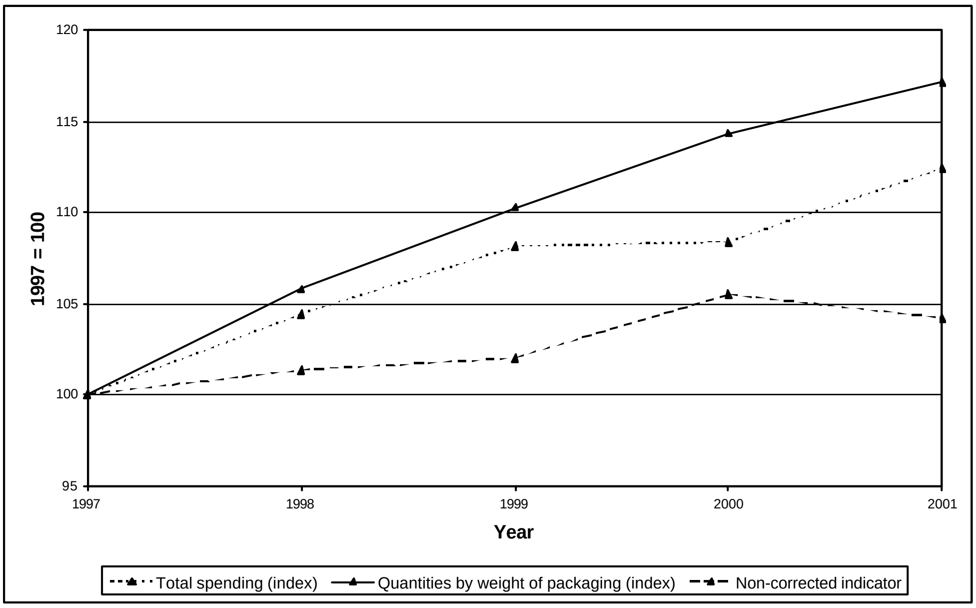
Only in the course of the coming years will it become apparent whether this trend for the portion of reusable packaging will continue or not.

3.4.5 Packaging per consumption unit

An active policy in relation to packaging waste has been conducted in recent years. Data show that the total quantity of packaging put on the market is still rising. An increase in the quantity of packaging used may have various causes. In order to eliminate the factor of economic growth as much as possible, the total quantity of packaging is related to a unit of economic activity, namely the unit of consumption spending for families (for further explanation see the indicator of waste per consumption unit in paragraph 3.3.2). In drawing up the indicator, account was only taken for spending (denominator) of the product categories which lead to the use of packaging.

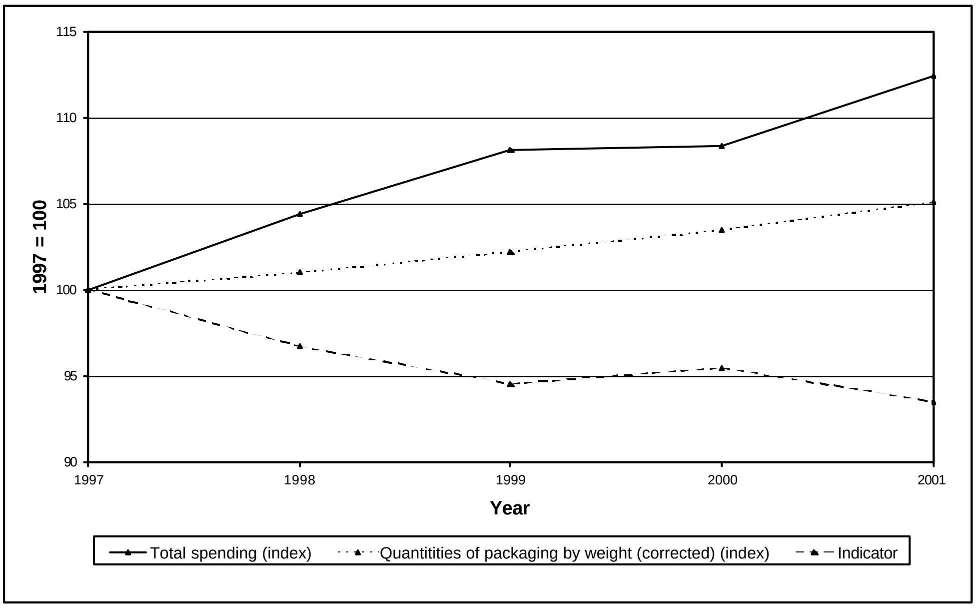
For the numerator (= quantity of packaging put on the market), use was made of the data from the members which are notified annually. These are data at the Belgian level. For this reason, a decision was taken to work with figures for Belgium for the denominator, that is to say the spending of households. The indicator progresses as follows.

Figure 3.9: Progression of the non-corrected indicator for disposable packaging per unit of consumption in Belgium



As far as consumption is concerned, there is a rising trend. The quantity of packaging put on the market is also rising. Juxtaposing the two variables provides an indicator which indicates whether the Flemish population is using more or less packaging per unit of consumption. The rise in the quantity of packaging in the above graph is, however, also a consequence of an increase in the number of businesses joining the sorting and recycling organisation Fost Plus. In order to exclude this as far as possible, the estimated quantity of packaging put on the market is worked with in the graph below. The total quantity of packaging has been corrected annually for non-affiliated businesses.

Figure 3.10: Progression of the quantities of disposable packaging per unit of consumption in Belgium



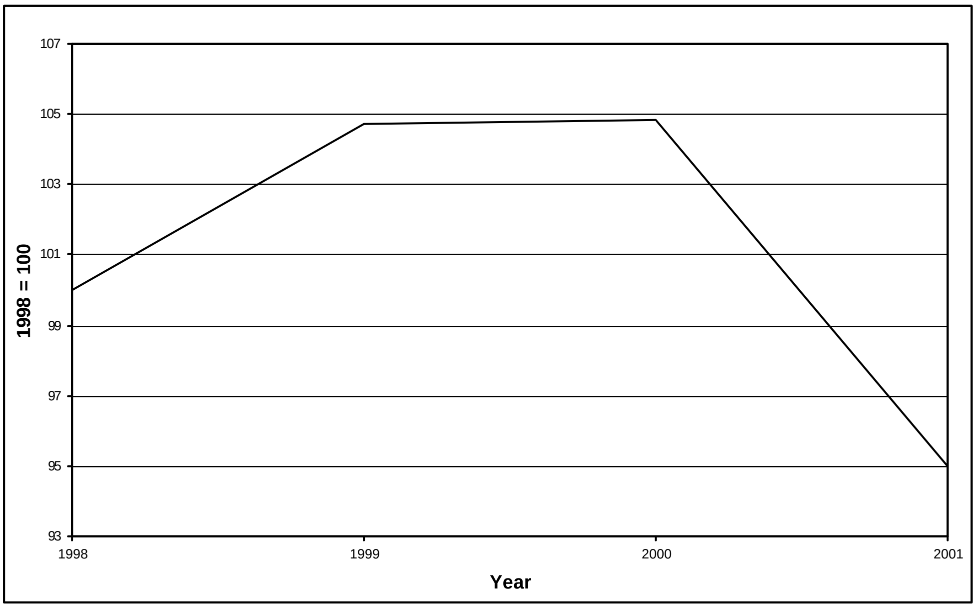
The indicator shows a downward trend. In other words, the quantity of packaging per consumption unit is falling. The fall in this indicator does not say anything about the causes: these may be both on the consumer side (the implementation of the prevention plans in the context of the cooperation agreement relating to the prevention and maintenance of packaging waste). The fall in the indicator may also be a consequence of change in the pattern of spending (more expenditure on expensive goods with relatively less packaging).

3.4.6 Amount of advertising material printed

The environmental policy agreements on paper included targets on the reduction of actually distributed print runs of the newspapers of the free regional press and printed advertising material. Agreements with distributors, awareness campaigns among the population, monitoring and the use of stickers on letterboxes must reduce the paper mountain.

The graph shows the progression in distributed print runs.

Figure 3.11: Progression of print runs of free printed advertising material in Flanders



The print runs notified under the environmental policy agreement on printed advertising material are decreasing. Compared to 1998 there is a decrease of about 5 %. The results should also be qualified as not all enterprises which put printed advertising material on the market are included in the graph.

3.5 Conclusions

A positive trend towards waste prevention for most of the indicators is noted, although this evolution is not always evenly pronounced. The slightly positive evolution of the indicator ‘waste per head of population’ and the evolution of the indicator ‘waste per consumption-unit’ point to possible prevention. In addition, the indicator ‘waste per consumption-unit’ points to a decoupling of the growth in waste generation and consumption.

The reusable household packaging portion shows a regression (reusable packaging is losing further ground). For one-time packaging per consumption-unit the trend is positive (the weight of one-time packaging per euro spent is declining). What is represented by the indicator for ‘no-advertising stickers’ is an overestimate, as dropouts are not taken into account, but it may be assumed that there is a positive trend.

Overall, it can be said that there is evidence that the Flemish population have in general been making increasing prevention efforts since 1997. For the total of municipal waste, there is for the first time since the registration came into effect a decline in the annual amount of waste instead of an increase. There are indications that the prevention efforts are paying off.

4 Attachments

4.1 Attachment 1: Extrapolation method

(Van Dijck, J. (1999) Extrapolatie van afvalstoffen. Gebruikershandleiding. Probabilitas, Heverlee. P. 46)

(Smeets, K., Umans, L., Van Acoleyen, M. (2003). Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking, invoer en uitvoer, OVAM, Mechelen. P.315)

The Flemish decree on waste products (VLAREA) contains an annual requirement for enterprises to report the volume of their waste generation. The aim of this legislated requirement is to gather all possible data from all enterprises or, in other words, to gain an exhaustive picture of the total extent of the waste generation. After more than 20 years of trying, this has not rendered satisfactory results. The objective of reaching all enterprises has proven a utopian dream; indeed, not all of the enterprises are known, and the OVAM is therefore unable to adequately enforce this regulation. The courts are lukewarm in their reaction to an enterprises dismissal of the reporting requirement. Furthermore, supervising this kind of gigantic operation is simply not feasible – organisation-wise, logistically, and qua enforcement – for the 150.000 or more enterprises operating in Flanders. Moreover, this sort of operation is not really needed for the collection of the needed figures.

For that reason, it was decided to adapt VLAREA on waste generation in 2004. As of 2005 (reporting on the 2004 production year), only a sampling of enterprises will be required to submit a report. This sampling survey will be annually adapted.

The response of the 2003 reporting on the production year 2002 came from 33.435 enterprises. Of these, 9.164 enterprises, or 62.174 reporting forms, were subjected to a detailed examination, this constituting a representative sampling of enterprise waste generation in Flanders. The collected data were extrapolated vis-à-vis the number of enterprises known in the reference data banks, primarily the NOSS-databank. From our pool of 33.435 enterprises, enterprises were selected sector by sector and dimension by dimension until per sub-population an optimal sampling total was collected. Sectors displaying a lot of variability require a larger sampling than the more homogeneous ones. More inputs than required for the optimal size of the sampling result in only minimal improvements in the final result. A specialist bureau developed for us the appropriate extrapolation methodology, and specific software was devised in order to accelerate the extrapolation process. In addition, appropriate methodology and software were further developed for carrying out regressions and trend analyses on the time series.

Estimates of the quantity of waste (if desired of a certain type and in accordance with a given processing method) are invariably carried out for each sector/dimension. Total amounts are obtained by adding up these quantities and by appropriately adapting the standard error as detailed in this chapter.

The estimate for one sector/dimension proceeds as follows: each sector is accompanied by a list of relevant reporting NACE codes, which allows us on the basis of the NOSS data to determine the total number of enterprises. One defines:

N = number of enterprises

It is to be noted that when the number of dossiers received for that sector/dimension exceeds N, N is made equal to this last value.

Each sector has also been assigned a list of NACE codes, which allows to classify the enterprises (possibly within a defined region) by sector. In each sector/dimension, the total quantity of waste X, of the type and treatment method for the designated extrapolation, is calculated for each reporting enterprise. When an enterprise does not report a waste product of the type and treatment code that is being examined, X is then equated with 0. On the other hand, it may happen that the examined waste product and treatment code are mentioned in various forms for the same enterprise. In that case, these quantities will be combined.

When one defines:

M = number of entered enterprises,

$\overline{X}$ = the survey's average of the total quantity of waste per enterprise,

s_X = the survey's standard deviation from the total quantity of waste per enterprise.

The total quantity of waste T for the sector/dimension being examined is then calculated as

$$T = \bar{X}\ N \tag{1}$$

This estimate is only an approximation since the exact quantities are not known for (N-M) enterprises and are assumed to be equal to the survey's average, which is only an approximation of the real unknown average for the other (N-M) enterprises. The standard error σ_T of the estimate T can then be calculated as:

$$\sigma_T = \sqrt{(N-M)^2 \frac{s_X^2}{M} + (N-M)s_X^2} \tag{2}$$

The first term under the square root represents the uncertainty for the estimated average, while the second term takes account of the independent variations of the quantities vis-à-vis this average. When M<N/2, then the first term is dominant.

To set up a 95 % confidence interval for the estimate T, the probability distribution vis-à-vis the real total (OT) must be known. If X has a normal distribution, then the standardized deviation (T-OT)/s_X t- is divided by M-1 degrees of freedom and the corresponding 100(1-α)% confidence is equal to:

$$T \pm t_{\alpha/2,M-1}\sigma_T \tag{3}$$

where $t_{\alpha/2,M-1}$ represents the quantile value of a t-distribution with M-1 degrees of freedom that is exceeded by probability α/2.

Previous confidence interval is such that, by application of the formula for independent surveys, the interval in 100(1-α)% of the cases encompasses the real OT total. When X is not normally distributed, then this is only valid by approximation. However, as M rises, this approximation becomes more exact, even for a non-normal distributed X, since the survey average in any case converges towards a normal distribution, as it pertains to the average of a great number of random variables.

Comparisons (1) to and including (3) can be used to calculate the total waste quantity, the standard error, and the reliability for each sector/dimension. The totals for a group of sectors and/or dimensions are calculated as follows:

$$T_{group} = \sum_{i \in group} T_i \tag{4}$$

where i refers to an index assigned to each sector/dimension that belongs to the group and T_i corresponds to the estimate for sector/dimension i.

The standard error for this kind of bundled total waste estimation corresponds to:

$$s_{T,group} = \sqrt{\sum s_{T,j}^{2}} \tag{5}$$

where $\sigma_{T,i}$ refers to the standard error of the estimate of the i sector/dimension in the group.

For the composition of the confidence interval of a bundled estimate, the probability distribution needs to be known again. In this case, no exact result is available for this, even under the assumption of a normally distributed waste amount X for every sector/dimension. By approximation, one can again assume that the standardized error (T_{group}-OT_{group})/σ_{Tgroup} has been normally distributed, with a number of adapted degrees of freedom ν that is defined as:

$$n = \frac{s_{T,group}^{4}}{\sum_{i \in group} \frac{s_{T,j}^{4}}{M_i + 1}} - 2 \tag{6}$$

where M_i refers to the number of entered enterprises for the sector/dimension i of the group.

This formula is a generalization of the approximate formula that is used in the composition of a confidence interval for the difference between two population averages, when the standard deviations of both populations are not known. Note that when $\sigma_{T,i}$ is zero except for one of the (sector/dimension)s, the number of degrees of freedom is equal to the number of entered enterprises in this sector/dimension reduced by one. This corresponds to the work method for the extrapolation in one sector/dimension. Where, on the other hand, all $\sigma_{T,i}$ and also all M_i are equal, then the number of degrees of freedom is equal to the sum of the number of reporting enterprises in the different (sector/dimension)s, plus the number (sector/dimension)s in the group, reduced by two. This fairly corresponds with the number of degrees of freedom to be used when one considers the standard deviations in the different (sector/dimension)s to be equal.

The 95 % confidence interval for the total waste quantities generated by the group of (sector/dimension)s corresponds to:

$$T_{group} \pm t_{a/2,n}\, s_{T_{group}} \tag{7}$$

The above extrapolation formulas are generally applicable both for the estimation of non-specified waste products and for the estimation of specific waste products (for instance, a specific waste product code).

By using the t-distribution, the afore-mentioned confidence intervals take account of the uncertainty regarding the estimated average as well as the estimated standard deviation. For an identical estimate of the survey average and the survey's standard deviation, one can find intervals of different breadth depending on the number of dossiers that were entered and used in the extrapolation.

4.2 Attachment 2 : Methodology use of hypothesis tests for decoupling indicators

(Van Dijck, J. (2004). Hypothese testen van indicatoren voor het afvalstofbeleid. Probabilitas, Heverlee. P. 23)

4.2.1 Introduction

This chapter contains the entire report of the study that was conducted to test out by means of hypothesis tests the indicators that are being used by the OVAM to evaluate the waste product policy and to establish whether or not they satisfy the proposed objective.

A number of general deviations and points of attention are emphasized in this chapter. These are being concretely illustrated by means of one specific example, namely the decoupling indicator that indicates if the total of the enterprise waste generation demonstrates a parallel or even more rapid growth than the GDP for the whole of the Flemish economy or if, in contrast, its progress is slower. In the latter case, there is question of a positive decoupling.

4.2.2 Definition of decoupling

Where:

- a(t) is an indicator of the economic activity in year t. Eventually, this indicator can be split up further into various sectors or sizes;
- m(t) is an indicator of the environmental pressure in year t: for instance, the real total of generated waste quantity in year t;

the decoupling indicator r is defnied as follows::

$$r(t)=1-\frac{\frac{m(t)}{m(t_0)}}{\frac{a(t)}{a(t_0)}} \qquad (1)$$

t_0 here represents a reference year. $\frac{m(t)}{m(t_0)}$ can then be interpreted as an environmental pressure index and $\frac{a(t)}{a(t_0)}$ as an economic activity index. When both are equal, r(t) is equal to 0. When the environmental pressure rises more rapidly than the economic activity, a negative decoupling occurs. When the environmental pressure experiences slower growth than the economic activity does a positive value result and may one speak of positive decoupling.

OECD proposes the exposition of r(t) in time in order to determine in this manner if and when decoupling is achieved. By means of Comparison (1), one may also state that positive decoupling occurs when:

$$m(t)<\frac{a(t)}{a(t_0)}m(t_0) \qquad (2)$$

The environmental pressure is negative decoupled as:

$$m(t) \geq \frac{a(t)}{a(t_0)} m(t_0) \tag{3}$$

4.2.3 Uncertainty regarding the estimates

When m(t) and a(t) are known to be exact, it is possible to accurately describe the progress of the decoupling indicator r(t). However, in reality, the values m(t) and r(t) are not known exactly, but are estimated on the basis of figures for a segment of the population.

To make this distinction clear, a different notation is used for such estimates. For the sake of simplicity, it is assumed that the economic activity indicator a(t) is known very accurately and that only the uncertainty of the amount of waste m(t) is considered. The estimate in year t is stated as m*(t).

If one should decide that the environmental pressure is decoupled positively as soon as the condition

$$m^*(t)\, a(t_0) < a(t)\, m^*(t_0) \tag{4}$$

is fulfilled, one then runs the risk that this conclusion in reality remains unsatisfied because of the errors in the estimates of m(t) and $m(t_0)$. Conversely, one could conclude that the decoupling condition has been met, while, in fact, this is not the case.

To express the risk of faulty conclusions in a quantitative form, it is necessary to know exactly the accuracy of the estimations of the environmental pressure. More precisely, one has to consider m*(t) as one of the many possible estimations that could have been obtained if for the same year independent surveys had been performed. In order to again make this distinction clear, the possible estimations are represented as $\hat{m}(t)$. Note: $\hat{m}(t)$ is not an ordinary value, but a random variable that is characterized by a probability distribution.

By studying the manner in which $\hat{m}(t)$ is calculated and by modelling the variability of the individual waste reporting, it is possible to determine the probability distribution of the error between the estimator $\hat{m}(t)$ and the true quantity m(t). For instance, this can be done by using the extrapolation software (EVA). Summarized, one arrives at the following:

$$\frac{\hat{m}(t)-m(t)}{\hat{s}_{\hat{m}(t)}}$$ is t-distributed with (n_{eq} – 1) degrees of freedom (5)

$\hat{s}_{\hat{m}(t)}$ in this comparison refers to an estimate of the standard deviation of the estimator $s_{\hat{m}(t)}$. n_{eq} represents the equivalent survey size that was used to arrive at this estimate. Here again, one needs to draw a careful distinction between the various variables:

- $s_{\hat{m}(t)}$ refers to the real standard deviation of the estimator $\hat{m}(t)$. This value could be determined accurately when the estimation method is applied several times to independent surveys of the same size for a given year. It would then become apparent indeed that the individual estimations manifest a variation and, when this is performed an infinite number of times, the standard deviation for these estimations can in effect be determined accurately. Since the estimator $\hat{m}(t)$ is a sum of estimators of the waste generation for variously sized enterprises and economic sectors and, since the waste reporting within an enterprise of a given dimension and economic sector the estimator corresponds with a sum of individual waste reporting dossiers, it may be held that the variations of $\hat{m}(t)$ are distributed normally (because of the central limit theorem). For a good estimation method, one can further demonstrate that the average corresponds with the real value m(t). Consequently it is enough to know $s_{\hat{m}(t)}$ to be able to completely characterize the probability distribution of the estimator $\hat{m}(t)$ (this means that it is possible to indicate the probability that an error of a given size is being exceeded). As an example, one can state that:

$$\frac{\hat{m}(t)-m(t)}{s_{\hat{m}(t)}} \text{ is normally distributed} \tag{6}$$

- in practice, $s_{\hat{m}(t)}$ can of course not be defined exactly (this would indeed mean that an infinite number of surveys were conducted). Therefore, $s_{\hat{m}(t)}$ is estimated – just like m(t) itself – on the basis of the data in the survey. The consequence of this is that, although Comparison (6) remains valid, it is no longer practically usable, in contrast to Comparison (5), which remains usable: in this comparison one does, in effect, use the estimated standard deviation and the error for this estimate is taken into account. This is being determined by the number of degrees of freedom for the t-distribution: in this case, n_{eq}-1. When n_{eq} is high, the t-distribution quasi corresponds with the normal distribution. For lower n_{eq} (for instance, below 50), a higher spread is common.

4.2.4 Hypothesis test for the decoupling

To take into account the uncertainty in the estimations, it is necessary to apply the technique of hypothesis testing when checking the occurrence or absence of decoupling.

If one wants to demonstrate that positive decoupling is indeed occurring and that this also can be proven on the basis of the measurements, the hypothesis test needs to be formulated as follows:

$$H_0: m(t) \geq \frac{a(t)}{a(t_0)} m(t_0) \text{ versus } H_1: m(t) < \frac{a(t)}{a(t_0)} m(t_0) \tag{7}$$

This hypothesis test is identical to testing for the equality of the population average for two populations $H_0 : m_1 \geq m_2$ versus $H_1 : m_1 < m_2$, except that in this case the population average m_2 is being multiplied with a known constant $\frac{a(t)}{a(t_0)}$.

In order to perform the test, it is necessary to be in possession of a statistic whose probability distribution is known in the assumption of the zero-hypothesis and whose probability distribution would change should that not be the case. A natural choice in this instance is:

$$\hat{\Delta}m(t) = \hat{m}(t) - \frac{a(t)}{a(t_0)}\hat{m}(t_0) \tag{8}$$

For the limit value of the zero-hypothesis it pertains that $m(t) = \frac{a(t)}{a(t_0)} m(t_0)$.

Since both $\hat{m}(t)$ and $\hat{m}(t_0)$ are unbiased estimators of m(t) and m(t_0), the mathematical expectation of $\hat{\Delta}m(t)$ equals 0. The variance of the estimator corresponds with (in the assumption that the estimation errors are independent):

$$Var\left(\hat{\Delta}m(t)\right) = Var\left(\hat{m}(t)\right) + \left(\frac{a(t)}{a(t_0)}\right)^2 Var\left(\hat{m}(t_0)\right) \tag{9}$$

Since the variances of $\hat{m}(t)$ and $\hat{m}(t_0)$ are not accurately known, it is necessary to estimate the variance of $\hat{\Delta}m(t)$, starting from the estimated standard deviations:

$$s^2_{\hat{\Delta}m(t)} = \hat{s}^2_{\hat{m}(t)} + \left(\frac{a(t)}{a(t_0)}\right)^2 \hat{s}^2_{\hat{m}(t_0)} \tag{10}$$

When, furthermore, no link can be assumed about the real unknown standard deviations $s^{2}_{\hat{m}(t)}$ en $s^{2}_{\hat{m}(t_0)}$, it can only be held that:

$$\frac{\hat{\Delta} m(t)}{s^{2}_{\hat{\Delta} m(t)}} \text{ is approximately t- distributed with } n \text{ degrees of freedom} \tag{11}$$

where n is calculated by using the formula:

$$n = \frac{\left(\hat{s}^{2}_{\hat{m}(t)} + \left(\frac{a(t)}{a(t_0)} \right)^2 \hat{s}^{2}_{\hat{m}(t_0)} \right)^2}{\frac{\hat{s}^{4}_{\hat{m}(t)}}{n_{eq}(t)+1} + \frac{\left(\frac{a(t)}{a(t_0)} \right)^4 \hat{s}^{4}_{\hat{m}(t_0)}}{n_{eq}(t_0)+1}} - 2 \tag{12}$$

The hypothesis test can then be performed in the following manner:

1. calculate the observed t-value t* starting from the estimates made:

$$t^{*} = \frac{\hat{m}^{*}(t) - \frac{a(t)}{a(t_0)} \hat{m}^{*}(t_0)}{\sqrt{\hat{s}^{*2}_{\hat{m}(t)} + \left(\frac{a(t)}{a(t_0)} \right)^2 \hat{s}^{*2}_{\hat{m}(t_0)}}} \tag{13}$$

2. calculate the number of degrees of freedom n using Comparison (12);
3. calculate the P-value: this is the chance that the value t* or a lower value might be found accidentally:

$$P = T_n^{-1}\left(t^{*}\right) \tag{14}$$

where T_n^{-1} represents the inverse of the cumulative probability distribution of the T-distribution with n degrees of freedom;

4. in case the P-value is lower than the selected significance level for the T-test (for instance, 5 % is usual), one may conclude that the deviation is 'significant' and that the data confirm the positive decoupling. If this is not the case, one may decide that such a strong conclusion cannot be drawn.

4.2.5 Confidence interval for the decoupling

Alternatively, one can draw up a confidence interval for the decoupling indicator. To this end, one starts from the previous result.

The $100\times(1-a)\%$ double confidence interval for the real difference

$$\Delta m(t) = m(t) - \frac{a(t)}{a(t_0)} m(t_0) \tag{15}$$

corresponds to:

$$\hat{\Delta} m(t) \pm t_{n,a/2} \sqrt{\hat{s}^2_{\hat{m}(t)} + \left(\frac{a(t)}{a(t_0)}\right)^2 \hat{s}^2_{\hat{m}(t_0)}} \tag{16}$$

where $t_{n,a/2}$ represents the upper quantile of the t-distribution with n degrees of freedom for a chance $a/2$.

The decoupling indicator r(t) in Comparison (1) can also be reformulated as:

$$r(t)=1-\frac{\frac{m(t)}{m(t_0)}}{\frac{a(t)}{a(t_0)}}=\frac{\frac{a(t)}{a(t_0)}-\frac{m(t)}{m(t_0)}}{\frac{a(t)}{a(t_0)}}=-\frac{1}{m(t_0)}\frac{m(t)-\frac{a(t)}{a(t_0)}m(t_0)}{\frac{a(t)}{a(t_0)}}$$

$$=-\frac{1}{m(t_0)}\frac{\Delta m(t)}{\frac{a(t)}{a(t_0)}} \tag{17}$$

This last comparison indicates that the value of r(t) is not only determined by $\Delta m(t)$ but also by m(t_0). Neither is known with accuracy and, therefore, r(t) is influenced by uncertainty in both variables. In fact, these uncertainties are correlated since $\Delta m(t)$ is a function of m(t_0).

However, to judge whether positive or negative decoupling occurs, the real value of m(t_0) is not relevant. Only the possible change in sign of the term $\Delta m(t)$ determines the conclusion whether positive or negative decoupling is occurring.

Thus, one can state the double 95% confidence interval for the product $r(t)\times m(t_0)$ as:

$$\frac{-\hat{\Delta} m(t)\pm t_{n,a/2}\sqrt{\hat{s}^2_{\hat{m}(t)}+\left(\frac{a(t)}{a(t_0)}\right)^2\hat{s}^2_{\hat{m}(t_0)}}}{\frac{a(t)}{a(t_0)}} \tag{18}$$

Following substitution of Comparison (15) and simplifying, one arrives at:

$$\hat{m}(t_0)-\hat{m}(t)\frac{a(t_0)}{a(t)}\pm t_{n,a/2}\sqrt{\hat{s}^2_{\hat{m}(t_0)}+\hat{s}^2_{\hat{m}(t)}\left(\frac{a(t_0)}{a(t)}\right)^2} \tag{19}$$

The previous comparison is nothing other than the 95 % confidence interval for the decline in the generated waste amount, after correction for the evolution of the economic indicator.

If this 95 % confidence interval lies above 0, one may draw a strong conclusion that positive decoupling is occurring. If the 95 % confidence interval lies below 0, this would indicate that there exists significant proof that the environmental pressure is mounting more rapidly than the economic activity. So in that case one can speak of negative decoupling. If the value 0 falls within the confidence interval, neither positive nor negative decoupling can be demonstrated.

One can of course standardize the previous expression vis-à-vis the estimate $\hat{m}(t_0)$. In order to correctly describe this representation, one might best speak of a decoupling indicator expressed for an assumed reference waste generation of $\hat{m}(t_0)$ in the year t_0. Comparison (19) is then further simplified to:

$$1-\frac{\hat{m}(t)}{\hat{m}(t_0)}\frac{a(t_0)}{a(t)}\pm t_{n,a/2}\frac{1}{\hat{m}(t_0)}\sqrt{\hat{s}^{\,2}_{\hat{m}(t_0)}+\hat{s}^{\,2}_{\hat{m}(t)}\left(\frac{a(t_0)}{a(t)}\right)^2} \qquad (20)$$

The coefficient of the variation of a total waste estimate typically lies around the 4 % mark and thus $\hat{s}_{\hat{m}(t_0)}/\hat{m}(t_0)$ is approximating 0,04. For $\hat{s}_{\hat{m}(t)}\left(\frac{a(t_0)}{a(t)}\right)/m(t_0)$ one can assume a value of the same order-size. When a 95 % confidence interval is used, and it is assumed that the number of degrees of freedom lies sufficiently high, then $t_{n,a/2}$ is approximately equal to 2. The breadth of the 95 % confidence interval (on both sides) vis-à-vis the best estimate for the decoupling factor is thus of the order-size of 0,12. Significant proof will therefore only be possible if the best estimate falls below –0,12 or above 0,12.

4.2.6 Using the EVATREND results

The uncertainty in the estimated waste amounts for individual years is relatively high, which further complicates the correct estimation of the presence or absence of decoupling.

In the trend analysis software (EVATREND), it is assumed that the real total waste generation demonstrates a linear trend in time, with possible random fluctuations from year to year:

$$m(t) = g_0 + g_1 \times \left(t - \bar{t}\right) + e_t \tag{21}$$

g_0 and g_1 in this case correspond with the regression coefficients of the linear model that is here formulated vis-à-vis a reference year $\bar{t}$, chosen in such a way that the estimation error in g_0 and g_1 is not correlated. e_t represents a random independent error from year to year. This error is assumed to be normally distributed with a mathematical expectation of 0 and an unknown standard deviation s_e.

The individual estimations $\hat{m}\left(t\right)$ per production year display vis-à-vis the true value m(t) an additional statistical estimation error $s_{\hat{m}(t)}$ as already discussed before.

EVATREND carries out the estimations of the regression line, taking into account these factors by means of a weighted regression.

Should it be assumed first that g_0, g_1 and s_e are known accurately and the expression for r(t)m(t_0) be reconsidered, the combination of Comparisons (15) and (17) leads to:

$$r\left(t\right) \times m\left(t_0\right) = m\left(t_0\right) - \frac{a\left(t_0\right)}{a\left(t\right)} m\left(t\right) \tag{22}$$

Following substitution of Comparison (21), one finds:

$$r(t)\times m(t_0)=g_0+g_1\times(t_0-\overline{t})+e_0-\frac{a(t_0)}{a(t)}(g_0+g_1\times(t-\overline{t})+e_t)$$
$$=g_0\times\left(1-\frac{a(t_0)}{a(t)}\right)+g_1\times\left((t_0-\overline{t})-\frac{a(t_0)}{a(t)}(t-\overline{t})\right)+e_0-\frac{a(t_0)}{a(t)}e_t \qquad (23)$$

The variance of $r(t)\times m(t_0)$ then corresponds to:

$$Var\left(r(t)\times m(t_0)\right)=\begin{array}{l} s_{\hat{g}_0}^2\times\left(1-\frac{a(t_0)}{a(t)}\right)^2+s_{\hat{g}_1}^2\times\left((t_0-\overline{t})-\frac{a(t_0)}{a(t)}(t-\overline{t})\right)^2 \\ +s_e^2\left(1+\frac{a(t_0)}{a(t)}\right)^2 \end{array} \qquad (24)$$

where $s_{\hat{g}_0}^2$ and $s_{\hat{g}_1}^2$ represent the estimation error of g_0 and g_1.

$s_{\hat{g}_0}^2$, $s_{\hat{g}_1}^2$ and s_e^2 are not known. Estimations of this are possible on the basis of the residues of the regression. Since it concerns an estimation with a limited number of performance indicators (the number of years), the distribution of the estimation error is again t-distributed, in this case with n-2 degrees of freedom (n=number of years).

Currently, only the estimation of s_e is written out by EVATREND (in row SEY, column ‘with W’). This value may be zero if the variation of the residues can be totally explained by the estimation errors for the individual years. The variances of the estimated parameters g_0 and g_1 are not written out and are always positive, even if s_e is estimated as 0.

The variance of g_0 and g_1 can be deduced indirectly from the EVATREND results when no breakpoints are applied in the trend analysis. The breadth (UC-LC) of the confidence interval on the trend estimate for the production year t varies in this instance quadratically with the difference between year t and the average year $\overline{t}$, after applying the weighting. The variation is further function of $s_{\hat{g}_0}^2$ and $s_{\hat{g}_1}^2$ as follows:

$$UC(t) - LC(t) = 2 \times t_{n,a/2} \times \sqrt{s_{\hat{g}_0}^2 + \left(t - \overline{t}\right)^2 s_{\hat{g}_1}^2} \qquad (25)$$

$t_{n,a/2}$ refers to the $a/2$ upper-quantile of a t-distributed random variable with n degrees of freedom. When the regression is based on n years, n corresponds with n-2.

Where C_t is taken as the breadth UC(t)-LC(t) of the confidence interval for year t. When the value of C_t for three different production years is available, the value of $\overline{t}$ needs to satisfy the following comparison:

$$\frac{\left(t_3 - \overline{t}\right)^2 - \left(t_1 - \overline{t}\right)^2}{\left(t_2 - \overline{t}\right)^2 - \left(t_1 - \overline{t}\right)^2} = \frac{C_3^2 - C_1^2}{C_2^2 - C_1^2} \qquad (26)$$

The solution of this corresponds to:

$$\overline{t} = \frac{1}{2} \times \frac{\left(C_3^2 - C_1^2\right)\left(t_2^2 - t_1^2\right) - \left(C_2^2 - C_1^2\right)\left(t_3^2 - t_1^2\right)}{\left(C_3^2 - C_1^2\right)\left(t_2 - t_1\right) - \left(C_2^2 - C_1^2\right)\left(t_3 - t_1\right)} \qquad (27)$$

The value of $s_{\hat{g}_1}^2$ can then be determined as:

$$s_{\hat{g}_1}^2 = \frac{\left(C_3^2 - C_1^2\right)}{\left(2 \times t_{n,a/2}\right)^2 \left(\left(t_3 - \overline{t}\right)^2 - \left(t_1 - \overline{t}\right)^2\right)} \qquad (28)$$

The value of $s_{\hat{g}_0}^2$ can finally be determined as:

$$s_{\hat{g}_0}^2 = \frac{C_1^2}{\left(2\times t_{n,a/2}\right)^2} - \left(t_1 - \overline{t}\right)^2 s_{\hat{g}_1}^2 \tag{29}$$

The above indirect calculations of $s_{\hat{g}_0}^2$ and $s_{\hat{g}_1}^2$ together with the value of s_e^2, which is calculated by EVATREND, can then be used to calculate the variance of r(t)m(t_0) for successive years in accordance with Comparison (24). The variance of r(t) can be determined by dividing these values by $m^2(t_0)$.

If the corresponding standard deviation is named s_r the double $100\times(1-a)$% confidence interval of r corresponds with $r \pm t_{n-2,a/2} s_r$ where $t_{n-2,a/2}$ represents the $a/2$ upper-quantile value of a t-distributed random variable with n degrees of freedom. n corresponds with the number of years.

If this confidence interval is wholly positive, it may be held that there is strong evidence of decoupling in case of a test with a significance level $a/2$. More precisely, in a hypothesis test formulation:

$$H_0 : r \leq 0 \quad \text{versus} \quad H_1 : r > 0 \tag{30}$$

the zero-hypothesis H_0 is rejected in favour of H_1. The value of r that is calculated on the basis of the waste estimations of EVATREND would in case of non-decoupling (r=0) only be exceeded by random errors with chance $a/2$. One might thus maintain with relatively high certainty that r>0.

If, in contrast, the confidence interval is wholly negative, it may be held that there is strong evidence of the volume of waste increasing much more rapidly than the economic indicator. More precisely, in a hypothesis test formulation:

$$H_0 : r \geq 0 \quad \text{versus} \quad H_1 : r < 0 \tag{31}$$

the zero-hypothesis H_0 is rejected in favour of H_1. The value of r that is calculated on the basis of the waste estimations by EVATREND would in case of non-decoupling (r=0) only with chance $a/2$ be underceded by random errors. One might thus maintain with relatively high certainty that r<0.

If the confidence interval comprises the 0-value, it is then logical to assume that there is no decoupling present (r=0): in other words, the enterprise waste volume is increasing in like measure with the economic indicator. If the best estimation is positive, one can only assume that there is an indication of positive decoupling. Because of the estimation errors, it is, however, not possible to prove this assumption with any degree of certainty. Values of r that are below the bottom-limit of the confidence interval are being rejected in a hypothesis test with significance level $a/2$.

Finally, note that the application of Comparison (20), using the results of the weighted regression and the variances of the estimations as they issue from the prediction interval that is shown in EVATREND is not a correct method of proceeding. Indeed, the waste estimates by EVATREND for two years are correlated, since both these estimations are influenced by the estimation errors for the parameters in the regression line. This is contrary to the assumption of independence of the estimations made for the deduction of Comparison (20).

4.2.7 Example of an application

4.2.7.1 Data and estimation of r

In this example of an application, the estimated total waste volume for the years 1995 to and including 2002 is considered. Table 4.1 shows extrapolation estimates of the total waste generation that is being exported to EVATREND for a paired analysis.

Table 4.1 - Total waste estimations used as input for the EVATREND analysis

YEAR	Y	SY	QUALY(U)	QUALY	DOFY	DOF1Y	TSTA(Y)	95% CI	NOSS - YEAR
1995	20,032,778	1,097,969	ZS	ZS	114	114	1.98	2,175,143	1995
1996	24,064,532	1,578,663	ZG	ZG	137	137	1.98	3,121,685	1996
1997	25,462,732	3,445,440	G	G	38	38	2.02	6,972,452	1997
1998	23,961,138	1,784,011	ZG	ZG	311	311	1.97	3,510,248	1998
1999	24,439,236	1,403,599	ZG	ZG	362	362	1.97	2,760,227	1999
2000	25,591,632	1,215,441	ZG	ZG	195	195	1.97	2,397,057	2000
2001	26,283,468	1,604,688	ZG	ZG	204	204	1.97	3,163,875	2001
2002	25,823,386	1,998,931	ZG	ZG	102	102	1.98	3,964,678	2002
YEAR	DY	SDY	QUALDY(U)	QUALDY	DOFDY	DOF1DY	WFAC		
1995	2,317,741	741,373	ZS	ZS	136	63	0.85		
1996	-1,490,750	916,690	M	M	173	4	0.94		
1997	1,706,578	686,704	ZG	ZG	54	51	0.97		
1998	931,520	489,941	ZG	ZG	206	165	0.95		
1999	3,751,882	921,169	ZG	ZG	289	173	0.75		
2000	1,800,796	505,194	ZG	ZG	226	217	0.94		
2001	-1,245,352	590,154	ZG	ZG	337	157	0.95		

The waste estimation for the year 1995 is notably lower than the estimations for the following years (see also Figure 4.1). This makes one assume that the estimation for this year is not representative of the estimations in the following years. Also waste estimations before 1995 (not shown here) are significantly lower. The sharp increases from 1992 to 1996 can be explained by 2 factors:

1. the gradually increasing number of reporting responses by the larger enterprises during this period means that for (sector/dimension)s where in the early years no reporting was available, figures are becoming available in more recent years. When this happens for larger-size enterprises, the extrapolation can produce sharply higher figures since the waste volume generated within such a sector/dimension can be considerable;

2. the enterprises are reporting their waste products more accurately, which leads to a rise in the average volume of waste generated per enterprise in a given sector/dimension and thus also in the total waste estimation.

In summary, one may assume that the waste estimations to and including 1995 are likely to be distorted. For that reason, the data from 1995 are not used to determine the trend. This year, however, has been added in order to arrive at a trend-based estimation for this year so that 1995 may be used as reference year for an analysis of the decoupling indicator.

The result of the EVATREND analysis based on these estimations is illustrated graphically in Figure 4.1. The best trend estimation points to a rise in waste volumes in time. For 1995, a substantially higher estimation is made which, however, may be considered to be more representative of the current reporting rate and completeness of the reporting responses.

Nonetheless, the 95 % confidence interval on the estimated trend also indicates that the average rise per year is uncertain. The individual variations observed for the different production years can be clearly explained by the individual estimation errors so that no additional chance term e is required to explain these variations (this means. $s_e = 0$). This is the reason why the prediction interval coincides with the confidence interval.

Figure 4.1: Result of the EVATREND analysis

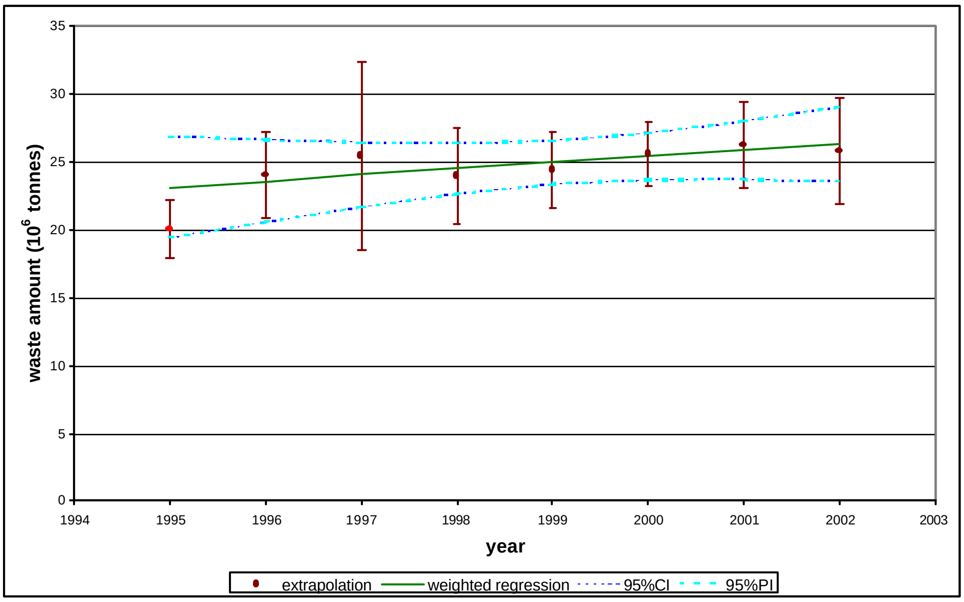


Table 4.2 shows the numerical results of the regression-analysis. As a reminder, the estimations for the individual production year 1995 and the increase from 1995 to 1996 for the paired observations are not accounted for here.

Table 4.2 - EVATREND results

Selection	NY	NDY	TSTA			
M	7	6	2.57			
STDEV	without W	with W				
SEY	0	0				
SEDY	1,962,813	1,787,544				
YEAR	DY	DY (W)	SDY	95%LC	95%UC	
1995	305,318	451,136	314,000	-356,026	1,258,298	
YEAR	YPRE	YPRE (W)	95%LC	95%UC	95%LP	95%UP
1995	23,868,176	23,166,432	19,425,006	26,907,858	19,425,006	26,907,858

1996	24,173,494	23,617,568	20,587,656	26,647,480	20,587,656	26,647,480
1997	24,478,812	24,068,704	21,688,476	26,448,932	21,688,476	26,448,932
1998	24,784,128	24,519,840	22,661,446	26,378,234	22,661,446	26,378,234
1999	25,089,446	24,970,976	23,375,734	26,566,218	23,375,734	26,566,218
2000	25,394,764	25,422,112	23,707,768	27,136,456	23,707,768	27,136,456
2001	25,700,082	25,873,250	23,720,070	28,026,430	23,720,070	28,026,430
2002	26,005,398	26,324,386	23,560,980	29,087,792	23,560,980	29,087,792

Application of Comparisons (27), (28) and (29) leads to the following estimations:

- The average year $\overline{t}$ that is used in the regression-analysis corresponds to 1999,20;
- the standard deviation of the estimation error of g_0 (the waste generation for the period 1999,20) corresponds to 617.470 tonnes;
- the standard deviation of the estimation error of g_1 (the average waste increase per year) according to Comparison (28) corresponds to 314.000 tonnes. Note that this estimation corresponds exactly with the EVATREND result in row '1995' under column 'SDY'.[*] This row in fact contains output for the estimated rise following each breakpoint (in this case as of the starting point 1995). The average rise per year is estimated as 451.136 tonnes (see row '1995', column 'DY (W)' in Table 4.2). Vis-à-vis the weighted estimate for 2002 (26.005.398 tonnes), this corresponds to a rise of 1,7 %. The 95 % confidence interval for the rise per year, however, also contains the value 0. The hypothesis that the waste volume has, in fact, remained constant or has

[*] This result could in fact be used to facilitate the estimation of $\overline{t}$, $s^2_{\hat{g}_0}$ and $s^2_{\hat{g}_1}$. In the present method, the result is used only as an independent check.

even declined thus cannot be rejected. On the other hand, it is of course always possible that the rise is higher than the best estimate, as is indicated by the confidence interval.

As mentioned earlier, the estimate is $s_e = 0$ (as indicated in the EVATREND result of Table 4.2 in row 'SEY' under column 'with W').

The GDP is used in this application as indicator for the economic activity at constant prices for Flanders. Table 4.4 shows the evolution of the GDP for the different production years, together with the waste estimations and the calculation of the decoupling indicator. The table is divided in two parts: the first part (top) uses the EVATREND estimations of the waste generation on the basis of the weighted trend analysis; the second part (bottom) uses the EVA estimations. But in this latter part, the waste estimation for 1995 has been replaced by the estimation of the trend analysis for this year, since for 1995, the EVA result must be judged to be non-representative.

Different alternative definitions are used for the decoupling indicator:

- 'r vav 95' refers to the instance where 1995 is used as reference year in the calculation of r on the basis of Comparison (1) of this chapter;
- 'r vav 96' refers to the instance where 1996 is used as the reference year;
- 'r vav t-4' refers to the instance where the estimation of r is based on a shifting reference year with t_0=t-4. Such values can only be calculated as of 1999. For 1999, the results might possibly be completed with the estimations for the constant reference year t_0=1995.

Table 4.3 : GDP for the different production years and calculation of the decoupling indicator for waste estimation with or without trend analysis and for different alternative choices of the reference year

YEAR	YPRE (W)	GDP = a(t)	Y/GDP	r vav 95	r vav 96	r vav t-4
1995	23,166,432	114,650,800	20.21%	0.000		
1996	23,617,568	115,453,356	20.46%	-0.012	0.000	
1997	24,068,704	119,840,583	20.08%	0.006	0.018	
1998	24,519,840	122,117,554	20.08%	0.006	0.018	
1999	24,970,976	126,025,316	19.81%	0.019	0.031	0.019
2000	25,422,112	131,192,354	19.38%	0.041	0.053	0.053
2001	25,873,250	132,504,277	19.53%	0.034	0.045	0.028
2002	26,324,386	133,431,807	19.73%	0.024	0.036	0.017
YEAR	Y	GDP = a(t)	Y/GDP	r vav 95	r vav 96	r vav t-4
1995	23,166,432	114,650,800	20.21%	0.000		
1996	24,064,532	115,453,356	20.84%	-0.032	0.000	
1997	25,462,732	119,840,583	21.25%	-0.052	-0.019	
1998	23,961,138	122,117,554	19.62%	0.029	0.059	
1999	24,439,236	126,025,316	19.39%	0.040	0.070	0.040
2000	25,591,632	131,192,354	19.51%	0.035	0.064	0.064
2001	26,283,468	132,504,277	19.84%	0.018	0.048	0.066
2002	25,823,386	133,431,807	19.35%	0.042	0.071	0.014

While the results for the decoupling indicator differ depending on the definition of the reference year, a consistent pattern emerges: since 1998, the decoupling indicator is slightly positive, which would indicate a decoupling of the waste generation vis-à-vis the economic activity.

To what extent one may assume with certainty that, in fact, a decoupling is taking place can only be determined by defining the accuracy of the estimated value of r. To this end, the two proposed techniques derived in this chapter are being used:

1. directly based on the EVA waste estimations;
2. based on the EVATREND results.

4.2.7.2 Accuracy of r based on the EVA waste estimations

Table 4.4 shows the calculation results for the instance where r is defined vis-à-vis the reference year 1996. The definition vis-à-vis the reference year 1995 makes little sense since, as already pointed out, the waste estimation for this year is likely to have been distorted. Therefore, in Table 4.3, the value has been replaced by the estimation based on the EVATREND analysis. Nonetheless, a correct calculation of the degree of accuracy is in this case no longer feasible.

Table 4.4 – Calculation of the accuracy of r vis-à-vis the reference year 1996 based on the waste estimations

YEAR	Y	SY	DOF1Y	GDP = a(t)	a(t0)/a(t)	v	R	sigr	tsta	conf
1996	24,064,532	1,578,663	137	115,453,356	1.000	274.0	0.000	0.000	1.969	0.000
1997	25,462,732	3,445,440	38	119,840,583	0.963	55.8	-0.019	0.153	2.004	0.306
1998	23,961,138	1,784,011	311	122,117,554	0.945	399.5	0.059	0.096	1.966	0.189
1999	24,439,236	1,403,599	362	126,025,316	0.916	325.1	0.070	0.085	1.967	0.166
2000	25,591,632	1,215,441	195	131,192,354	0.880	253.8	0.064	0.079	1.969	0.156
2001	26,283,468	1,604,688	204	132,504,277	0.871	308.7	0.048	0.088	1.968	0.172
2002	25,823,386	1,998,931	102	133,431,807	0.865	226.0	0.071	0.097	1.971	0.192

Data required for the calculations are:

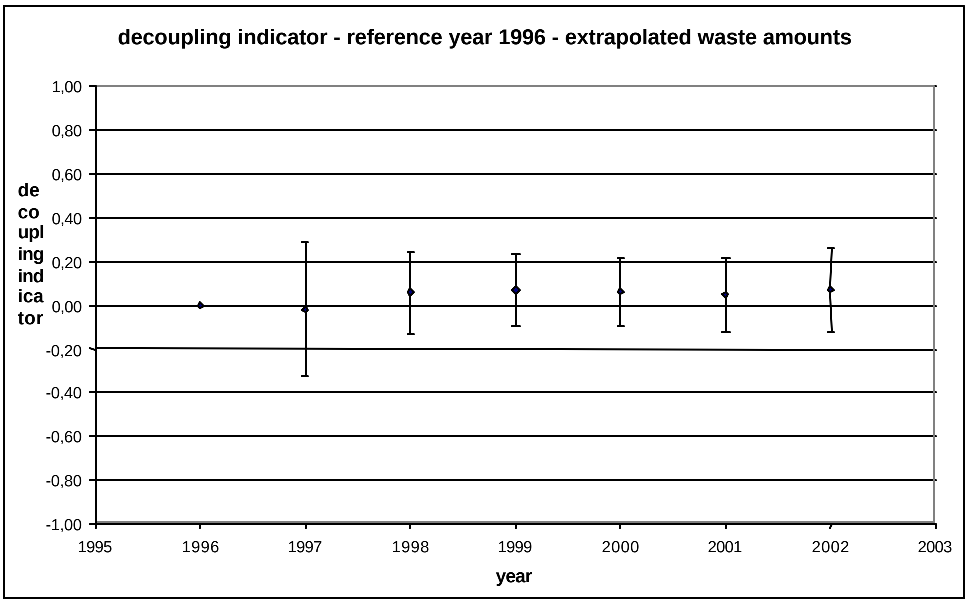
- the EVA waste estimation Y;
- the standard deviation of the estimation error SY;
- the number of equivalent degrees of freedom DOF1Y;
- the economic indicator GDP.

The rest of the columns are then calculated as follows:

- 'a(t0)/a(t)' refers to the ratio of the GDP in the reference year (1996) vis-à-vis the considered year;
- 'v' refers to the calculation of the number of degrees of freedom for the estimation error on r and occurs in keeping with Comparison (12);
- 'r' is calculated on the basis of Comparison (1);
- 'sigr' corresponds to the standard deviation of the estimation error of r and corresponds to the square root in Comparison (20);
- 'tsta' stands for the t-statistic $t_{n,a/2}$ in Comparison (20). In Table 4.4, $a = 0.05$ is used and the derived double confidence interval thus has a 95 % reliability level. The upper limit of the confidence interval is in the case of non-decoupling (r=0) exceeded only in 2,5 % of estimations per coincidence. The lower limit of the confidence interval is in the case of decoupling only in 2,5 % of estimations underceded per coincidence;
- 'conf' refers to the breadth of the confidence interval (on either side of the best estimation).

The estimation of r and the 95 % confidence interval is graphically illustrated in Figure 4.2.

Figure 4.2: Estimation of the decoupling indicator vis-à-vis 1996 and 95 %-confidence interval – extrapolated waste amounts



While the decoupling indicator as of the production year 1998 is consistently estimated as positive, the estimation error is such that it is impossible to conclude definitively that there is, in fact, decoupling going on.

4.2.7.3 Accuracy of r based on the EVATREND waste estimations

The detailed calculations of the accuracy of r are illustrated here in case the starting point is the reference year 1995. End results are also shown for the reference year 1996 and the shifting reference year t_0=t-4.

Table 4.5 – Interim results for the calculation of $\bar{t}$ and the variances of g_0 and g_1

Year	95%LC	95%UC	t-t1	t^2-(t1)^2	c	c^2	tave	vargam1	Vargam0	siggam1	siggam0
1995	19,425,006	26,907,858			7,482,852	5.60E+13			3.81E+11		617,470
1996	20,587,656	26,647,480	1	3991	6,059,824	3.67E+13		9.86E+10	3.81E+11	314,000	617,470
1997	21,688,476	26,448,932	2	7984	4,760,456	2.27E+13	1999.20	9.86E+10	3.81E+11	314,000	617,470
1998	22,661,446	26,378,234	3	11979	3,716,788	1.38E+13	1999.20	9.86E+10	3.81E+11	314,000	617,470

1999	23,375,734	26,566,218	4	15976	3,190,484	1.02E+13	1999.20	9.86E+10	3.81E+11	314,000	617,471
2000	23,707,768	27,136,456	5	19975	3,428,688	1.18E+13	1999.20	9.86E+10	3.81E+11	314,000	617,471
2001	23,720,070	28,026,430	6	23976	4,306,360	1.85E+13	1999.20	9.86E+10	3.81E+11	314,000	617,472
2002	23,560,980	29,087,792	7	27979	5,526,812	3.05E+13	1999.20	9.86E+10	3.81E+11	313,999	617,473

Table 4.5 shows the interim calculations required for the calculation of the average production year $\bar{t}$ and the variances of g_0 and g_1:

- the production ‘year’ and the lower limit (‘95%LC’) and upper limit (‘95%UC’) of the 95 % confidence interval of the regression are directly entered from the EVATREND analysis;

- ‘t-t1’ corresponds to the difference between the production year t and the first value (here 1995). ‘t^2-(t1)^2’ is a simple additional interim calculation;

- ‘c’ refers to the difference between the ‘95%UC’ and ‘95%LC’ value; ‘c^2’ is the square power of this;

- ‘tave’ is then calculated using Comparison (27). Here, the calculation is applied to the years (1995, 1996, 1997), (1995,1996, 1998), (1995,1996, ...). Obviously, the result always needs to be the same;

- ‘vargam1’ refers to $s_{g_1}^{2}$ and is calculated using Comparison (28). The value of $t_{n,a/2}$ in this Comparison needs to correspond to the value expressed by EVATREND for ‘TSTA’ (see Table 2 above). For $\bar{t}$, use is made of the estimation that is based on the first three years. The Comparison is in this case applied to the different pairs of production years (1995, 1996), (1995, 1997), (1995,...) and, of course, always leads to the same result. ‘siggam1’ corresponds to the standard deviation s_{g_1}. This result indicates that, because of the numerical accuracy, there may be very minor differences that, from a practical point of view, pose no problems;

- ‘vargam0’ refers to $s_{g_0}^2$ and is calculated using Comparison (29). For $\bar{t}$, use is made again of the estimation based on the first three years; for $s_{g_1}^2$, the estimation based on the first two years is used. The Comparison can be applied to each of the production years and lead to quasi-identical values. The standard deviation ‘siggam0’ does, nonetheless, show some (very minor) differences.

An additional verification of this result is produced by the fact that the estimation of ‘siggam1’ corresponds to the estimation in EVATREND (see Table 4.2, value ‘SDY’).

Table 4.6 – Detailed calculations for determining the confidence interval of r on the basis of EVATREND results for the reference year 1995

year	YPRE (W)	GDP = a(t)	a(t0)/ a(t)	1- a(t0)/ a(t)	(t0-tave) -(t-tave)* a(t0)/a(t)	1+ a(t0)/a(t)	var(r(t))	sigr	r	confr
1995	23,166,432	114,650,800	1.000	0.000	0.000	2.000	0.00E+0	0.000	0.000	0.000
1996	23,617,568	115,453,356	0.993	0.007	-1.022	1.993	1.92E-04	0.014	-0.012	0.036
1997	24,068,704	119,840,583	0.957	0.043	-2.095	1.957	8.08E-04	0.028	0.006	0.073
1998	24,519,840	122,117,554	0.939	0.061	-3.073	1.939	1.74E-03	0.042	0.006	0.107
1999	24,970,976	126,025,316	0.910	0.090	-4.018	1.910	2.97E-03	0.055	0.019	0.140
2000	25,422,112	131,192,354	0.874	0.126	-4.899	1.874	4.42E-03	0.066	0.041	0.171
2001	25,873,250	132,504,277	0.865	0.135	-5.757	1.865	6.10E-03	0.078	0.034	0.201
2002	26,324,386	133,431,807	0.859	0.141	-6.606	1.859	8.03E-03	0.090	0.024	0.230

Table 4.6 shows interim results for the further calculation:

- The production year ‘year’ and the trend estimation of the waste generation ‘YPRE (W)’ correspond to input data that can be directly entered from EVATREND. ‘GDP’ refers to the economic indicator that also needs to be entered as input;

- the 4 following columns refer to simple interim calculations that can be used in the calculation of Comparison (24);

- ‘var(r(t))’ refers to the result of Comparison (24) after this value has been divided by the quadratic waste generation in the reference year t_0 (here 1995); In this, the estimations of $\overline{t}$, $s_{g_0}^2$ and $s_{g_1}^2$ are used in the way they were previously derived at (the first estimation is always used); ‘sigr’ corresponds to the standard deviation;

- ‘r’ and ‘confr’ finally refer to the estimation of the decoupling indicator in Comparison (1) and the confidence interval that is equated with $t_{n-2,a/2}$ where n refers to the number of production years that is effectively being used in the trend analysis (this value is also part of the EVATREND output: see NY at the top of Table 4.2). The significance level a can be chosen and needs not necessarily be equal to 0,05. In this example, however, this value was chosen so that the confidence interval corresponds to a 95 % confidence interval.

The calculation for the reference year 1996 occurs in an identical manner: in this case, the values in Tables 4.5 and 4.6 as of 1996. The change of the reference year does not, however, alter the results in Table 4.5, since the same estimated regression line is being used, thus keeping the uncertainty at the same level.

For a shifting reference year, the same calculations can be used for the reference years 1997 and 1998. The end result for production year t is in that case taken from the table where t_0=t-4 (for instance, for the year 2002, the result for the reference year 1998 is used).

Table 4.7 – Summary of the results for the estimation of the decoupling indicator and the 95% confidence interval

year	EVATREND						EVA	
	vav 1995		vav 1996		vav t-4		vav 1996	
	R	*confr*	r	*confr*	r	*confr*	r	*confr*
1995	0.000	*0.000*						
1996	-0.012	*0.036*	0.000	*0.000*			0.000	*0.000*
1997	0.006	*0.073*	0.018	*0.037*			-0.019	*0.306*
1998	0.006	*0.107*	0.018	*0.071*			0.059	*0.189*
1999	0.019	*0.140*	0.031	*0.103*	0.019	*0.140*	0.070	*0.166*
2000	0.041	*0.171*	0.053	*0.134*	0.053	*0.134*	0.064	*0.156*
2001	0.034	*0.201*	0.045	*0.163*	0.028	*0.129*	0.048	*0.172*
2002	0.024	*0.230*	0.036	*0.192*	0.017	*0.124*	0.071	*0.192*

Table 4.7 shows a summary of the results that are obtained for the decoupling indicator ‘r’ and the breadth of the 95 % confidence interval (‘confr’) for the different analyses. As a reference, also the result of the direct estimate based on the EVA results have been added.

The EVATREND results indicate that (in contrast to the EVA results) already since 1997 there has been a slight suspicion of positive decoupling. Other than that, there is no significant evidence of positive decoupling for any year.

Table 4.7 further shows that EVATREND leads only to significantly smaller confidence intervals and thus more accurate estimations when the difference between the year t and the reference year t_0 is smaller than or equal to 4 to 5 years.

While, in principle, one could hold that for each year the best estimation ought to be used, it is not advisable to mix the results issuing from a different definition of a reference year (although one could eventually replace the EVATREND result with the EVA result for the same reference year when this latter result shows a smaller confidence interval; however, the fact that in the first instance there is division by the weighted waste estimation in t_0 and in the second instance by the direct estimation in t_0 is somewhat misleading).

Also in the event of the shifted reference year, it is to be noted that in the calculation of the decoupling indicator for a given year, each time a different value has to be used for the waste volume $m(t_0)$ when calculating the decoupling indicator. This, however, is in this case a lesser problem in the interpretation since a consistent procedure is being used (each time a shift of 4 years).

It is indeed to be noted that for each of the results the confidence interval can only be used to check whether or not it contains the 0- value.

In summary, it may be concluded from this application example that the best estimations of the waste indicator point to a positive decoupling for the waste generation rather than a negative one. Nonetheless, the estimated decoupling is on the weak side and, because of estimation errors, the decoupling cannot be statistically demonstrated with sufficient reliability. To this end, further monitoring of the waste generation is needed.

4.3 Attachment 3: List of the literature

Smeets, K., Umans, L., Van Acoleyen, M. (2003). Bedrijfsafvalstoffen. Cijfers en trends voor productie, verwerking, invoer en uitvoer, OVAM, Mechelen. P.315

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OECD (2004).Towards Waste Prevention Performance Indicators (ENV/EPOC/WGWPR/SE(2004)/FINAL). OECD. P. 197

Van Dijck, J. (2004). Hypothesis testen van indicatoren voor het afvalstofbeleid. Probabilitas, Heverlee. P. 23

De Baere, P. (2004). Resultaten bedrijfsenquête eco-efficiëntie 2004. OVAM, Mechelen. P. 21

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Putseys, L., De Roover, G., (2003). Indicatoren voor de preventie van huishoudelijke afvalstoffen in Vlaanderen. OVAM, Mechelen. P. 47