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THE COMMON AGRICULTURAL POLICY AND THE GREENHOUSE GASES EMISSIONS

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The Common Agricultural Policy and the greenhouse gases emissions

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Abstract.

The evolution of greenhouse gases emissions in the EU-15 countries is accessed. While the absolute level of emissions turns out to be declining in the last thirty years in EU-15 Member States, emissions per output tend to rise. A relationship between the adoption of the Common Agricultural policy and the emissions level can be detected for Spain, Austria, Finland and Sweden.

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1. Introduction

It is well known and documented that the implementation of the Common Agricultural Policy (CAP) brought about important productivity increases in member state agricultural sectors.¹

For more than 30 years the driving engine of agricultural development in the European Economic Community was the CAP price policy. Highly supported producers prices led to the adoption of new, or improved, technologies based upon higher mechanization, better plant and animal breeding, and increased use of fertilizers and pesticides. This policy produced not only the initially desired results but ended by overshooting some of them.

The sound increases in productivity boost domestic supply, bringing self-sufficiency for almost all the agricultural commodity markets and generated sizeable excess supplies in quite a few. For crops the price induced increased supply was to a large extent due to yield increases.

But it was not until the early nineties that policy makers started to worry about the overshooting effects of CAP. The McSharry reform of 1992 was the first sign of a different approach to farm income support as well as the first alert to the agriculture's role in both environment protection and disruption.

Amidst the ongoing environment discussions and world wide preoccupations, greenhouse gases (GHG) emissions play an important role. Although agriculture is not the major responsible for GHG emissions it cannot be excluded from the list of important contributors to the dangerous green house effect, which consequences on future climate changes are not fully known but, very likely, will be important.

The theme of gaseous emissions from agricultural activity has been addressed by individual researchers as well as by international organizations like the Food and Agriculture Organization (FAO) of the United Nations (UN) and the Organization for Economic Cooperation and Development (OECD). FAO² estimated gaseous emissions of ammonia (NH₃), nitric oxide (NO) and nitrous oxide (N₂O) from agricultural land in

¹ Annual Reports on the Situation of Agriculture, published by the European Commission, clearly illustrate this behaviour although the rates in productivity increase differ among Member states.

² FAO (2001)

17 regions of the world in 1995. OECD³ evaluated the agricultural GHG emissions in its member countries (except for Korea and Mexico) for the 1990-92 and 1995-97 periods. Both studies are concerned with the methods and techniques to measure emissions and its application to get global emission values originating in both crop and livestock production. None of them attempts to relate emission values with economic indicators or computes time series long enough to give an idea of the evolution of emission levels in the recent past.⁴

The purpose of this work is then twofold. First to establish, for the EU-15 member states, as long as possible time series for GHG emissions, expressed in Mg (metric tonnes) of CO₂ as well as in terms of Mg of CO₂ per Agricultural Gross Value Added (AgGVA). Secondly, try to relate the evolution of these values with the presence or absence of CAP implementation.

In the next section the sources of emissions are identified and the evaluation process used is described, given the data availability restrictions. In section 3. the evolution of emission levels is analysed and average annual change rates are computed. Section 4. is devoted to the attempt of relating this evolution with the agricultural policy pursued in the EU. Some concluding remarks are presented in the last section.

2. Greenhouse gases emissions from agriculture

The green house effect is the result of emissions of three gases: carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O).

Emissions of carbon dioxide result from both croplands and permanent grasslands; methane is produced by livestock and by rice cultivation; and nitrous dioxide has both direct and indirect origins.

Direct emissions of N₂O come from the utilization of mineral fertilizers, the cultivation of organic soils (histosoils), and crop residuals and excreta from animals. Indirect emissions are due to NH₃ emissions/deposition from synthetic fertilizer use and grazing animals and are also due to nitrogen (N) leaching/runoff from synthetic fertilizer use and grazing animals.

In order to compute the emissions from these different sources we need to quantify:

- a) crop, permanent grass, histosoils and rice cultivated areas;

³ OECD (2001)

⁴ The OECD study only compares the 1990-1992 and the 1995-97 periods.

- b) crop residuals;
- c) number of animals in each category (dairy cows, other cattle, pigs, sheep and goats, horses and donkeys, poultry and hens, and buffalos);
- d) animal excreta from grazing animals;
- e) amount of N resulting from fertilizers applied;
- f) leaching/runoff coefficients;
- g) emission coefficients for the different sources.

While crop, permanent grass and rice cultivated areas and the number of animals are available from the EUROSTAT, AgrIs database, the area of histosols cultivated in the EU member states is not easy to obtain. Values for items b), d) and f) are not available also. Nevertheless the error involved in not computing emissions from these sources is negligible. The same can be said for rice cultivation (for which CH₄ emission coefficients are hard to establish), insofar as only four EU-15 countries produce rice, and the volume of emissions from this source is also relatively small.

As to the emission coefficients, we used the EMEP/CORINAIR⁵ values that are showing in Tables A.1 to A.5 in the Annex A.

The annually volume of GHG emissions for each of the fifteen countries was then computed using the following equations:

Carbon dioxide

$$CO_2 (Mg) = 15 \times \text{Arable land area (ha)} + 10 \times \text{Permanent grassland area (ha)}$$

Methane emissions

$$CH_4 (Mg) = \sum_i ef_i \times \text{Number of animals}_i + \sum_i mm_i \times \text{Number of animals}_i$$

Nitrous oxide

$$N_2O (Mg) = 0.0125 \times \text{Total N applied (Mg)} + 0.01 \times (\text{NH}_3 + \text{NO}) \text{ emitted (Mg)}$$

Ammonia

$$NH_3 (Mg) = \sum_j cf_j \times \text{N applied with fertilizer}_j (Mg) + \sum_k mm_k \times \text{Number of animals}_k$$

Nitric oxide

$$NO (Mg) = 0.007 \times \text{Total N applied (Mg)}$$

⁵ European Environment Agency (2004)

The volume of GHG emissions in terms of CO₂ equivalent is then given by

$$GHG \text{ (Mg of CO}_2 \text{ equivalent)} = CO_2 \text{ (Mg)} + 21 \times CH_4 \text{ (Mg)} + 310 \times N_2O \text{ (Mg)}$$

where 1, 21 and 310 are the Global Warming Potentials (GWP's) over 100 years for the three gases.

The emissions values showing in Annex B were computed in this manner.

3. Evolution of greenhouse gasses emissions in the recent past

From Figure B.1 in Annex B the impression one gets is that the level of GHG emissions has been declining in absolute terms for the vast majority of EU Member States. In fact the only exception is Germany that experiences a sudden increase in emissions after 1991 (year of reunification) which is not surprising given the increase in arable land and livestock numbers. But after this jump, in more recent years, the emissions tend again to decrease.

It is also interesting to compare the values we obtained with those of OECD (2001). The results are showing in Table 3.1.

The first conspicuous fact emerging from the table is that our computations give much larger emission values. Though, this is not surprising due to one important difference between the two approaches. While in the OECD study, emission coefficients from croplands and permanent grasslands were equal to 3.7 and 1 Mg of CO₂ / ha / year respectively, we used the EMEP/CORINAIR recommended values of 15 and 10 Mg of CO₂ / ha / year.⁶ In addition the OECD study includes emissions from fossil fuel combustion in agriculture, which are not taken into account in our computations, and do not seem to be very important.

Given these differences the two sets of figures in Table 3.1 look much more compatible, even

because different countries have different proportions of crop and permanent grasslands.

⁶ Based on more recent measures for Europe, European Environment Agency (EMEP/CORINAIR) recommended values are 15 ± 5 and 10 ± 5 Mg of CO₂ / ha / year for croplands and permanent grasslands respectively.

Table 3.1 - Total national emissions of agricultural greenhouse gases
(million Mg)

| | OECD (2001) | | Our computations | |
|-----------------------|-------------|---------|------------------|---------|
| | 1990-92 | 1995-97 | 1990-92 | 1995-97 |
| Belgium | 13 | 15 | 23 | 24 |
| Denmark | 18 | 18 | 47 | 48 |
| Germany | 70 | 65 | 244 | 275 |
| Greece | 15 | 14 | 56 | 45 |
| Spain | 43 | 43 | 349 | 339 |
| France | 98 | 95 | 422 | 420 |
| Ireland | 20 | 20 | 60 | 61 |
| Italy | 50 | 51 | 215 | 192 |
| Luxembourg | 1 | 1 | 2 | 2 |
| Netherlands | 26 | 27 | 36 | 35 |
| Austria | 5 | 5 | 46 | 45 |
| Portugal | 8 | 8 | 48 | 47 |
| Finland | 7 | 6 | 41 | 35 |
| Sweden | 10 | 10 | 52 | 49 |
| United Kingdom | 55 | 54 | 231 | 220 |

Sources: OECD (2001) and computed

In the whole our computations are 2 to 5 times larger than the OECD ones, the only exceptions to this pattern being Spain and Austria. For Austria the reason for our figures being almost ten times larger is that in the OECD study CO₂ emissions are not included for this country. As to Spain there is no such indication, but the size of its agricultural sector being about 2/3 of the French one raises the suspicion that OECD values are under estimated.

But from an economic analysis point of view the interesting exercise is to relate these values with economic variables and analyse its evolution as well as its possible connections with policy decisions.

OECD (2001) suggests that one can get information on the economic efficiency of energy use in agriculture and its environment implications by calculating GHG emissions per unit of output.

The most obvious (and also easy to get data on) variable to use as output indicator is the agriculture value added in real terms. Using EUROSTAT, AgrIs data for the Agricultural Gross Value Added (AgGVA) and GDP deflator we computed values showing in Table 3.2

Table 3.2 - GHG emissions in CO₂ equivalent / Real AgGVA (Mg of CO₂ / Mio EUR)

| | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Belgium | | | | | | | | 771,684 | 736,475 | 761,223 | 747,213 | 765,481 | 796,685 | 785,177 | 830,207 | 813,757 |
| Denmark | 878,856 | 907,395 | 1,098,102 | 1,032,427 | 969,124 | 975,382 | 1,129,450 | 1,252,093 | 1,239,822 | 1,136,167 | 1,316,370 | 1,081,534 | 1,159,648 | 1,113,005 | 1,350,709 | 1,335,071 |
| Germany | | | | | | | | | | | | | | | | |
| Greece | | | | | | | | | | | | | | | | |
| Spain | | | | | | | | | | | | | | | | |
| France | | | | | | | | 1,126,260 | 1,178,767 | 1,102,660 | 1,251,464 | 1,319,757 | 1,335,231 | 1,373,575 | 1,439,237 | 1,497,634 |
| Ireland | | | | | | | | | | | | | | | | |
| Italy | | | | | | | | 350,143 | 397,235 | 432,343 | 422,833 | 473,886 | 502,643 | 520,228 | 542,407 | 593,485 |
| Luxembourg | | | | | | | | | | | | | 1,504,734 | 1,395,624 | 1,401,314 | 1,420,810 |
| Netherlands | | | | | | | | | | | | | | 442,489 | 427,207 | 415,498 |
| Austria | | | | | | | | | | | | | | | | |
| Portugal | | | | | | | | | | | | | | | | 1,392,495 |
| Finland | | | 871,763 | 818,587 | 957,139 | 1,081,439 | 1,131,963 | 1,017,831 | 1,086,498 | 924,410 | 907,208 | 862,226 | 913,917 | 901,218 | 1,297,397 | 1,257,934 |
| Sweden | | | | | | | | 1,274,790 | 1,116,546 | 1,146,534 | 1,495,880 | 1,261,439 | 1,553,976 | 1,635,549 | 1,802,404 | 1,795,602 |
| U K | 1,057,829 | 1,154,046 | 1,304,781 | 1,334,098 | 1,445,669 | 1,548,716 | 1,563,344 | 1,550,996 | 1,430,226 | 1,362,925 | 1,537,724 | 1,409,540 | 1,651,258 | 1,860,151 | 1,917,921 | 1,910,797 |

Source: Computed

Table 3.2 (cont.) - GHG emissions in CO₂ equivalent / Real AgGVA (Mg of CO₂ / Mio EUR)

| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|-------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Belgium | 692,968 | 745,959 | 754,662 | 775,082 | 798,652 | 811,285 | 859,914 | 844,253 | 833,392 | 891,279 | 964,890 | 915,049 | 896,594 | 1,007,566 | 980,914 |
| Denmark | 1,186,630 | 1,196,295 | 1,282,730 | 1,363,778 | 1,383,104 | 1,311,489 | 1,161,350 | 1,298,912 | 1,368,570 | 1,709,338 | 1,775,996 | 1,562,911 | 1,286,914 | 1,631,867 | 1,695,087 |
| Germany | | | 1,786,714 | 1,853,509 | 1,849,991 | 1,866,902 | 1,729,087 | 1,682,275 | 1,709,694 | 1,815,650 | 1,786,231 | 1,574,211 | 1,382,199 | 1,711,942 | 1,806,440 |
| Greece | | | | | 662,549 | 646,205 | 670,500 | 740,872 | 307,035 | 330,332 | 954,808 | 1,003,769 | 1,009,988 | 792,864 | 828,856 |
| Spain | | 1,363,872 | 1,424,329 | 1,713,294 | 1,771,944 | 1,670,343 | 1,764,422 | 1,572,596 | 1,562,026 | 1,559,412 | 1,530,473 | 1,448,016 | 1,373,682 | 1,471,945 | 1,383,977 |
| France | 1,369,410 | 1,317,641 | 1,497,193 | 1,431,823 | 1,493,497 | 1,397,032 | 1,360,831 | 1,376,516 | 1,391,010 | 1,355,047 | 1,380,749 | 1,386,139 | 1,408,007 | 1,448,221 | 1,507,686 |
| Ireland | | 1,857,503 | 1,974,008 | 1,761,309 | 1,922,332 | 1,980,000 | 2,001,974 | 2,030,668 | 2,167,798 | 2,445,778 | 2,771,430 | 2,626,301 | 2,966,068 | 3,269,024 | 3,194,371 |
| Italy | 562,547 | 663,988 | 623,842 | 653,488 | 757,394 | 772,074 | 816,266 | 730,907 | 715,846 | 731,877 | 742,139 | 758,939 | 746,324 | 779,545 | 771,768 |
| Luxembourg | 1,281,656 | 1,338,661 | 1,652,579 | 1,446,719 | 1,467,412 | 1,525,595 | 1,400,389 | 1,569,456 | 1,815,970 | 1,649,672 | 1,576,318 | 1,813,638 | 1,746,121 | 1,744,190 | 1,818,499 |
| Netherlands | 363,502 | 364,073 | 356,871 | 366,007 | 396,591 | 370,430 | 361,527 | 372,066 | 402,007 | 389,235 | 421,213 | 402,831 | 407,000 | 443,952 | 449,595 |
| Austria | | 1,157,818 | 1,189,697 | 1,305,300 | 1,316,611 | 1,306,522 | 1,399,294 | 1,540,653 | 1,645,350 | 1,725,995 | 1,727,808 | 1,698,151 | 1,604,313 | 1,709,684 | 1,788,636 |
| Portugal | 1,222,129 | 1,196,587 | 1,336,391 | 1,768,030 | 2,086,081 | 1,841,104 | 1,753,620 | 1,699,718 | 1,933,225 | 1,985,529 | 1,742,662 | 1,901,166 | 1,588,667 | 1,687,352 | 1,639,064 |
| Finland | 1,051,844 | 1,068,960 | 1,362,474 | 1,744,704 | 1,742,501 | 1,815,638 | 2,136,206 | 2,192,627 | 2,307,042 | 3,374,710 | 2,916,531 | 2,537,808 | 2,578,686 | 2,583,905 | 2,778,691 |
| Sweden | 1,704,009 | 1,911,421 | 2,232,946 | 2,578,538 | 2,831,913 | 3,009,040 | 2,949,999 | 2,899,230 | 2,842,495 | 3,045,891 | 3,472,281 | 3,034,335 | 3,339,859 | 3,357,094 | 3,405,344 |
| U K | 1,873,435 | 1,967,259 | 1,995,036 | 2,016,523 | 1,872,090 | 1,793,694 | 1,783,591 | 1,871,766 | 1,980,445 | 2,177,831 | 2,229,522 | 2,194,443 | 1,790,573 | 1,570,100 | 1,787,716 |

Source: Computed

Looking at the table it is evident that, contrary to its absolute values counterparts, GHG emissions per Agricultural Gross Value Added have been increasing for the last thirty years. The same conclusion can be drawn if we take the 3 year moving averages of these values, as depicted in Figure 3.1.

To get a more accurate perspective on this evolution we estimated the linear trends for the values in Table 3.2 as well as for its 3 year moving averages values.

For that purpose we estimated the following equation for each country

$$[3.1] \quad \frac{GHG}{AgGVA} = \alpha + \beta T$$

where $GHG/AgGVA$ = volume of emissions in Mg of CO₂/AgGVA per year

T = year

and α and β are parameters

The results are presented in Table 3.3, where average annual rates of change are also computed.

Table 3.3 – Emissions/value added: trend and annual rate of change

| | Linear trend coefficient β | | Annual average rate of change (%) | |
|-----------------------|----------------------------------|----------------------------|-----------------------------------|----------------------------|
| | Original series | Three year moving averages | Original series | Three year moving averages |
| Belgium | 9522.29 | 9302.78 | 1.05 | 1.15 |
| Denmark | 21082.76 | 19816.99 | 2.21 | 1.69 |
| Germany | -16983.83 | -26303.65 | 0.05 | -0.57 |
| Greece | 28658.68 | 38303.85 | 2.26 | 3.63 |
| Spain | -12887.50 | -21880.42 | 0.11 | -0.56 |
| France | 9984.73 | 8354.74 | 1.28 | 1.18 |
| Ireland | 116089.60 | 121439.20 | 4.26 | 4.86 |
| Italy | 18771.49 | 18914.40 | 3.50 | 3.23 |
| Luxembourg | 24156.15 | 26314.02 | 1.06 | 1.32 |
| Netherlands | 1581.48 | 1988.66 | 0.09 | 0.08 |
| Austria | 49392.57 | 50114.38 | 3.40 | 3.09 |
| Portugal | 27477.08 | 30171.91 | 1.09 | 1.98 |
| Finland | 79187.80 | 81855.59 | 4.23 | 4.32 |
| Sweden | 111869.40 | 116337.20 | 4.36 | 5.12 |
| United Kingdom | 26211.73 | 27282.10 | 1.76 | 1.37 |

Source: Computed

While the annual average rates of change are all positive for the original series, its moving averages values confirm the decreasing trend observed for Germany and Spain.

The German case may find explanation in the fact that computations were made only for post reunification years, which softens the emission effects of a much higher intensity type of agriculture in the former West Germany. As to Spain there is no clear cut explanation for the reduction in the emissions/value added ratio.

The observed tendency for decline in the volume of emissions can be seen as positive in view of the Kyoto protocol targets, although agricultural emissions represent only around 8 percent of total emissions in OECD countries.⁷

But our objective was a little more ambitious than the simple computation of emissions evolution figures. The idea was to relate this evolution with the implementation of CAP. This is tried in the next section.

⁷ OECD (2001)

4. Does the Common Agricultural Policy matter?

One possible way to access the existence of a relationship between CAP implementation and GHG emissions is to compare its levels before and after a country joined the EU. Unfortunately this exercise cannot be performed for the fifteen member states insofar our database starts in 1973 and thus there are no observations for the six founding fathers of the European Economic Community *before* they joined the Community. The same applies to Denmark, Ireland and the United Kingdom that became members in 1973. Our analysis is then confined to the remaining six countries: Greece, Portugal, Spain, Austria, Finland and Sweden.

To access the possible impact of CAP in the evolution of GHG emissions we modified the trend equation [3.1] that was estimated for each country.

The modification consisted in adding a new variable, defined as $(X_1 - X_2)$, to equation and thus getting the absolute volume of GHG emissions

$$[4.1] \quad GHG = \alpha + \beta T + \gamma (X_1 - X_2)$$

where $X_1 \left\{ \begin{array}{l} = 1 \text{ in the years before joining the EU} \\ = 0 \text{ in the years after joining the EU} \end{array} \right.$

and $X_2 \left\{ \begin{array}{l} = 0 \text{ in the years before joining the EU} \\ = 1 \text{ in the years after joining the EU} \end{array} \right.$

So the variable $(X_1 - X_2)$ takes the value 1 in the years before EU accession and the value -1 in the years after accession.

Then, if $\gamma > 0$ and statistically significant we conclude that in pre-accession years the volume of GHG emissions was increased. In other words, after accession the volume is decreased.

If $\gamma < 0$ and statistically significant we conclude that after accession the volume of GHG emissions increases. In other words, adoption of CAP caused higher volumes of emissions.

If γ is not statistically significant, then nothing can be concluded.

The estimation results for equation [4.1] are shown in Table 4.1 and the graphs for the adjustments are in Annex C.

Table 4.1 – GHG emissions evolution estimation results

| Country | γ | t-statistic | Probability (%) | R ² |
|-----------------|-----------|-------------|-----------------|----------------|
| Spain | -13814552 | -3.527632 | 0.15 | 0.83 |
| Greece | -1539395 | -1.236942 | 22.64 | 0.58 |
| Austria | 234991.9 | 2.801867 | 0.91 | 0.95 |
| Portugal | 293194.7 | 0.429116 | 67.11 | 0.86 |
| Finland | 2061209 | 7.945206 | 0.00 | 0.86 |
| Sweden | 1227443 | 4.999747 | 0.00 | 0.92 |

Source: estimated

For Spain, Austria, Finland and Sweden it appears that CAP adoption had an impact on the GHG emissions level. While for Spain the level of emissions increased after adoption, for the remaining three countries it looks like the CAP had a beneficial effect on the level of emissions. The γ coefficient for Greece and Portugal is not significantly different from zero and so nothing can be concluded in these cases. The same conclusions are apparent from the graphs in Annex C where the change in emissions level is well marked for Spain, Austria, Finland and Sweden.

If we now turn to the analysis of the evolution of emissions per value added, the sample of countries is further reduced to three: Austria, Finland and Sweden. This is because, as it can be seen in Table 3.2, for Spain, Greece and Portugal the absence of values for AgGVA before EU accession does not allow the computation of emissions per value added.

Using the equation [4.1] with the left hand-side divided by AgGVA we obtained the estimates of γ showing in Table 4.2 and the graphs of Annex D.

Table 4.2 – GHG/AgGVA emissions evolution estimation results

| Country | γ | t-statistic | Probability (%) | R² |
|----------------|-----------|--------------------|------------------------|----------------------|
| Austria | -77899.95 | -2.177702 | 5.21 | 0.91 |
| Finland | -436357.5 | -4.915332 | 0.00 | 0.89 |
| Sweden | 27381.09 | 0.333733 | 74.19 | 0.94 |

Source: estimated

Table estimates reveal that for Austria and Finland GHG/AgGVA emissions increased with the adoption of CAP, while for Sweden nothing can be concluded.

5. Concluding remarks

Despite the limitations of the analysis, namely not including emissions from histosoils cultivation, from crop residuals, leaching/runoff and fossil fuel combustion, the evidence gathered leads to the general conclusion that, during the last thirty years, the GHG emissions originated in the agricultural sectors of the EU-15 member States under observation experienced a decline in its absolute level.

Amazingly the evolution for emissions per value added point towards the opposite direction. Except for Germany and Spain, emissions per output show a positive trend.

The decline in the absolute volume of emissions can be explained by two major facts. On the one hand arable land has remained constant or even decreased for a few countries. On the other hand after the eighties the reduction in the amount of nitrogen applied in fertilization is a common feature for all countries.

The increase in emissions per output denounces a loss in economic efficiency in energy use in agriculture.

Relationships between CAP adoption and the absolute level emissions could be detected for Spain, Austria, Finland and Sweden. While for Spain it looks like the policy effect was negative, for the other three countries it looked positive.

On the other hand CAP adoption seems to have caused jumps in the level of emissions per value added in Austria and Finland while no effect could be detected for Sweden.

A final word of caution has to be said. The coefficients showing in tables of Annex A were the same for all countries in our sample. The analysis would benefit from the adoption of specific coefficients according to each country particular conditions in land use and livestock management.

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ANNEX A

Table A.1 – Carbon dioxide emission coefficients
(Mg of CO₂ / ha / year)

| | CO ₂ emission coefficients |
|----------------------------|---------------------------------------|
| Cropland | 15 |
| Permanent grassland | 10 |

Source: EMEP/CORINAIR

Note: Mg = Megagramme = 1 metric tonne

Table 2.2 – Methane emission coefficients
(Kg of CH₄ /animal /year)

| | CH ₄ emission coefficients | |
|------------------------|---------------------------------------|-------------------|
| | Enteric fermentation | Manure management |
| Dairy cows | 100 | 14 |
| Other cattle | 48 | 6 |
| Sheep | 8 | 0.19 |
| Pigs | 1.5 | 3 |
| Horses | 18 | 1.39 |
| Mules and asses | 10 | 0.76 |
| Goats | 5 | 0.12 |
| Poultry | not relevant | 0.078 |

Source: EMEP/CORINAIR

Table A.3 – Nitrous oxide emission coefficients

| | N ₂ O emission coefficients |
|---------------------------|--|
| Direct emissions | 0.0125 Mg of N ₂ O / Mg of N applied / year |
| Indirect emissions | 0.011 Mg of N ₂ O / Mg of (NH ₃ + NO) applied / year |

Source: EMEP/CORINAIR

Table A.4 – Ammonia emission coefficients

| | NH₃ emission coefficients |
|--|--|
| <i>Cultures with fertilizers</i> | <i>Mg of NH₃ / Mg of N applied / year</i> |
| | <i>(cf_i)</i> |
| Ammonium nitrate | 0.02 |
| Ammonium sulphate nitrate | 0.05 |
| Ammonium sulphate | 0.08 |
| Calcium ammonium nitrate | 0.02 |
| Calcium cyanamid | 0.02 |
| Calcium nitrate | 0.02 |
| Ammonia | 0.04 |
| Ammonium phosphate | 0.02 |
| Di-ammonium phosphate | 0.05 |
| Other complex fertilizers | 0.02 |
| Other nitrogenous fertilizers | 0.02 |
| Sodium nitrate | 0.02 |
| Urea | 0.15 |
| Mixed urea and ammonium nitrate | 0.08 |
| <i>Animal grazing</i> | <i>Kg / ha / year</i> |
| Permanent grassland | 4 |
| <i>Manure management</i> | <i>Kg / animal / year</i> |
| | <i>(mm_k)</i> |
| Dairy cows | 28.5 |
| Other cattle | 14.3 |
| Fattening pigs | 6.39 |
| Sows | 16.43 |
| Sheep | 1.34 |
| Goats | 1.34 |
| Horses, mules and asses | 8 |
| Laying hens | 0.37 |

Source: EMEP/CORINAIR

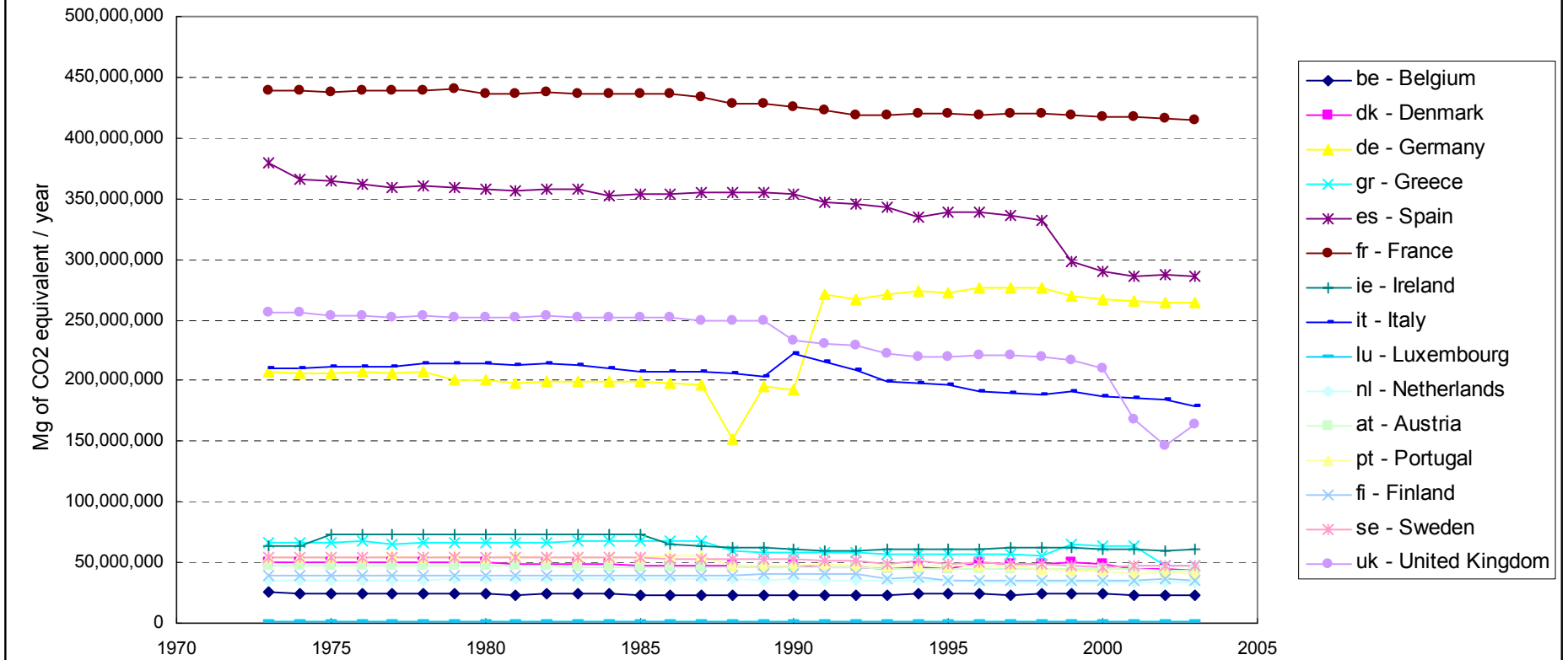
Table A.5 – Nitric oxide emission coefficients

| | NO emission coefficient |
|----------------------------------|---|
| Cultures with fertilizers | 0.007 Mg of NO / Mg of N applied / year |

Source: EMEP/CORINAIR

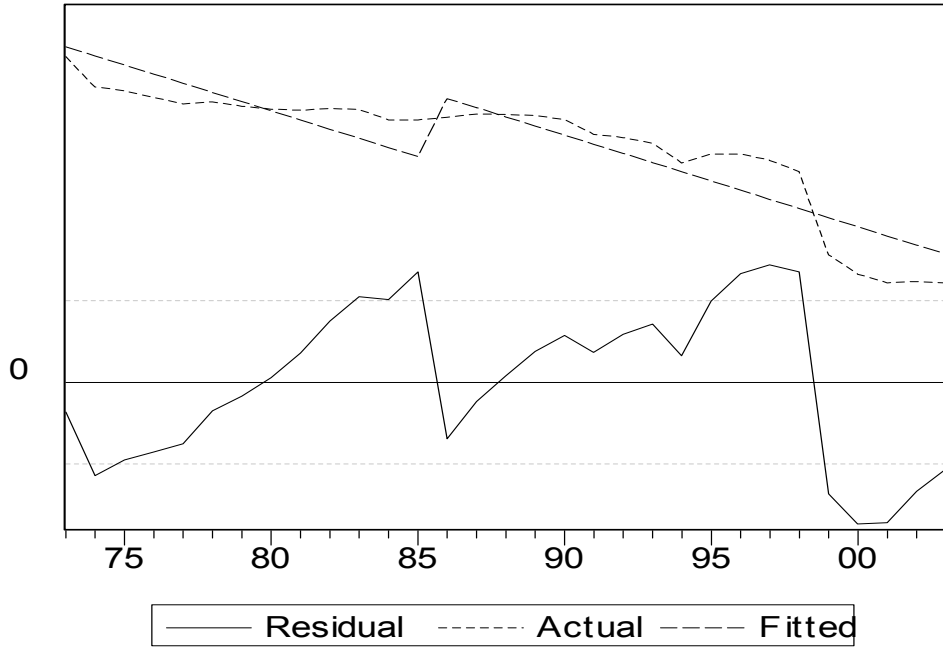
ANNEX B

Figure B.1 - GHG emissions

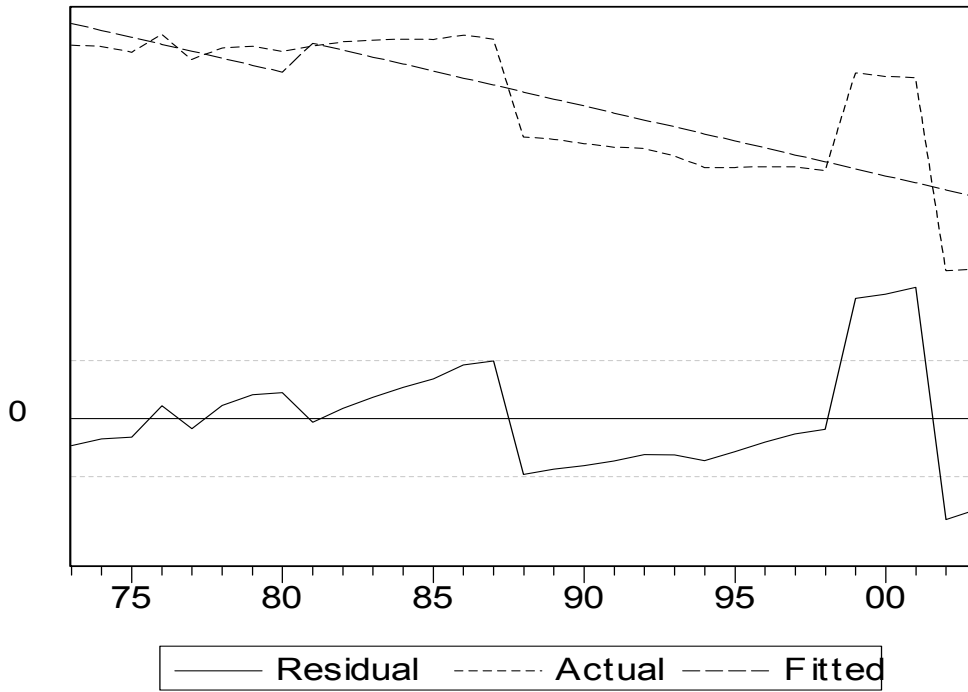


ANNEX C

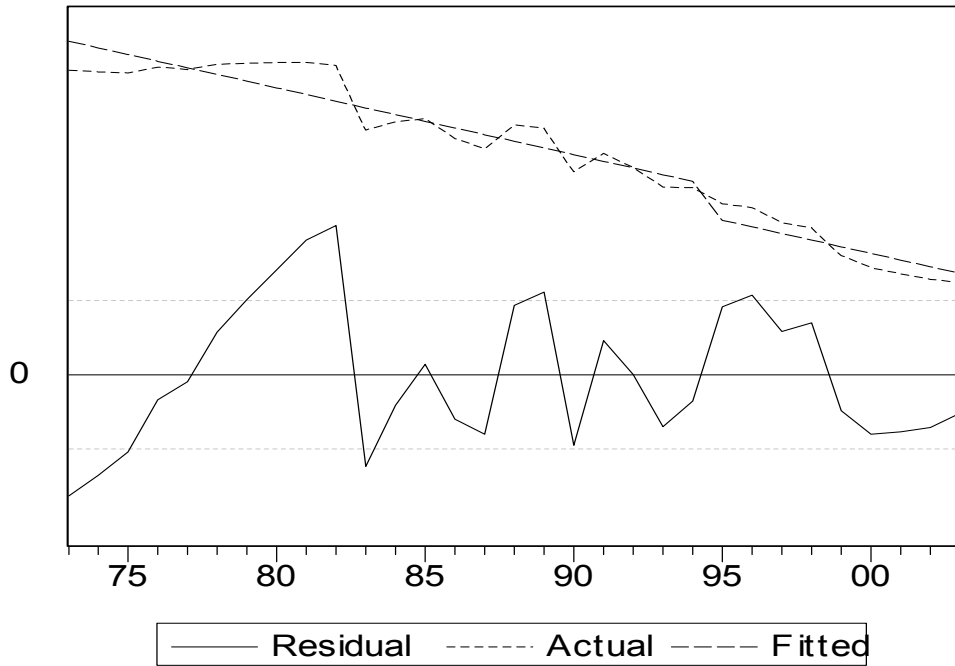
SPAIN - GHG emissions evolution



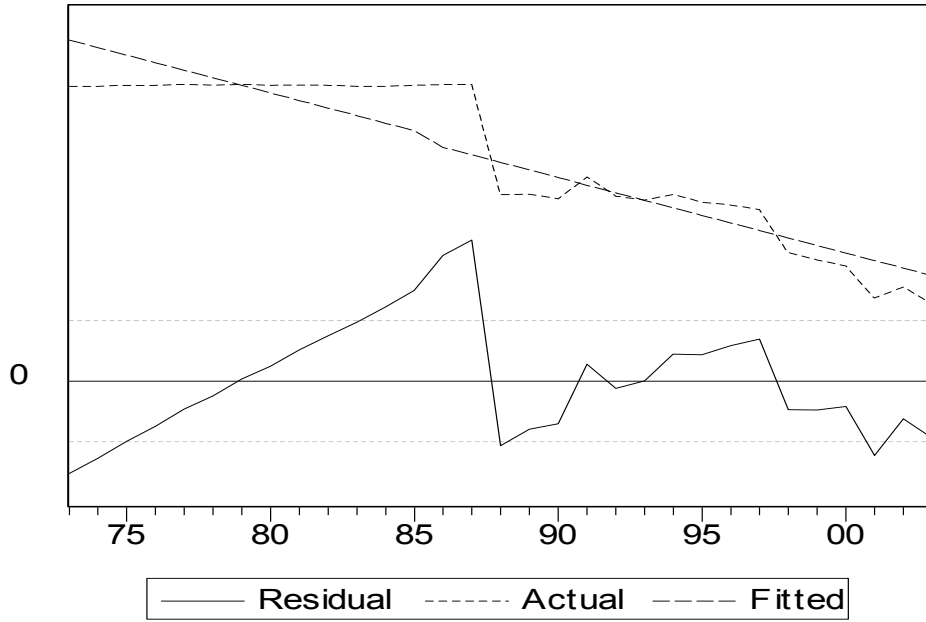
GREECE - GHG emissions evolution



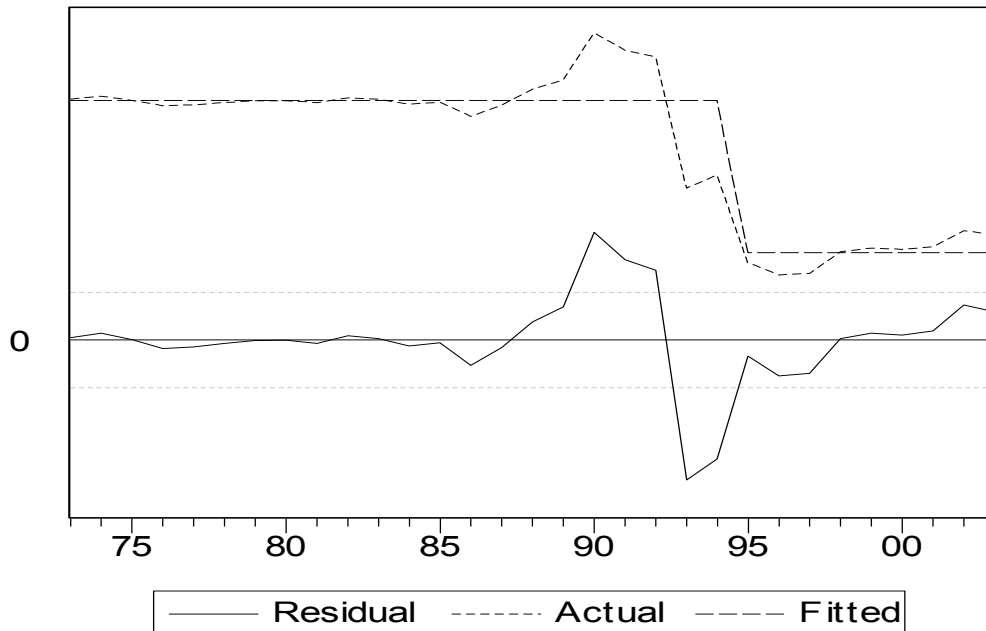
AUSTRIA - GHG emissions evolution



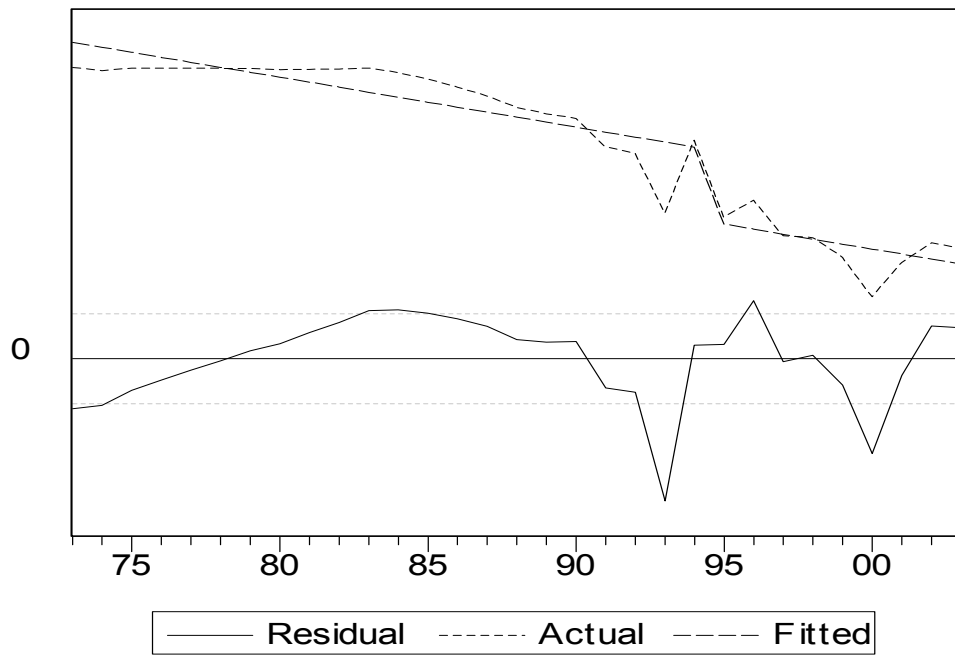
PORTUGAL - GHG emissions evolution



FINLAND - GHG emissions evolution

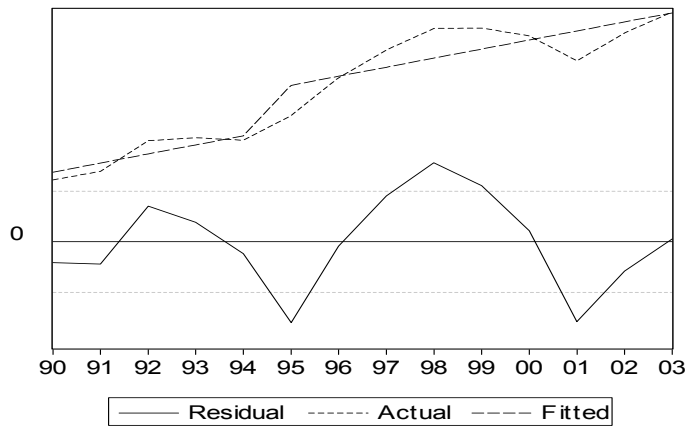


SWEDEN - GHG emissions evolution

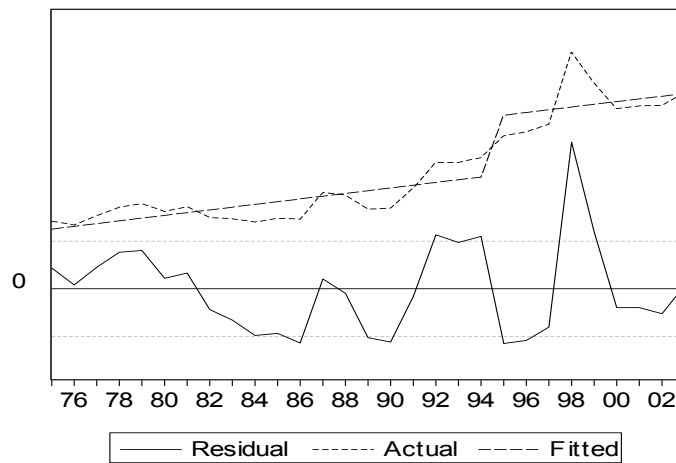


ANNEX D

AUSTRIA - GHG/GAVA emissions evolution



FINLAND - GHG/GAVA emissions evolution



SWEDEN - GHG/GAVA emissions evolution

