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Environmental Input-Output Analysis Based on NAMEA Matrix

Edyta Gajos[1], Konrad Prandecki[2]

[1,2]General Economics Department, Institute of Agricultural and Food Economics National Research Institute, Warsaw, Poland

***Corresponding Author:** Edyta Gajos, General Economics Department, Institute of Agricultural and Food Economics – National Research Institute, Warsaw, Poland*

ABSTRACT

The aim of the article is to incorporate some parts of environmental external effects into the input-output analysiscalculated on the NAMEA-Air boards. The study covered the issue of four gases listed in NAMEA-Air matrix, the emission valuation and the division between the sectors of the economy in terms of flows to and from agriculture were done. Presented results indicate the low impact of the environmental flows on the overall flows. It should be stressed, however, that this is the first attempt in Poland to estimate and incorporate part of the flows related to the environment into the input-output analysis. This attempt shows how much sectors that are apparently unrelated to the environment can be responsible for pollution by indirect consumption of goods coming from the coal-burning sectors.

Keywords: *NAMEA, Emissions, Input-Output Analisis, Environmental Flows, Agriculture, Poland*

INTRODUCTION

Due to the continuous growth of the human population, human influence on the environment is also increasing. Despite technical progress limiting this impact, humanity consumes more and more resources and increasingly affects natural processes occurring in nature. The scale of human pressure on the environment is difficult to estimate, but it is increasingly pointed out that the continuation of this behavior over the long term may result in catastrophic environmental change globally (Rockström et al., 2009; Steffen et al., 2015) and even the global catastrophe (Prandecki & Michałowski, 2016). For this reason, it is necessary to take remedial measures to take into account the effects of humans conduct in their activities. The first step for this purpose is to measure external effects - the effects of economic activity, which are not included in the economic account[1]. The next step is to include additional costs and benefits in the input-output analysis and by doing so to assess their impact on different sectors of the economy.

The purpose of this paper is to include some parts of environmental external effects, i.e. selected gases air emission cost, into the input-output analysis. The implementation of this objective makes it possible to show the environmental burden of sectors that are generally, but perhaps wrongly, considered low-carbon.

The study includes carbon dioxide, nitrous oxide, methane and nitrogen oxides. All these gases are very harmful and its emission to air is common, which justifies analyzing them in the first place. In addition, carbon dioxide, nitrous oxide and methane are considered to be greenhouse gases that contribute significantly to climate change. This further emphasizes the importance of valuing their emissions. In the case of nitrogen oxides (as a group of compounds) their climate harm is not unequivocal, which makes them rarely described as greenhouse gases, but there are references in the literature indicating their harmfulness also in this regard.

Extending the input-output matrix with external environmental effects is difficult due to the limited availability of data from this topic. For this reason, authors have chosen to use international statistical data collected within the National Accounting Matrix with Environmental Accounts (NAMEA), which justified the choice of substances included in the study. This paper focuses on air emissions as they are best

[1] More about externalities and challenges associated with them in (Prandecki, Gajos, & Buks, 2015).

documented under the NAMEA-Air dataset. This makes it possible to compare flows in different European countries in the longer perspective. Such research and comparison of emissions with individual countries' economic situation may lead to interesting conclusions about the emission efficiency of individual economies.

Input-output tables show the changes, dynamics and dependences between different sectors of the economy. By including environmental factors in these tables the environmental impact of the relationship between the recipients of the good or service and the supplier at different stages of the production process is shown. In this way the environmental burden of any particular good and the economic dependences affecting the sustainable development of the country can be shown (Gajos & Prandecki, 2016). Often, these dependencies explain why pollution reduction initiatives do not deliver the expected results. Therefore, the input-output analysis is a complement to the indicator approach as a way of assessing the level of economy's sustainability.

METHODOLOGY

The study covered the input-output tables extended with air emissions listed in NAMEA-Air tables: carbon dioxide, nitrous oxide, methane and nitrogen oxides. The input-output tables were published by the Central Statistical Office in 2014 and include data for 2010. These are the latest national input-output tables that could be used.

The study was divided into two phases. The first one was the economic valuation of air emissions. This was a necessary condition for the second stage – the inclusion of these emissions into classical input-output tables.

The economic valuation of air emissions was started with its unifying –emissions were brought to carbon dioxide equivalent by using the global warming potential (GWP) for greenhouse gases. Table 1 compares the different conversion factors for carbon dioxide, methane and nitrous oxide. Differences in values are due, among others. the adopted period (20 or 100 years) for which the warming potential is calculated. Authors decided to adopt the latest data included in the fifth IPCC (2013) - AR5 report (Table 1). This decision results from their widespread use in scientific studies and a thorough justification for the applied potential converters. In addition to the already discussed gases information on nitrogen oxides (NO_x) emissions is available in the NAMEA database. This is a group of gases that affect the climate in a variety of ways, which is a major handicap for precisely determining carbon dioxide equivalents. In this work, based on the literature (Hock & Tribe, 2011) it was assumed that the GWP conversion factor for nitrogen oxides was 0.7[2].

Table1. *Harmfulness of methane and nitrous oxide on the equivalent of carbon dioxide*

Compound	**Chemical formula**	**Global Warming Potential)**		
		SAR	AR4	AR5
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrousoxide	N_2O	310	298	265

GWP calculated in a 100-year time horizon;

SAR – Second Assessment Report –IPCC;

AR4 – FourthAssessment Report – IPCC;

AR5 – Fifth Assessment Report –IPCC.

Source: *own study based on (IPCC, 2013; Solomon et al. 2007).*

The price of rights to emit carbon dioxide connected with produce process from European Union's trading system of emission allowances was used to economic valuation of air emissions[3]. European Union Emission Trading System (EU ETS) is a market where all interested entities can buy rights to emit. This market is governed by the law of demand and supply - the use of the market value determined in this market allows us to take into account the real economic value of the emission of 1 tonne of carbon dioxide. Authors decided to use the quotations from the European Energy Exchange (EEX), based in Leipzig, Germany, which is one of the longest-running emit allowances trading markets (operating since 2008). For the purpose of the study, the average annual price of 1 tons of carbon dioxide emissions was calculated as the arithmetic mean of the daily quotations of emission rights.

[2]A more detailed presentation of method used in the study can be found in (Prandecki & Gajos, 2017).

[3]Emissions trading are one of the mechanisms set out in the Kyoto Protocol. Its goal is to reduce emissions of greenhouse gases that have been identified as the most dangerous. This solution is one way to implement the 1992 UN Convention on Climate Change. More on the United Nations' efforts to reduce climate change in (Prandecki & Sadowski, 2010).

In 2010 this price was EUR 14.34[4]. Subsequently, the value of the issue was converted into Polish zloty using the PLN/EUR exchange rate - the annual arithmetic mean of average daily exchange rates published by the National Bank of Poland was calculated[5]. In 2010, the average calculated PLN/EUR exchange rate was PLN 3.99 / EUR.

The second phase of the study consisted of implementing estimated air emissions into the standard input-output tables. To this end, emissions from a given sector were divided into shares that flowed to the other sectors of the economy. This division was done by a 1:1 ration relation to the standard input-output tables. Emissions from the sector are directly related to the production of goods and services. The flow of these goods and services between sectors determines the financial value of those flows. It is therefore reasonable to assume that the valuated environmental flows from given sector should be distributed proportionally to other sectors and to final consumption in relation to financial flows. Authors realize that this is not the ideal method because of the different emissions of different gases in the production of different goods and services, however at present, due to the lack of detailed data, it is not possible to assign separate allocation keys to individual gases. In addition, there is no similar study available in Polish literature, which further highlights the added value of the proposed solution.

Analysed substances, due to their influence on the climate, are considered to be greenhouse gases. In view of their harmfulness, authors decided to include them in the standard input-output tables as costs and thus subtract them from flows. As a result, the value of flows between sectors was reduced.

The data was derived from two sources: the input-output tables and NAMEA-Air tables. Both matrixes, although published by the same institution - the Central Statistical Office, differ slightly in the classification of economy sectors. Because of this, it was necessary to check the compatibility of the two classifications and, in some cases, to change the grouping in order to standardise the division into economy sectors in both matrixes. Authors are aware of the potential further minor inconsistencies, however, because of their minimal scope, they do not have a significant impact on calculations and results of the study. Due to the length of official sector names, authors use their own names, which are short for official names. Abbreviated names were used in the sectors selected for detailed discussion - in the field of flows from agriculture the sectors with a flow of more than PLN 100 million were selected, and in the case of flows to agriculture the sectors with a flow of over PLN 500 million were selected. Where it was necessary to indicate other sectors in the paper, the original names of the matrix discussed in that part of the study were used.

Input – Output Analysis

In Poland, the input-output tables are published every five years. The latest publication from 2014 (GUS, 2014) presents data for 2010. In total, products of the value of PLN 3 464.1 billion were produced in the Polish economy, of which PLN 1 569.2 billion fall on intermediate consumption, and 1 894, PLN 9billion on final consumption. The sectors with the largest production are: Constructions and construction works - PLN 297.5 billion; *Food sector* - 205.7; *Wholesale trade* - 160.2; *Retail trade*- 146.6; *Motor vehicles* - 145.4; *Real estate market* - 136.4; *Land and pipeline transport* - 119,9; *Agriculture* - 112.5; *Computer, electronic and optical products* - 106; *Chemicals and chemical products* -102.5 and *Electricity, gas, steam and air conditioning* - 102.4.

In the paper, authors focus on intermediate consumption in selected sectors of the economy linked to agriculture (Table 3). The selection criteria for the sectors were set out in methodology. The aim was to show the impact of one of many environmental factors on input-output flows linked to agriculture.

As shown in Table 2, the share of intermediate consumption in *Agriculture* is almost 55%, which is about 10 percentage points higher than the average for the whole economy (45%). The relationship between intermediate consumption and final demand is due to the specific nature of the sector, i.e. the high share of agricultural processing in high-developed countries. This means that *Agriculture* is most closely linked to the *Food sector*. The highest value of products is consumed by this sector - less than PLN 39.1 billion, i.e. 63.1% of intermediate consumption (Table 3). It is also worth noting that products of *Food sector* are an important factor for further agricultural production (mainly feed). This consumption amounts to PLN 10.6 billion, which represents 20.6% of the flows to *Agriculture*

[4] More detailed information on EU-ETS system, evaluation method and its limitations can be found in (Prandecki & Gajos, 2017).

[5] http://www.nbp.pl/home.aspx?f=/kursy/arch_a.html

described in this article, and less than 19.5% of total intermediate consumption used by *Agriculture*. As a result, there may be some feedback - an increase in demand for meat (*Agriculture*) causes an increased demand for feed (*Food Sector*), which in turn requires an additional flow of agricultural products necessary for the feed production.

Table2. *Intermediate consumption and final demand in selected economy sectors (PLN millions)*

Products (PKWiU 2008)	Intermediate consumption	Final demand	Total intermediate consumption and final demand	Percentageof intermediate consumption
Public administration	6494,2	91784,9	98279,1	6,61 %
Chemicals and chemical products	65010,2	37485,6	102495,8	63,43 %
Electricity, gas, steam and air conditioning	67721,0	34633,2	102354,2	66,16 %
Mining and quarrying	85449,5	9293,8	94743,3	90,19 %
Retail trade	38340,0	108231,5	146571,5	26,16 %
Wholesale trade	86326,6	73866,5	160193,1	53,89 %
Coke, refined petroleum products	48971,6	24560,9	73532,5	66,60 %
Machinery and other equipment	23779,7	53849,9	77629,6	30,63 %
Agriculture	61854,6	50670,0	112524,6	54,97 %
Real estate market	29460,0	106964,1	136424,2	21,59 %
Security and office maintenance	21466,2	7108,8	28575,0	75,12 %
Food sector	69140,8	136521,2	205662,0	33,62 %
Accommodation and food services	8777,8	28363,7	37141,5	23,63 %
Land and pipeline transport	75702,5	44216,8	119919,4	63,13 %
Financial services	34381,2	23931,7	58312,8	58,96 %
Veterinary and other professional services	8609,0	6400,5	15009,5	57,36 %
Fabricated metal products	56146,7	30251,9	86398,7	64,99 %
Rubber and plastic products	52188,7	24791,9	76980,6	67,79 %

Source: "*own study based on (GUS, 2014)*"

In terms of intermediate consumption, the self-supply in Agriculture is also worth noting, i.e. high intermediate consumption within the sector – PLN 19 billion (30.7%). The high value of self-supply comes from the specifics of Polish agriculture, i.e. Functioning of many self-supply farms, where production is mostly for own use. It is an element of tradition, lifestyle, or a way to provide products of the right quality. In Poland there were 509 thousand self-supply farms[6] in 2010, which accounted for 34.1% of total number of farms (Toczyński, Wrzaszcz & Zegar, 2013).

Environmental Flows Based on NAMEA-Air Tables

National Accounting Matrix with Environmental Accounts tables - NAMEA - are developed and published by Eurostat in cooperation with EU-member countries (however providing Eurostat with necessary data is not obligatory). Tables include data on emissions to the environment by each economy sector. Their main purpose is to incorporate data on environmental emissions into standard input-output analysis (Eurostat, 2002).This makes it possible to determine the sources of emissions and hence the pressure exerted on the environment by particular economy sectors. Ultimately, it will be also possible to identify environmental flows between sectors. In the final predicted form, the NAMEA tables will be matrixes that combine the traditional input-output tables and emission matrixes into a single unit (Eurostat, 2009) in monetary terms. At present, however, they contain data on the physical value of emissions, not their financial valuation. In addition, they are not included in the form of an input-output matrix, but in the form of tables with information on emissions from particular sectors (Gajos & Prandecki, 2016).

Due to the difficulty in gathering necessary data, the range of NAMEA tables is still small. NAMEA-Air tables (NAMEA tables containing data about air emissions) are the only one of NAMEA tables that is complete to a large extent. For the purposes of this article, the focus is on data for Poland, but it should be noted that different countries provide data in different areas of detail. Although the full list of emissions includes 20 substances (Eurostat, 2004), the tables currently contain data on only four main emissions to air. For this reason, despite of the fact that Poland provides data on more emissions, the study focuses on four emissions available in the NAMEA-Air database.

[6] Only individual farms were included and farms with less than 1 ha of agricultural land were omitted in the survey.

Table3. *Intermediate consumption in selected economy sectors (PLN thousands)*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	18 973 431	17 746	39 057 527	43	181 481	968 000	2 831	28 713	124 566
2.	558 411	2 252 063	463 626	40 238 259	3 767 550	165 591	149 553	70 600	22 929 524
3.	10 590 184	16 172	39 139 304	117 231	171 881	29 572	20 798	39 474	45 044
4.	2 662 413	497 030	920 996	1 935 761	811 527	315 401	166 015	111 662	632 935
5.	5 394 171	364 950	1 661 599	2 080 925	15 398 135	11 879 419	1 411 885	515 589	270 985
6.	124 057	305 808	2 305 256	67 457	1 135 323	10 225 457	641 297	665 416	158 128
7.	666 089	685 211	1 653 845	29 435	258 676	765 806	11 728 995	3 432 790	508 943
8.	943 789	754 410	413 658	181 780	223 990	54 784	903 959	2 953 691	596 983
9.	1 802 944	1 795 797	3 785 561	301 580	3 436 840	1 553 995	1 433 062	690 048	3 040 105
10.	3 520 173	417 175	15 322 968	839 654	2 332 200	2 865 877	78 409	960 434	2 024 518
11.	3 539 880	262 776	5 457 328	570 070	919 144	928 952	1 985 679	516 963	565 722
12.	939 259	1 292 356	4 202 999	1 974 695	1 911 702	1 184 715	805 964	716 080	3 403 937
13.	13 052	93 006	187 344	24 064	66 484	78 254	1 302 818	77 772	42 872
14.	661 133	266 671	1 171 153	409 856	277 256	337 609	82 517	204 233	532 400
15.	112 484	68 303	531 792	50 649	227 358	188 934	563 862	166 125	410 872
16.	688 362	185 169	475 742	96 076	112 186	41 921	250 722	92 657	616 169
17.	83 951	297 373	883 695	181 398	280 635	166 388	100 150	158 487	952 695
18.	107 010	136 022	262 106	37 900	95 758	112 743	293 444	60 564	304 522

	10.	11.	12.	13.	14.	15.	16.	17.	18.
1.	749 028	395 914	30 941	205 237	593	101 383	150	404 302	122 285
2.	35 450	23 456	152 984	11 602	9 668	73 797	5 877	175 535	79 471
3.	3 714 174	4 277 162	73 328	7 143 595	128 454	94 816	7 729	173 480	323 504
4.	2 654 380	1 170 191	16 552 155	272 042	344 604	429 745	57 355	308 454	887 503
5.	1 571 271	815 549	445 606	233 867	137 279	679 093	53 300	630 215	227 850
6.	2 377 999	1 692 015	939 205	39 021	67 135	97 348	3 241	265 838	317 223
7.	1 280 092	532 468	255 327	29 253	16 059	724 163	8 757	44 237	2 725 151
8.	551 544	655 005	227 855	68 592	44 634	215 104	39 391	81 244	96 963
9.	1 462 127	2 424 747	2 393 732	1 223 285	155 846	15 584 480	50 323	577 484	1 431 922
10.	3 458 216	2 428 500	2 022 729	2 326 666	351 239	692 767	167 283	520 734	1 228 023
11.	1 191 631	747 618	3 805 780	911 052	144 319	485 649	67 069	212 418	699 292
12.	9 646 314	3 561 804	8 955 691	246 258	99 243	497 433	348 835	307 652	815 583
13.	671 173	318 349	447 870	446 675	91 141	55 606	15 740	89 722	189 211
14.	1 930 396	1 000 860	704 581	169 246	9 206 330	2 245 235	138 067	248 658	1 190 074
15.	3 584 545	3 524 117	572 118	840 453	1 062 643	2 835 415	230 714	396 381	506 943
16.	708 256	549 219	238 374	20 572	58 039	15 069	712 638	141 154	6 586
17.	1 160 746	1 299 236	589 272	278 947	409 128	954 376	31 385	2 506 027	333 463
18.	644 320	435 975	263 101	137 339	82 662	169 087	67 783	139 067	328 660

1. Agriculture.
2. Mining and quarrying.
3. Food sector.
4. Coke, refined petroleum products.
5. Chemicals and chemical products.
6. Rubber and plastic products.
7. Fabricated metal products.
8. Machinery and other equipment.
9. Electricity, gas, steam and air conditioning.
10. Wholesale trade.
11. Retail trade.
12. Land and pipeline transport.
13. Accommodation and food services.
14. Financial services.
15. Real estate market.
16. Veterinary and other professional services.
17. Security and office maintenance.
18. Public administration.

Źródło: (GUS, 2014).

A detailed discussion on NAMEA tables, air emissions and their valuation can be found in previous authors' articles on this subject[7].

Table 4 shows the value of environmental flows - air emissions in 2010 from and to *Agriculture* in relation to selected sectors. As far as flows from *Agriculture* are concerned, the highest environmental flows are from *Agriculture* to *Food Sector* - over PLN 925 million. The following areas are *Agriculture*, *Rubber and Plastic Products* and *Wholesale trade*. The link between *Agriculture* and *Food Sector* with *Agriculture* is explained in the earlier chapter of the study. Due to the simple way of dividing environmental emissions between sectors of the economy - by a 1:1 ratio in relation to the standard input-output tables- there are no significant differences in the environmental flows from *A*griculture in terms of structure and interrelationships.

In the case of flows to Agriculture, the highest environmental flow to *Agriculture* is from the same sector (almost PLN 500 million), which confirmed the thesis of the high self-supply level in this sector. The following places are *Electricity, gas, steam and air conditioning*; *Chemicals and chemical products* and *Coke, refined petroleum products*. Their high link with *Agriculture* sector is due to the fact that *Agriculture* derives energy and means for agricultural production from these sectors. At the same time, the air emissions produced by these sectors can also be attributed essentially to *Agriculture* in similar terms - *Agriculture* consumes energy produced by other sectors and at the same time consumes emissions generated during the this energy production.

In conclusion, the analysis of environmental flows based on NAMEA-Air tables using a simple dividing key - 1:1 ratio in relation to the standard input-output tables - shows that proposed method, despite certain flaws and imprecision, allows for environmental emissions' distribution with a essential justification.

RESULTS

Polish economy emitted 352.3 million tons of carbon dioxide equivalents (only gases selected for this study) in 2010. The value of this emission was estimated at PLN 20.1 billion. According to NAMEA-Air, the most emitting sectors are (in tones of carbon dioxide equivalent): *Electricity, gas, steam and air conditioning* - 160.5 million; *Manufacturing* - 61.8 million; *Agriculture* - 47.3 million; *Transportation and storage* - 26,5 million; *Mining and quarrying* - 17.6 million and *Water supply, sewerage, waste management and remediation activities*- 13.3 million.

The valuation of this emission and its implementation into input-output analysis means that sectors that generate pollution can be significantly burdened with emission costs. It should be borne in mind though, that calculation takes into account only a narrow slice of environmental external costs. However, even considering such a small share of environmental externalities results in a 8.96% change in flows linked to *Electricity, gas, steam and air conditioning*. In turn, in *Water supply, sewerage, waste management and remediation activities* it is 2.5% and in *Mining and quarrying* just over 1%. This shows that the influence of the same factor will affect different sectors differently and thereby change the scale of the input-output flows.

In *Agriculture*, the emission's value was estimated at PLN 2.7 billion. According to the assumption on emissions' proportional distribution the majority, i.e. almost 55% (less than 1.5 billion PLN), falls on intermediate consumption. After deducting self-supply (PLN 2.4 million), this can be interpreted as a "transfer" of emissions to other economic sectors. Final demand is just over 45% of total emission, i.e. PLN 1.2 billion. The above-mentioned values are treated as environmental costs of conducting economic activity, which causes them to be subtracted from the analogous figures from the input-output tables. As a result, the value of intermediate consumption decreased to PLN 59.1 billion, and the final demand to PLN 49.5 billion.

The relationships between flows and economy sectors do not change after implementing emission costs due to the assumed proportionate method of dividing emission costs between individual flows. In addition, the decline in volume is around 2.4 percent. This is not a significant change. However, it should be borne in mind that presented calculation takes into account only estimates of emission costs of four substances (three compounds and one group of compounds), rather than total environmental costs resulting from agricultural activity. Furthermore, it is worth emphasizing that the

[7] (Gajos & Prandecki, 2016);(Prandecki & Gajos, 2017)

input-output tables taking into account agri-environmental factors should be extended not only to costs but also to benefits of the sector functioning. This means that the use of environmentally friendly practices or keeping the balance of organic matter in the soil should be valued higher than use of neutral practices. The justification for the partial approach presented in this paper is the need to demonstrate the interplay between the economy and the environment, and to highlight the links between sectors emitting pollution. In the case of *Agriculture*, the distribution of emissions between intermediate consumption and final demand makes it easier to realize how much of the responsibility for the greenhouse gas emissions from *Agriculture* should also be linked to other sectors of the economy.

Table 5 shows the study results - the intermediate consumption of selected sectors after implementing costs of air emissions. As in the case of the above-mentioned general data, the adopted method only shows a proportional change in intermediate consumption from a given sector. For this reason, on the basis of this study, the possibilities for evaluating agricultural flows are limited. Introduction of a more detailed research method would be necessary so the production of particular types of food would be linked to the economy sectors to which it is addressed. For example, animal products are more burdened by emissions than crops. As a result, flows to the food sector that use meat and other products of animal origin should be more burdensome than flows to sectors, where mainly crops are used. However, the purpose of this study was to examine the scale of changes after implementation of one group of environmental factors into input-output analysis. For this reason, detailed study was not conducted.

Table4. *The value of emissions from and to Agriculture in regard to selected economy sectors in 2010 – environmental flows*

Economy sector	**The value of environmental flow from Agriculture [PLN thousands]**	**The value of environmental flow to Agriculture [PLN thousands]**
Public administration	2899,1	201,1
Chemicals and chemical products	4302,5	43477,8
Electricity, gas, steam and air conditioning	2953,2	161764,8
Mining and quarrying	420,7	5933,4
Retail trade.	9386,3	5669,7
Wholesale trade.	17757,9	3059,1
Coke, refined petroleum products	1,0	23636,0
Machinery and other equipment	680,7	173,1
Agriculture	449820,4	449820,3
Real estate market	2403,6	30,8
Security and office maintenance	9585,2	164,3
Food sector	925972,2	14380,7
Accommodation and food services	4865,8	15,9
Land and pipeline transport	733,5	11482,5
Financial services	14,1	507,3
Veterinary and other professional services	3,6	310,9
Fabricated metal products	67,1	226,2
Rubber and plastic products	22949,3	
Final consumption expenditure	1006424,0	X
Gross capital formation	17567,7	X
Export	177287,8	X

Source: *own study.*

The obtained results are much more suited to assess changes occurring in the case of flows from other sectors to *Agriculture* than the other way around. The total amount of these emissions is much lower than the flows from this sector[8] and amounted to PLN 729.3 million, of which over PLN 720.9 million was fall on the analysed sectors. This was mainly due to high emissions from the following sectors: *Agriculture* (self-supply), *Electricity, gas, steam and air conditioning* (electricity and heat), *Chemicals and chemical products* (fertilizers and plant protection products) and *Food sector* (feed). In other cases, these changes are significantly smaller.

[8] In both cases, intra-industry emissions were taken into consideration - consumption of agricultural production by the agricultural sector.

Table5. *Intermediate consumption with environmental flows in selected economy sectors (PLN thousands)*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	18523611	17325	38131555	42	177178	945051	2764	28032	121613
2.	552478	2228134	458700	39810711	3727518	163832	147964	6985	22685889
3.	10575803	16150	39086156	117072	171648	29532	20770	39420	44983
4.	2638777	492618	912820	1918576	804323	312601	164541	110671	627316
5.	5350693	362008	1648206	2064152	15274024	11783669	1400505	511433	268801
6.	123988	305637	2303965	67419	1134687	10219732	640938	665043	158039
7.	665863	684978	1653283	29425	258588	765546	11725013	3431625	508770
8.	943616	754272	413582	181747	223949	54774	903793	2953149	596874
9.	1641179	1634673	3445911	274521	3128478	1414567	1304484	628135	2767339
10.	3517114	416812	15309652	838924	2330173	2863387	1983953	959599	2022758
11.	3534210	262355	5448587	569157	917672	927464	804673	516135	564816
12.	927777	1276557	4151617	1950554	1888331	1170232	1286891	707326	3362324
13.	13036	92893	187116	24035	66403	78159	82417	77677	42819
14.	660626	266466	1170254	4095415	277043	337350	563430	204076	531991
15.	112453	68284	531647	50635	227296	188882	250653	166080	410760
16.	688051	185085	475527	96033	112135	41902	100105	92615	615891
17.	83787	296791	881966	181043	280086	166062	292870	158177	950830
18.	106809	135766	261613	37829	95578	112531	75510	60450	303950

	10.	11.	12.	13.	14.	15.	16.	17.	18.
1.	731270	386528	30207	200371	579	98979	146	394717	119386
2.	35073	23207	151358	11479	9565	73013	5815	173670	78627
3.	3709130	4271354	73228	7133895	128280	94687	7719	173244	323065
4.	2630815	1159802	16405210	269627	341545	425930	56846	305716	879624
5.	1558606	8089756	442014	231982	136173	673619	52870	625135	226013
6.	2376668	1691068	938679	38999	67097	97293	3239	265689	317045
7.	1279657	532287	255240	29243	16054	723917	8754	44222	2724226
8.	551443	654885	227813	68579	44626	215065	39384	81229	96945
9.	1330941	2207192	2178960	1113529	141863	14186200	45807	525670	1303446
10.	3455211	2426390	2020971	2324644	350934	692165	167138	520281	1226956
11.	1189723	746421	3799685	909593	144088	484871	66962	212078	698172
12.	9528387	3518261	8846207	243247	98030	491352	344570	303891	805612
13.	670356	317962	447325	446131	91030	55538	15721	89613	188981
14.	1928915	1000092	704040	169116	9199265	2243512	137961	248467	1189161
15.	3583564	3523153	571961	840223	1062352	2834639	230651	396273	506804
16.	707936	548971	238266	20563	58013	15062	712316	141090	6583
17.	1158474	1296693	588119	278401	408327	952508	31324	2501122	332810
18.	643109	435156	262606	137081	82507	168769	67656	138806	328042

1. Agriculture.
2. Mining and quarrying.
3. Food sector.
4. Coke, refined petroleum products.
5. Chemicals and chemical products.
6. Rubber and plastic products.
7. Fabricated metal products.
8. Machinery and other equipment.
9. Electricity, gas, steam and air conditioning.
10. Wholesale trade.
11. Retail trade.
12. Land and pipeline transport.
13. Accommodation and food services.
14. Financial services.
15. Real estate market.
16. Veterinary and other professional services.
17. Security and office maintenance.
18. Public administration.

Źródło: (GUS, 2014).

As a result the change in the value of flows to *Agriculture* from analysed sectors was lower and equal to 1.4%. Finally, the total value of flow from selected sectors to *Agriculture* is PLN 50.7 billion. Taking into account the value of intermediate consumption used by *Agriculture* and comparing the percentage change between intermediate consumption to and from *Agriculture*, it can be stated that *Agriculture* is dependent on sectors with a lower share of greenhouse gas emissions than in the case of *Agriculture*. This is not surprising since *Agriculture* is one of the main greenhouse gas emitters (considering only four analysed substances presented in NAMEA-Air tables).

In most cases (Table 5), the impact of analyzed emissions on the flows' value is minimal. Out of the eighteen analyzed sectors in fourteen cases, the change in the input-output analysis was less than one percent. The smallest change occurred within the *Machinery and other equipment*, and amounted to 0.02% (PLN 173 thousand). In the four sectors, changes were greater than 1%: *Agriculture* (change in intra-industry flows amounted to 2.38%), *Mining and quarrying* (1.64%), *Electricity, gas, steam and air conditioning* (8.98% %) and the *Accommodation and food services* (7.33%). As can be seen, these changes may already be considered significant, especially since only one group of environmental effects was considered in the analysis.

In absolute terms, the inclusion of emission' value has had the greatest impact on flows within the agricultural sector. The reduction of the volume amounted to PLN 449.8 million. Then there were the following sectors: *Electricity, gas, steam and air conditioning* - PLN 161.8 million; *Chemicals and chemical products* - PLN 43.5 million; *Coke, refined petroleum products* - PLN 23.6 million; *Food sector* - PLN 14.4 million and *Land and pipeline transport* - PLN 11.5 million.

Presented results show little influence of the included environmental flows on the overall input-output analysis. It should be stressed, however, that this is the first attempt in Poland to estimate and incorporate flows related to the environment into the input-output analysis. It is important to show the relationship between classical and environmental flows. Interest in the inclusion of environmental costs in the economic account, including the input-output analysis, is high from both science and policy and to some extent from economic practice.

When evaluating achieved results, it is worth remembering that the method of air pollutants valuation has one significant imperfection. The emissions' value is based on the market mechanism, i.e. the average annual price of emission rights calculated based on Leipzig stock transactions. The market price is the result of seeking a balance between demand and supply, which causes the value of the emission allowance to change over time. In 2010 it amounted to EUR 14, 34, while in 2013 it was only EUR 4, 47 (Prandecki & Gajos, 2017). Such variability causes a number of doubts. First of all, it is difficult to assume which of these prices or other available values would be more appropriate for calculations. Theoretically, the average price for several years can be used, but then it would be necessary to justify the period for which such averaging is performed. For this reason, it was decided to use the average price for a given year. Secondly, the valuation of the emission's harmfulness, depending on the price chosen for calculation, will also be subjected to fluctuations. This means that the valuation of emissions' harmfulness for the individual years will vary, although the harmfulness itself will not change. Unfortunately, such a limitation is related to the use of market-based methods of external effects valuation. In this case it can be pointed out that the price change resulting from the change in demand for carbon dioxide emission allowances is the result of other actions resulting from the emission trading scheme. Taking into account that the EU-ETS allowances pool is decreasing year by year, it may be more cost-effective to physically reduce emissions than to buy allowances on the market. Many opinions, however, point out that the high fluctuation of the emission allowances price is due to the speculative activity characteristic for stock market transactions.

CONCLUSION

In the study an attempt was made to develop input-output tables that take into account selected environmental flows. Due to the limitations in access to data, only four substances listed in NAMEA-Air tables were taken into account: carbon dioxide, methane, and nitrous oxide and nitrogen oxides. The emissions' value was recognized as costs and proportionately divided to flows from the given sector. As a result, there was a slight decrease in flows between various sectors. The most significant changes were observed in *Electricity, gas, steam and air conditioning* - 8.98%. This

change is unique because in most sectors the change was less than 1%. The results show that flows from *Agriculture* decreased by PLN 2.7 billion, i.e. by 2.38% (one of the highest changes among analyzed sectors). The proportionate method of emissions division used in the study method allows to state, that the majority of emissions (55%) fall to intermediate consumption rather than to final demand. This makes the assessment of environmental flows in *Agriculture* an important issue.

Applied method allows showing general changes occurring in flows from *Agriculture*. It can be seen that among analyzed sectors, the largest decrease in flows occurred in the *Food sector* (a change of PLN 926 million), and the lowest in the *Public administration* (PLN 2.9 million).

Flows from analyzed sectors to *Agriculture* are slightly lower, amounting to PLN 50.7 billion after consideration of emission costs, which means a change in the amount of flows to *Agriculture* by 1.4% (including self-supply) in comparison to flows calculated by GUS (PLN 51.4 billion). A significantly smaller percentage change in case of flows to *Agriculture* is due to a higher share of low-emission sectors, like *Wholesale trade* and *Retail trade*.

Generally speaking, the presented proportionate method of incorporating environmental factors into input-output analysis has many limitations. It can be used to a greater extent for cross-sect oral comparisons, i.e. the assessment of general sector-wide changes rather than the analysis of flows within a sector. In the latter case, it may only apply to the assessment of flows to the sector and possibly to the assessment of final demand. Its use in the context of flows from the sector is unjustified due to the proportional distribution of changes. In addition, it is important to note the significant imperfection of the adopted method of air emissions valuation - the price of carbon dioxide significantly vary year to year, which results in significantly different results depending on the time period covered by the study.

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