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Valuation of Public Goods: The Case of Emissions from Livestock Holdings in the Czech Republic

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Abstract

Designed paper is focused on the analysis of public goods in the form of greenhouse gas emissions in livestock production in Czechia. The main aim of the paper is to quantify the amount and valuation of greenhouse gas emissions produced in beef cattle breed (dairy and meat), pig breed, and poultry breed (meat and eggs). The partial aim of this paper is to compare greenhouse gas emissions production across sectors of livestock production and to evaluate a development of volume, value and share of emissions as a form of public goods. The methodology is based on the conceptual model MITERRA-Europe (The model was developed to assess the effects and interactions of policies and measures in agriculture on N losses and P balances at a regional level in EU-27), which is partly based on the CAPRI (Common Agricultural Policy Regionalised Impact) and the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) models using the tools for quantification of the emission factors indicators defined by the IPCC (Intergovernmental Panel for Climate Change) organizations. Part of the solution is to determine the value of public goods quantified through a European platform for carbon emissions trading with its futures contract based on the EU Allowances. The result of this paper is quantified emission value of public goods in livestock production in Czechia and their appreciation in the period 2000-2014. In the final consequence is quantified the proportion of the value of public goods in the total production of the analyzed livestock sector.

Keywords

Public goods, greenhouse gas, emissions, valuation, livestock, polluter, emission factor, conversion ratio, agriculture, willingness to pay.

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Introduction

Production of public goods in the form of greenhouse gases is currently an integral component of a number of processes which are, unfortunately, connected with a wide range of human activities. In the present paper between public goods included greenhouse gas emissions. Classification, respectively designation of greenhouse gases as public goods is not entirely clear where the differences arise classifications of different scientific disciplines. At the political level, public goods are replaced by synonymous with "public benefit or harm" and are referred to as products or services available to the public, which can be stated as well as greenhouse gases. Therefore, their emissions seen as a public good. The amounts and growth of the total emissions is a very serious problem which humanity will have to tackle in a relatively short term if it wants to continue inhabiting this planet sustainably. The total emission has been growing massively in the long term; according to the Intergovernmental Panel for Climate Change (IPCC, 2006), greenhouse gases themselves are largely liable for the climate change on the planet. The structure of origin of the global production of said gases is an interesting fact. Generally speaking, it can be concluded that the transport sector is primarily responsible for the production, but a considerable part is produced by the agricultural sector, in which livestock production is the chief producer (see e.g. Dace and Blumberga, 2016). The paper at hand is then focused on an analysis of production and valuation of greenhouse gases in the livestock production sector in the Czech Republic. The current rate of knowledge derived from scientific publications in the Czech Republic is aimed quite generally to the production of greenhouse gases without sufficient disaggregation to the agricultural sector, see e.g. (Picek et al., 2007), (Exnerová and Cienciala, 2009) or (Andrlík, 2014).

At the same time it is not currently published research on the valuation of public assets in the form of coherent emission (carbon dioxide - CO_2, nitrogen oxides - NO_x, methane - CH_4) from livestock production broken down into sub-sectors. Given the above, the main objective is to quantify the amount and value of greenhouse gases generated by the breeding of beef and dairy cattle, pigs and poultry, and to compare the structure of the polluters. The analysis will deal with emissions of the three most debated gases, namely methane (CH_4), nitrogen oxides (NO_x) and carbon dioxide (CO_2). A secondary goal is to compare the production of gases both among sectors in Czechia. Last but not least, we will also make an assessment of the development of the amount and value of emissions produced by livestock production including the determination of the ratio value of the share of public goods in production in the direction of the utility. Determining the value of public assets in the form of greenhouse gases were carried out in accordance with the methodology of the European Climate Foundation (ECF, 2015), which uses the tools of indirect valuation of public goods by willingness to pay (WTP).

Materials and methods

The achievement of the set objective is conditioned by acquisition of information and data, which in this case means sectoral indicators for the different branches of livestock production in Czechia. The resulting dataset is composed of aggregate indicators of livestock production emissions in the form of time series with an annual periodicity from 2000 to 2014. The final database is then expanded with emission indicators for the studied country; the total extent of the database is 927 observations. The dataset is generated from databases provided by the Czech Statistical Office - CSO CR (CSO, 2016), Ministry of Agriculture - MA CZ (MA, 2016), EUROSTAT (Eurostat, 2016), European Climate Exchange - ECX (ECX, 2016) and the Directorate General for Energy of the EU (DG Energy, 2013) and of course, all data (using basic indicators of the sectoral economy) were recalculated to adequate (comparable) units. The solution is then based on the conceptual model MITERRA-Europe, which is partly based on the CAPRI (Common Agricultural Policy Regionalized Impact) and GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) models, (Lesschen et al., 2011). Based on the above approach, we construct indicators of feed conversion, specify the development of utility trends in the disciplines in question, and last but not least, determine indicators of areal burden as an indicator of the degree of concentration to account for the different types of animal breeding, notably divided into intensive and extensive. The above is then quantified into "conversion ratios", used to express the so-called emission factor, which is decisive for the production of each gas by the specific livestock production category. The methodology described has been applied in similar studies; see, e.g., Lesschen et al. (2011), Monteny (2006), etc. The derivation of the emission factor can be illustrated on an example based on Equation (1) (IPCC, 2006), but it is advisable to keep in mind that the necessity to include a specific constant makes the resulting equation only applicable for the derivation of the emission factor for methane. Nitrogen oxides and carbon oxides require an adequate transformation of the specific constant.

$$EF_i = VS_i \times 365 \times B_i \times 0{,}67 \times \sum_{jk} CF_{jk} \times MS_{jk} \quad (1)$$

Where:

EEF_i annual emission factor (kg) for animal type i

VS_i daily VS - volatile solids[1] excreted (kg) for animal type *i*

B_i maximum gas production capacity (m^3/kg of *VS*) for manure produced by animal type *i*

CF_{jk} conversion factors for each manure management system j by climate region *k*

MS_{jk} fraction (%) of animal type *i*`s manure handled using manure system *j* in climate region *k*

From the defined equation (1), a simple modification (see equation 2) is used to derive the total production of the gas in question in the given year by the specific livestock production category.

$$E = \frac{EF \times P}{10^6} \quad (2)$$

Where:

E Emissions (Gg^2/yr.)

EF Emission Factor (kg/head/yr.)

P Population (head), alternatively animal production (kg)

Due to the possible adjustment to the emission factor,

[1] Volatile solids are the organic fraction of total solids in manure that will oxidize and be driven off gas at a temperature of 600°C.

[2] Gg = Gigagrams

or its units, the total gas emission is quantifiable in a number of alternative forms. The most commonly used include the "per head" gas emission, but a number of studies (e.g., Herd et al., 2015, Solilová and Nerudová, 2015, and Turčeková et al., 2015) use probably more accurate calculations, which most frequently employ a conversion to a final production unit, but that requires further corrections, particularly in the category of beef, pork and poultry meat, consisting in a conversion of production of slaughter-processed meat to "edible meat" using a fixed coefficient; see, e.g., Lesschen et al. (2006). The same procedure will be applied by the paper at hand. The above correction does not apply to production of milk and eggs, but they too require some adjustments when converting units, particularly between litres and kilograms of milk, and pieces and kilograms of eggs.

For pricing of agricultural production were quantified weighted price of the analyzed sectors, in the form of weighted prices of the agricultural producer (MA CZ, 2016). To determine the appropriate weight ratios were quantified representation of individual utility lines in the output of which was using the session set the final price. Determining the value of public goods in the form of greenhouse gases were carried out in accordance with the methodology of the European Climate Foundation (ECF, 2015) and European Environment Agency (EEA), which uses the tools of indirect valuation of public goods by willingness to pay (WTP). WTP method is based on the valuation of the output of greenhouse gases through the European Climate Exchange (ECX), which is a form of commodity exchanges set the price of CO_2 emission allowances. ECX futures is the most liquid, pan-European platform for carbon emissions trading, with its futures contract based on the underlying EU Allowances (EUAs) and Certified Emissions Allowances (CERs) attracting over 80% of the exchange-traded volume in the European market (EEA, 2016). The value of emission allowances (ECX/ivesting.com [cit.on-line 06.12.2016]) is determined exchange-only CO_2 and is therefore also used the methodology of the Ministry of Industry of the Czech Republic, which determines the possible conversion coefficients (Global Warming Potential - GWP) for the conversion of NO_x and CH_4 to CO_2 equivalent. Total greenhouse gas emissions is defined as the sum of the products of the greenhouse gas emissions of the relevant conversion coefficients GWP. These coefficients indicate how many times a given gas absorption of terrestrial radiation more effective than carbon dioxide. GWP values for basic gases and time horizon of 100 years are as follows: CO_2 1, CH_4 21 a NO_x 310.

Results and discussion

With reference to the methodology formulated above, we first derived the emission factors, see Table 1, which make significant contributions to the final emissions from the livestock production category.

As part of the assessment of the emission factors attained, it can be said that there are significant differences among the livestock production branches in terms of predisposition for production of the gases assessed, which constitutes, with respect to the methodology, a fundamental basis for a comparison among the livestock production branches.

In the following, an analysis of the production of the gases in question is made based on the Emission factors (EF) attained (see Table 2), with an assessment of the amount and overall development of the emissions, including a quantification of the structure of emitters in livestock production in Czechia. Table 2 below shows an insight into the estimated development of the methane emissions in Czechia for the branches analyzed.

The results indicate that the cattle breeding sector is an absolutely dominant branch of livestock production in Czechia in terms of the CH_4 emission – its total contribution (summing up the meat and milk) is almost 90%. The remaining branches are incomparable by orders of magnitude, primarily due to the different composition of the feed rations, which is the primary reason

Emission	*Beef*	*Crow (milk)*	*Pork*	*Poultry*	*Eggs*	
CH_4	57.5	101.3	3.0	0.3	0.1	kg/animal/year
CO_2	13.3	1.3	3.5	1.6	1.7	kg /kg production
NO_x	20.0	30.0	40.0	14.6	12.7	g/kg production

Source: own calculation by Cederberg et al. (2009), IPCC (2006), Monteny et al. (2006), Jelínek and Plíva (2003)

Table 1: Emission factors.

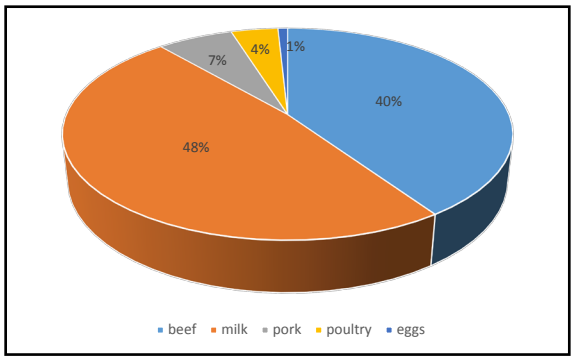
Year	Beef	Milk	Pork	Poultry	Eggs	SUM
2000	55128	62247	11156	4952	1643	135126
2001	55809	61907	10871	5295	1635	135518
2002	53121	60375	10409	6008	957	130870
2003	50802	59770	10172	5156	986	126886
2004	49188	58005	9458	4966	895	122512
2005	47356	58090	8702	5052	832	120032
2006	46571	57077	8592	5049	884	118173
2007	47536	57174	8562	4759	880	118912
2008	47892	57580	7360	5462	883	119178
2009	46196	56680	5964	5207	905	114952
2010	45887	55814	5775	4842	870	113188
2011	45549	55843	5291	3929	859	111471
2012	46141	55812	4776	3988	750	111466
2013	46052	55882	4800	4166	1014	111913
2014	46552	57101	4892	3824	946	113315
ø	**40.46%**	**48.20%**	**6.48%**	**4.03%**	**0.83%**	**100%**

Source: own calculation

Table 2: Emission CH_4 (t).

for the extremely different emission factor of cattle. This is manifested even when comparing the dairy and beef sectors of cattle breeding. An interesting fact is that the overall development of the emission has one identical element in all the branches but totally different trends. The common feature is an overall decrease in the emissions, clearly due to a reduction in the numbers. The most radical decrease of the emission during the study period was that in methane production from pig breeding, showing a slump to almost one-third of the period-initial figures. The second-biggest decrease was realized on average in the egg production sector. The cattle breeding sectors assessed then differ slightly from each other – beef production showed a more noticeable decrease in the emission than the dairy sector, but the overall amount of the emission from these two branches determines that the volume decrease significantly exceeds the total production from all the other sectors, which documents the importance of environmental policy interventions in exactly this branch. Another remarkable aspect is the relatively high variability in the emission amounts in the poultry sector, which does not quite match the development of the numbers, probably indicating a change in the structure of the fodder dose, which influenced the emission factor in the individual years. A detailed definition of the structure (on average for the study period) of the methane emissions in Czechia is shown in Figure 1.

The other area of study is the emissions of nitrogen oxides (NO_x), among which primary attention is paid to nitrous oxide, which currently represents the greatest threat to the climate, since its negative effects are multiplicatively stronger than those of methane and carbon oxides due to its ease of reaction with ozone (see, e.g., Araujo et al., 2006).



Source: own calculation

Figure 1: Structure of CH_4 emitters in Czechia.

Based on equations (1) and (2), we quantified the emissions of NO_x associated with livestock production emissions in Czechia; see Table 3.

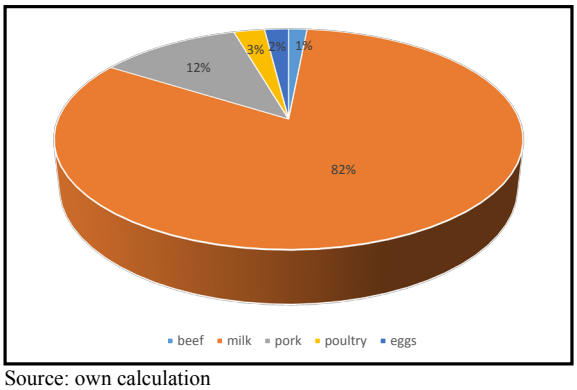
The derived outcomes are relatively shocking, as it can be concluded that the dairy production sector is absolutely the biggest polluter, generating by itself more than 82% of the overall production of nitrogen oxides. The high proportion is all the more surprising that the beef cattle breeding sector is conversely the smallest emitter. In this connection, the second biggest emitter

Year	Beef	Milk	Pork	Poultry	Eggs	SUM
2000	1947	83680	14260	2608	2653	105148
2001	1909	84296	14420	2728	2427	105780
2002	1971	83433	14785	2913	2249	105352
2003	1946	83249	14803	2787	2341	105126
2004	1740	84050	13562	2860	2151	104363
2005	1459	81523	12227	2980	2085	100274
2006	1425	80168	11989	2840	1947	98369
2007	1428	84389	12271	2705	1785	102577
2008	1440	83002	11411	2650	1817	100322
2009	1386	82694	10245	2552	1891	98768
2010	1337	84050	9933	2473	1943	99734
2011	1298	83433	9466	2235	1897	98329
2012	1183	80476	8631	2005	1560	93855
2013	1167	82068	8434	1947	1591	95207
2014	1180	84440	8496	1963	1469	97548
ø	**1.51%**	**82.41%**	**11.58%**	**2.53%**	**1.97%**	**100%**

Source: own calculation

Table 3: Emission NO_x (t).

is the pig breeding sector, making an almost 12% contribution, followed by the meat poultry and egg poultry sectors (for the exact breakdown of the structure, see also Figure 2). The documented results are considerable different from the structure of emitters of the other greenhouse gases; the possible cause may be the high degree of dependency on the final production amount, not the numbers of animals in the different livestock production categories. Therefore, viewing the high overproduction of milk and the representation of pork in the overall meat consumption in Czechia, the proportional composition of the emitters is matching. Nevertheless, another significant effect is the development of the emission amount, which, unfortunately, does not decrease for the dominant polluter.

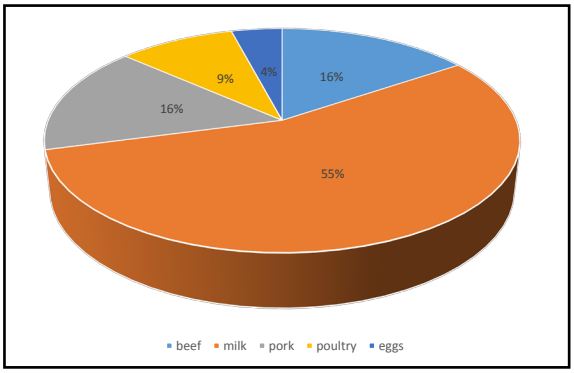


Source: own calculation

Figure 2: Structure of NO_x emitters in Czechia.

Afterwards, based on the results in Table 1 and the quantified values of net production and its conversion to "edible meat production", we made a quantification of the CO_2 emissions, with a comparison of the emission structure of livestock production in Czechia. The results of the emission estimate are shown in summary in Table 4.

Based on the derived outcomes, we can determine the shares of the livestock production branches in the total CO_2 emission; their relative contributions are then provided in Figure 3.



Source: own calculation

Figure 3: Share of categories of livestock production on the CO_2 emissions.

From this point of view, the dairy sector is the biggest emitter in Czechia, contributing approx. 55% to the total emission from agriculture in Czechia. The joint second/third-biggest polluter is the pig breeding sector (approx. 16%) and the beef cattle breeding sector (16%), followed

Year	Beef	Milk	Pork	Poultry	Eggs	SUM of the analyzed sectors	Total agriculture emissions	Livestock/ total emission CZ	Total emission CZ
2000	1294675	3626132	1247737	625140	356439	7150122	9094860	5.57%	128350000
2001	1269359	3652834	1261720	654047	326070	7164029	9220880	5.60%	128040000
2002	1310655	3615451	1293721	698415	302110	7220352	8955860	5.78%	124870000
2003	1294256	3607440	1295261	668118	314534	7179610	8314940	5.57%	128850000
2004	1157020	3642153	1186677	685686	288997	6960533	8750490	5.37%	129730000
2005	969941	3532675	1069850	714300	280123	6566889	8385030	5.16%	127370000
2006	947868	3473930	1048997	680750	261586	6413131	8249770	4.98%	128720000
2007	949556	3656839	1073718	648352	239795	6568261	8403040	5.06%	129780000
2008	957839	3596759	998503	635333	244134	6432568	8583060	5.16%	124690000
2009	922001	3583408	896402	611894	253994	6267699	8134290	5.38%	116510000
2010	888880	3642153	869101	592758	260994	6253886	7964570	5.30%	118060000
2011	863334	3615451	828274	535765	254782	6097607	8064840	5.24%	116300000
2012	786585	3487281	755222	480731	209525	5719344	8019420	5.11%	111860000
2013	775955	3556283	737960	466748	213785	5750731	8008490	5.27%	109170000
2014	784382	3659083	743372	470642	197332	5854810	8002780	5.42%	108050000
ø	**15.55%**	**55.27%**	**15.68%**	**9.39%**	**4.10%**	**77.37%**	100%	5.33%	

Source: own calculation

Table 4: Emission CO_2 (t).

by the meat poultry sector (about 9%) and egg production (4%).

Moreover, the research compared the production of the analyzed sectors with the total emissions of CO_2 by agriculture in Czechia, and found out that the above branches make a great contribution to the total agricultural emission: approx. 77%; that is, only 23% of the CO_2 production originates from the remaining livestock production categories and plant production. However, comparing the contribution of the livestock production emissions to the overall CO_2 emissions in Czechia, the contribution is relatively very small, approx. 5.3% (and decreasing), which is approx. 3-7 times less than in most West European countries, since the estimate in those countries is 15-40% (DG Energy, 2013).

Based on the previous quantification of the amounts of greenhouse gases produced by the individual sectors of livestock production in Czechia, the following section makes a valuation of the public goods generated. At the same time, it valuates the attained agricultural production in the specified branches (see Table 5), making it ultimately possible to compare the value of the public goods with the value of the primary production and thus determine the mutual ratio, which attains surprising levels in many cases. The production valuation made (determined using normal weighted prices of agricultural production) indicates that whereas beef, chicken and eggs show a stagnating level over the study period, the value of the pork production decreases significantly and milk, on the other hand, increases, which is in line with the indicators obtained in other studies (e.g., MA CZ, Green Report, 2016).

The WTP method was then used to price the greenhouse gases generated, with methane values first; see Table 6.

The results permit us to conclude that the methane production shows the highest values (almost CZK 8.5 billion) in the milk sector, which is relatively closely followed by the beef sector (CZK 7.2 billion). Both the production and the price are significantly lower in the other sectors; the price is actually lower by an order of magnitude towards the end of the study period (CZK 3-18 million).

Figure 4 presents a very interesting comparison. The chart allows us to infer the mutual ratio between the value of production and methane emission generated; the rate of the emission exceed 6.5% in the beef sector, and attains nearly 3% of the priced production of milk. The gases produced by the other sectors are below 1%, meaning that their production is relatively negligible from the point of view of negative externality theory.

Year	Beef	Milk	Pork	Poultry	Eggs
2000	8523.40	20174.60	20291.53	6351.44	6036.08
2001	7041.86	21075.60	25018.73	8112.08	6061.00
2002	7533.12	22151.36	18726.11	6948.97	4630.98
2003	7339.44	20612.34	16908.95	6392.68	5000.16
2004	7015.87	20581.82	17476.94	6859.07	4775.40
2005	6783.54	21802.44	15457.38	6787.76	3575.04
2006	7050.33	21552.00	13896.55	6078.03	4506.32
2007	6587.50	23055.56	13084.80	6221.67	4611.04
2008	6954.00	23951.84	12921.12	7820.33	4632.25
2009	7084.34	21988.96	10955.70	6539.22	4211.92
2010	6657.03	20922.12	9790.50	5260.96	3442.50
2011	7137.01	22002.02	9623.70	4859.53	3100.53
2012	7907.88	21021.02	9843.92	5598.47	4462.97
2013	7352.41	23611.17	10161.97	5737.16	3822.38
2014	7846.84	26763.85	9992.67	5898.55	4116.85
Total	**108814.56**	**331266.70**	**214150.58**	**95465.93**	**66985.43**

Source: own calculation

Table 5: Production value (millions CZK).

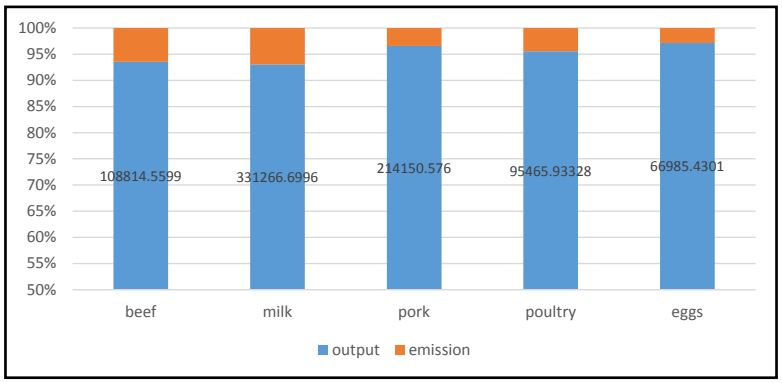
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*898.23*	*1014.23*	*181.77*	*80.68*	*26.78*
2001	*870.34*	*965.44*	*169.53*	*82.58*	*25.49*
2002	*749.04*	*851.33*	*146.77*	*84.72*	*13.50*
2003	*740.17*	*870.84*	*148.21*	*75.12*	*14.37*
2004	*718.00*	*846.70*	*138.06*	*72.49*	*13.07*
2005	645.30	791.55	118.58	68.84	11.33
2006	453.98	556.40	83.76	49.22	8.62
2007	412.40	496.02	74.28	41.29	7.64
2008	413.13	496.70	63.49	47.12	7.62
2009	321.48	394.44	41.50	36.24	6.30
2010	341.66	415.56	43.00	36.05	6.48
2011	165.36	202.73	19.21	14.26	3.12
2012	157.88	190.96	16.34	13.64	2.56
2013	122.09	148.16	12.72	11.04	2.69
2014	178.72	219.22	18.78	14.68	3.63
Total	**7187.77**	**8460.29**	**1276.01**	**727.98**	**153.20**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)

Source: own calculation

Table 6: The value of CH_4 emissions (millions CZK).

Analogously to the above, the value of the nitrogen oxide emissions was quantified in Table 7 below. Unfortunately, these gases have many times stronger interaction with the ozone layer, so that their presence is a serious problem even with a seemingly small amount. The aforesaid fact is then reflected in the pricing, where the rate of the emission generated is very close to the priced agricultural production in the respective sectors, particularly at the start of the study period. From the perspective of absolute magnitude, the nitrogen oxide emission from the dairy sector attains unambiguously the highest value of approx. CZK 176 billion; this is an order of magnitude above those in the other sectors: CZK 27 billion for pork; CZK 5.7 billion for chicken; CZK 4.5 billion for eggs; and CZK 3.5 billion for beef.



Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 4: The share values of emissions CH4 and production value (%).

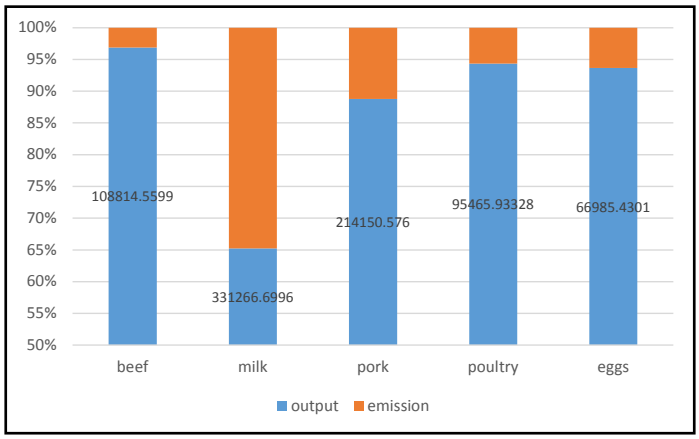
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*468.27*	*20127.13*	*3429.85*	*627.22*	*638.20*
2001	*439.43*	*19405.85*	*3319.55*	*628.09*	*558.79*
2002	*410.25*	*17367.01*	*3077.63*	*606.43*	*468.13*
2003	*418.59*	*17904.92*	*3183.79*	*599.42*	*503.59*
2004	*374.91*	*18110.99*	*2922.34*	*616.33*	*463.57*
2005	293.39	16398.61	2459.46	599.36	419.46
2006	205.12	11536.41	1725.19	408.64	280.22
2007	182.87	10807.53	1571.54	346.37	228.61
2008	183.41	10569.32	1453.11	337.48	231.42
2009	142.43	8495.08	1052.42	262.21	194.24
2010	146.91	9237.99	1091.70	271.77	213.54
2011	69.57	4471.25	507.29	119.77	101.64
2012	59.74	4064.77	435.95	101.29	78.78
2013	45.67	3211.89	330.07	76.20	62.28
2014	66.85	4785.48	481.47	111.26	83.25
Total	**3507.42**	**176494.23**	**27041.39**	**5711.86**	**4525.72**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 7: The value of NO_x emissions (millions CZK).

The extreme value of nitrogen oxide emissions from the dairy industry is a major warning for authors of both agricultural and environmental policies, since, as shown in Figure 5, the ratio of this emission to the value of the production generated is almost 35%! Casey and Holden (2005), for example, obtained similar results. For pork, the ratio exceeds the significant 10% threshold, and the poultry sector too (in both the meat utility branch and eggs) exceeds 5%, a threshold considered to be the warning level that should indicate the setting of processes leading to a reduction of the emission.

The last gas analyzed is carbon dioxide; its emissions are priced in Table 8. The outcomes indicate that again the emission attains the highest rate in the dairy industry (approx. CZK 25 billion), followed by the very similar sectors of beef (approx. CZK 7.5 billion) and pork (approx. CZK 7.6 billion). The poultry meat sector generates emissions worth approx. CZK 4.4 billion, and the egg sector emits at approx. CZK 2 billion.



Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 5: The share values of emissions NO_x and production value (%).

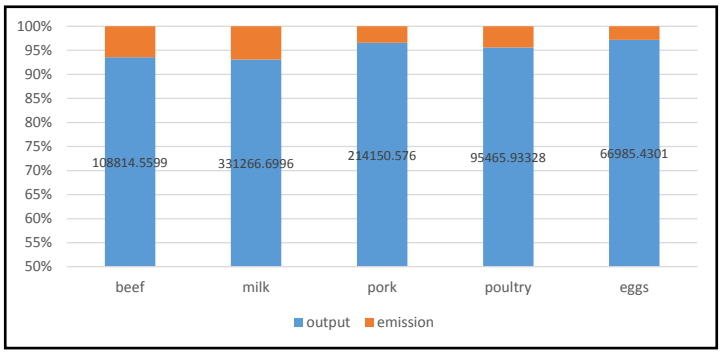
Year	Beef	Milk	Pork	Poultry	Eggs
2000	*1004.52*	*2813.47*	*968.10*	*485.04*	*276.56*
2001	*942.64*	*2712.65*	*936.97*	*485.70*	*242.14*
2002	*880.06*	*2427.65*	*868.69*	*468.96*	*202.86*
2003	*897.95*	*2502.84*	*898.65*	*463.54*	*218.22*
2004	*804.24*	*2531.64*	*824.85*	*476.62*	*200.88*
2005	629.37	2292.28	694.20	463.49	181.77
2006	440.01	1612.62	486.95	316.01	121.43
2007	392.29	1510.73	443.58	267.85	99.07
2008	393.45	1477.43	410.15	260.97	100.28
2009	305.54	1187.48	297.05	202.77	84.17
2010	315.15	1291.33	308.14	210.16	92.54
2011	149.25	625.01	143.19	92.62	44.04
2012	128.16	568.19	123.05	78.33	34.14
2013	97.96	448.97	93.17	58.93	26.99
2014	143.40	668.94	135.90	86.04	36.08
Total	**7523.99**	**24671.24**	**7632.65**	**4417.03**	**1961.16**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 8: The value of CO_2 emissions (millions CZK).

Looking at Figure 6, it can be concluded that the aforesaid warning threshold of 5% of share in the value of own production is exceeded by cattle breeding, in both the utility branches: milk and meat. The remaining branches of livestock production analyzed are below the set limit, even though the poultry meat production, for instance, comes relatively close to it. On the other hand, the development trends that can be inferred from Table 8 above indicate that all the sectors show a considerable decrease in both volume and emission rates, which can be recognized as a positive factor in the area of production of negative public goods.

The last analyzed area was the very interesting comparison of the value of the total emission in the agricultural production generated, as presented in Table 9. Thanks to the GWP conversion coefficients, the particular gas emissions can be expressed as the equivalent of the most voluminous gas, carbon dioxide, ultimately permitting a simple addition of the generated emissions and its valuation according to the method set. The results are shown in Table 9, which is divided into two parts, showing the total emission value as such and its



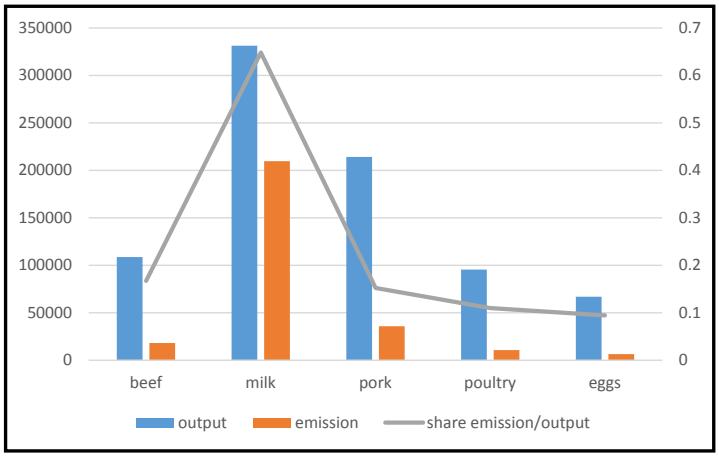
Note: Different production value (inside the chart in millions CZK) is always considered 100%.
Source: own calculation

Figure 6: The share values of emissions CO_2 and production value (%).

	Value GHG emissions (mil CZK)					Share emission values on the valuation of output				
Year	**Beef**	**Milk**	**Pork**	**Poultry**	**Eggs**	**Beef**	**Milk**	**Pork**	**Poultry**	**Eggs**
2000	*2371.03*	*23954.83*	*4579.73*	*1192.94*	*941.54*	*27.82%*	*118.74%*	*22.57%*	*18.78%*	*15.60%*
2001	*2252.41*	*23083.94*	*4426.06*	*1196.37*	*826.43*	*31.99%*	*109.53%*	*17.69%*	*14.75%*	*13.64%*
2002	*2039.35*	*20645.98*	*4093.09*	*1160.12*	*684.48*	*27.07%*	*93.20%*	*21.86%*	*16.69%*	*14.78%*
2003	*2056.72*	*21278.60*	*4230.65*	*1138.08*	*736.18*	*28.02%*	*103.23%*	*25.02%*	*17.80%*	*14.72%*
2004	*1897.14*	*21489.33*	*3885.25*	*1165.44*	*677.51*	*27.04%*	*104.41%*	*22.23%*	*16.99%*	*14.19%*
2005	1568.06	19482.44	3272.25	1131.70	612.56	23.12%	89.36%	21.17%	16.67%	17.13%
2006	1099.10	13705.43	2295.90	773.87	410.27	15.59%	63.59%	16.52%	12.73%	9.10%
2007	987.56	12814.28	2089.40	655.51	335.31	14.99%	55.58%	15.97%	10.54%	7.27%
2008	989.99	12543.45	1926.75	645.57	339.32	14.24%	52.37%	14.91%	8.25%	7.33%
2009	769.45	10077.00	1390.97	501.22	284.70	10.86%	45.83%	12.70%	7.66%	6.76%
2010	803.73	10944.89	1442.84	517.98	312.56	12.07%	52.31%	14.74%	9.85%	9.08%
2011	384.18	5298.99	669.68	226.65	148.81	5.38%	24.08%	6.96%	4.66%	4.80%
2012	345.78	4823.93	575.34	193.26	115.48	4.37%	22.95%	5.84%	3.45%	2.59%
2013	265.72	3809.02	435.97	146.17	91.96	3.61%	16.13%	4.29%	2.55%	2.41%
2014	388.96	5673.64	636.15	211.99	122.96	4.96%	21.20%	6.37%	3.59%	2.99%
Total	18219.18	209625.76	35950.04	10856.87	6640.07	Average **16.74%**	Average **64.83%**	Average **15.26%**	Average **11.00%**	Average **9.49%**

Note: For the period 2000-2004 are estimated values based on extrapolation of EUA (not traded)
Source: own calculation

Table 9: The value SUM of GHG emissions and share on the valuation of output (%/mil CZK).



Source: own calculation

Figure 7: The value of sector output and SUM of GHG emissions (millions CZK) and share on the valuation of output (%).

contribution to the value of production generation in the respective livestock production branches in the CR.

The outcomes indicate warning signals based on the average values of the contributions of the priced emissions. The contributions exceed the 10% level in all the verticals analyzed (except eggs). However, the extreme rate for the dairy sector is absolutely unprecedented; the greenhouse gas emission makes up almost 65% of the value of the primary production. However, similarly high rates have been identified in other publications, such as Žáková-Kroupová et al (2016) and FAO (2010); moreover, they applied different methods (shadow price method), thus supporting our finding.

Figure 7 documents the situation outlines; it offers a direct comparison of the value of the total emission and the value of the production generated in the analyzed sectors while showing the relative contributions.

Conclusion

A number of partial conclusions can be made from the results presented. In the area of methane emissions, the beef cattle breeding sector is the biggest emitter - summing both the utility lines (milk and meat) has the almost 90% share of the methane emissions. The remaining livestock production categories make only a minor contribution, while the overall CH4 emission is decreasing. In the segment of nitrogen oxide emissions, the dairy sector is an extremely strong polluter; it generated over 82% of the total production on average over the study period. The second-biggest emitter is the pig breeding sector, but it only contributes about 11-12%. In this respect, it is highly desirable to pay an increased attention to the dairy sector, in terms of both the current and long-term overproduction of milk, and the destructive market mechanisms, which fully impact on domestic producers (the effect of the purchase price level and the zero profitability threshold), but also from the point of view of being the producer of an extremely dangerous greenhouse gas as proven by the analysis made. Unfortunately for Czechia, the nitrogen oxide emissions are decreasing very slowly. In addition, it can be concluded that the biggest emitter of greenhouse gases in the form of CO_2 from agriculture is again the cattle breeding sector, more specifically again the dairy production sector, which contributes more than one half to the livestock production emissions in Czechia. The second most important emitter is the pig breeding sector, but it only makes about 15% of the livestock emissions. Comparably pig is a major producer of CO_2 further breeding cow meat (with a slightly smaller contribution of approx. 11%). A very interesting finding is the development of greenhouse gas emissions and compared with the value in the EU. In 1990 was the proportion of greenhouse gases produced by EU 28 agriculture to total emissions 9.6 % and 9.9 % in 2014. In Czechia 1990 was the share of agriculture emissions to total 6.1% and 5.33% in 2014. (EUROSTAT, 2016). In terms of comparing the production of greenhouse gases among the EU-28, the share of the Czech Republic is about 2.87 %, Slovakia 0.92 %, Poland 8.64 %, Hungary 1.31 %, Germany 21.93 % (Germany is the biggest polluter). Warning finding is the fact, that only 7 of the EU-28 is a large producer of greenhouse gases than the Czech Republic – Germany, United Kingdom, France, Italy, Poland, Spain and Netherlands. (EEA, 2016)

Czechia has been managing to reduce its overall emission burden very fast. Last but not least, it can be concluded that the livestock production sectors analyzed in the Czech agriculture contribute 77% of the production of the most voluminous greenhouse gas – carbon dioxide, thus being an enormous producer of greenhouse gases, which deserves adequate attention both under the Czech Republic's Environmental Policy and when designing tools of the Common Agricultural Policy in the context of moral responsibility in production of necessary goods such as staple foods.

As part of the component assignment of pricing the greenhouse gas emissions generated, the research project has resulted in a number of serious findings. Whereas carbon dioxide is unambiguously the most voluminous of the gases emitted, the nitrogen oxide emissions are a major problem primarily from the point of view of gas valuation in the form of public goods connected with the conventional production. Thanks to its high reactive capacity, this gas is a hidden threat, which is fully identified when giving it a monetary value. The results show that nitrogen oxides are generated, for the greatest part, in the dairy sector, where they attain nearly 35% of the total value of the dairy production generated on average in the study period. Another major conclusion is the situation after conversion of all the gases to the CO_2 equivalent followed by a pricing and comparison with the value of the agricultural production. In this respect, the high ratio of the emission public goods produced to the value

of the livestock production is an alarming result. This ration exceeds 15% of the production value on average in the beef and pork sectors; it is at 11% of the production value on average in the poultry meat sector, but the greenhouse gas emissions from the dairy sector attain almost 65% of the value of the milk production, which is a very serious fact, which should be reflected by instruments of agricultural and environmental policies of the CR.

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