LONG-TERM FORECASTING OF AGRICULTURAL INDICATORS AND GHG EMISSIONS IN LATVIA

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***Abstract**. In Latvia, the agricultural sector contributes to approximately **20%** of the total national GHG emissions and is the **second largest** source of GHG emissions behind the energy sector (68%). In this context, it is of great importance to prepare necessary forecast data on the agricultural sector and to assess their credibility and effect on calculation results. Agriculture develops in a very changing environment; it is affected by climatic conditions, the market situation and technological progress. Forecasting in this sector is associated with specific problems; therefore, it has to be performed employing carefully prepared data and appropriate forecasting methods. The paper deals with long-term forecasting of agricultural indicators and GHG emissions in Latvia, which is based on a macroeconomic model and the use of a multifactor linear regression equation.*

***Key words:** agricultural indicators, GHG emissions, long-term forecasting.*

INTRODUCTION

After regaining its independence, Latvia actively participates in the process of mitigating global climate change. The Parliament of the Republic of Latvia ratified the UN Framework Convention on Climate Change (hereinafter the Convention) [1],[2] in 1995 and the Kyoto Protocol of the Convention in 2002, which was a legal framework for Latvia's participation in mitigating climate change. In accordance with the Kyoto Protocol, Latvia had to achieve an 8% reduction in GHG emissions individually or together with other countries in the period 2008-2012, compared with the amount of GHG emissions in 1990. Latvia successfully achieved this target.

Even higher targets were set for the Kyoto Protocol's second commitment period until 2020 [3], which were adopted in 2012. In accordance with the second Kyoto Protocol, the European Union and thus its Member States have to reduce their emissions by 20% compared with 1990. To achieve this common goal in the EU, the commitments within both the ETC and the non-ETC sector have to be met. The non-ETC sector includes agriculture as well. The non-ETS commitments are imposed by the EP decision [3]. In Latvia, in accordance with the above-mentioned decision, the non-ETC sector's emissions may not exceed +17% compared with the 2005 data. The common EU-28 target is to achieve a 10% emission reduction in the non-ETC sector by 2020. The Energy Policy Framework for 2030 [Climate and Energy Policy Framework for 2030] sets a number of objectives and tasks that all the EU Member States have to achieve until 2030 in order to mitigate the negative effects of climate change. The EC has set a target to reduce GHG emissions by 40% until 2030, compared with the level of 1990, in order to achieve a reduction of 80-95% until 2050 and to achieve the international objective of not letting the atmosphere warm up by 2 degrees Celsius [16].

Latvia's National Development Plan includes an objective to increase the proportion of the productively exploited agricultural area by reintegrating the abandoned and inefficiently used agricultural area into production. In order to increase agricultural production and achieve the set climate policy targets until 2030, Latvia has to seriously assess the measures needed for the reduction of emissions, although in this respect agriculture is characterised as a particularly "inelastic" industry. In making the urgent climate and air policies, it is stressed agriculture is an industry that is potentially emission-effective and has not used its emission potential until now.

Certain targets have been set for the non-ETS sector for each year after 2013; if the targets are not achieved, the way how to meet the commitments has to be found. In accordance with the UN Framework Convention on Climate Change, the Member States, including Latvia, have to submit an inventory of GHG emissions and their removal to the Conference of the parties (COP) every year.

Since 2011, in Latvia GHG emissions in the agricultural sector have tended to increase (Figure 1). In 2012, the total national GHG emissions equaled 10 978 Gg CO_2eq., the agricultural sector was the second largest source of GHG emissions (22%) behind the energy sector (65.8%) (*Latvia`s National Inventory Report 1990-2012*) [4]. GHG forecasts indicate that without extra measures, Latvia will not achieve its international GHG emission targets for the period 2013-2020 that have been set by decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 **o**n the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 [3]. For this reason, it is of great importance to make GHG forecasts for the agricultural sector, which are based on high-quality data on national activities [7],[8].

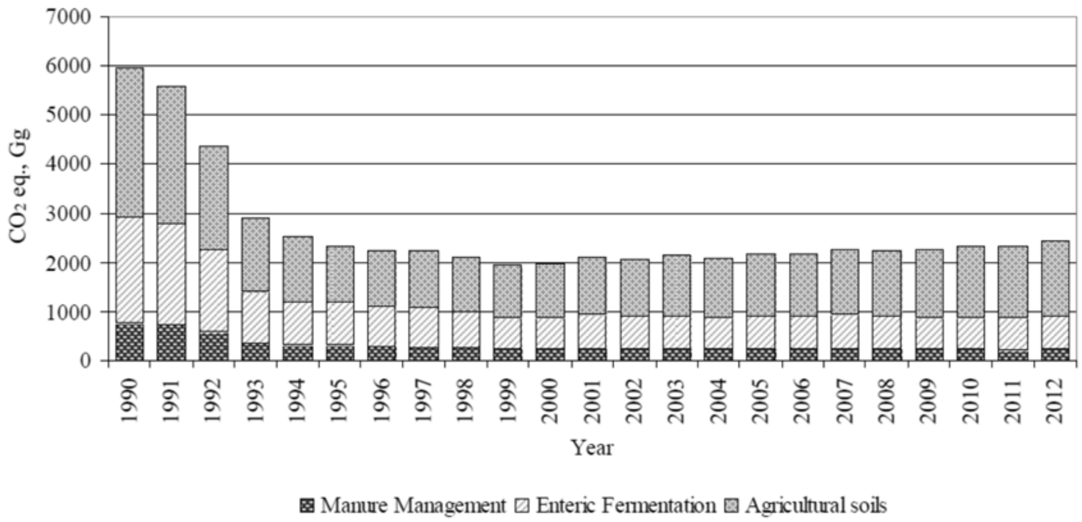

Figure 1. **Changes in GHG emissions in the agricultural sector [4]**

Making and reporting agricultural GHG forecasts in Latvia is carried out in accordance with the Convention on Climate Change and Regulation No 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change. The Regulation requires the Member States to report on their forecasts regarding greenhouse gas anthropogenic emissions to the EC and the secretariat of the Convention on Climate Change. The calculations of emissions are performed based on growth forecasts for various industries, which are also prepared for the agricultural sector for 2015, 2020, 2030 and 2050.

MATERIALS AND METHODS

Time series trend models are most often employed for the short- and long-term forecasting of agricultural indicators (up to 10 years). For instance, the following trend models were used to make forecasts for 2015 and 2020 in Latvia [7],[9],[10]: the linear trend model, the power trend model, the semi-logarithmic trend model, the exponential trend model and the polynomial trend model. The CAPRI system module CAPTRD also employs the power trend model in forecasting agricultural indicators [8].

Time series trend models are not suited for *long-term forecasting* (over 10 years), as the forecast period is too long. In this case, more complicated econometric or dynamic models are employed [13],[15].

In 2013, a correlative relationship between the GDP and the corresponding agricultural indicator was used for forecasting agricultural indicators for 2030 [7]. A GDP forecast for 2030 was produced by the Ministry of Economics (MoE) by employing a complex macro-model for Latvia's national economy [13],[14].

The present paper suggests using the MoE macro-model for the national economy and its forecasts to a greater extent and in more detail, i.e. indicators such as share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products have to be employed along with the GDP indicator. So, it is advised to employ a multifactor linear regression equation for forecasting agricultural indicators for 2030 [11].

RESULTS AND DISCUSSION

Summarising information on GHG emissions produced by a sector in Latvia and forecasting changes in the GHG emissions are necessary to be able to control compliance with the emission reduction targets and, if necessary, to take appropriate measures for reducing the level of emissions. This conception suggests using the MoE macro-model for the national economy and its forecasts to a greater extent and in more detail, i.e. indicators such as share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products have to be employed along with the GDP indicator.

So, it is advised to employ a multifactor linear regression equation for forecasting agricultural indicators for 2030 [11]:

$$\tilde{y}_{jt} = a_0 + a_1 x_{1t} + a_2 x_{2t} + a_3 x_{3t} + a_4 x_{4kt} + a_5 x_{5kt} + a_6 x_{6kt} \ , \quad (1)$$

where: $\tilde{y}_{ji}$ – j-th forecasted agricultural indicator (number of cattle, number of pigs, area sown with wheat, etc.) in the t-th year,
x_{1t} – GDP, bln EUR, in 2010 constant prices, in the t-th year,
x_{2t} – share of agriculture in GDP, %, in the t-th year,
x_{3t} – number of population, mln, in the t-th year,
x_{4kt} – price of the k-th agricultural product, thou EUR/t. (the price of beef, the price of pork, the grain price, the milk price, ect.) in the t-th year,
x_{5kt} – amount of exports of the k-th agricultural product, thou EUR, in the t-th year;
x_{6kt} – average consumption of the k-th agricultural product per household member per year, kg, in the t-th year.

Initially, the model includes all the six factors. If a factor with the smallest absolute value of the partial correlation coefficient is not statistically significant, the factor is excluded from the model. The exclusion is stopped if there are no more factors being statistically insignificant, i.e. their p-value is less than a=0.05.

The average confidence interval boundaries of the dependent variable are calculated according to the following equation [11]:

$$\Delta_{xid,x_t} = \pm t_{\alpha,\vartheta} \sqrt{s^2 \vec{x}_t^T \left(X^T \mathbf{X}\right)^{-1} \vec{x}_t} \, , \quad (2)$$

where: $t_{\alpha;\vartheta}$ – critical value of Student's t-distribution;
a – tolerable probability of error of the forecast, a is assumed to be 0.1;
ϑ – number of degrees of freedom ϑ = n-k, n – number of observations, k – number of regression equation coefficients, k=5;
s_{yx} – regression standard deviation;

$$s_{yx} = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \tilde{y}_i)^2}{n-k}} \quad (3)$$

$$\vec{x}_t = \begin{bmatrix} 1 \\ x_{1,t} \\ x_{2,t} \\ x_{3,t} \\ \cdots \\ x_{6,t} \end{bmatrix} \quad (4)$$

$$X = \begin{pmatrix} 1 & x_{1,1} & x_{2,1} & \cdots & x_{6,1} \\ 1 & x_{1,2} & x_{2,2} & \cdots & x_{6,2} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & x_{1,24} & x_{2,24} & \cdots & x_{6,24} \end{pmatrix} \quad (5)$$

If the multifactor linear regression model (1) is recorded in the form of matrixes:

$$Y = X * A \quad (6)$$

where:

$$A = \begin{pmatrix} a_0 \\ a_1 \\ \dots \\ a_6 \end{pmatrix} \quad (7)$$

GDP forecasts, population number forecasts and forecasts of exports and private consumption will be based on the macroeconomic forecasts for Latvia for 2030 by the Ministry of Economics [1]. Forecasts on prices of agricultural products are based on a FAO research study [17].

Example of forecasting

Based on the forecasts for 2020 and 2030 by the Ministry of Economics of the Republic of Latvia, one can make the following forecast (see Figure 2.) by using formulas (1),…,(7):

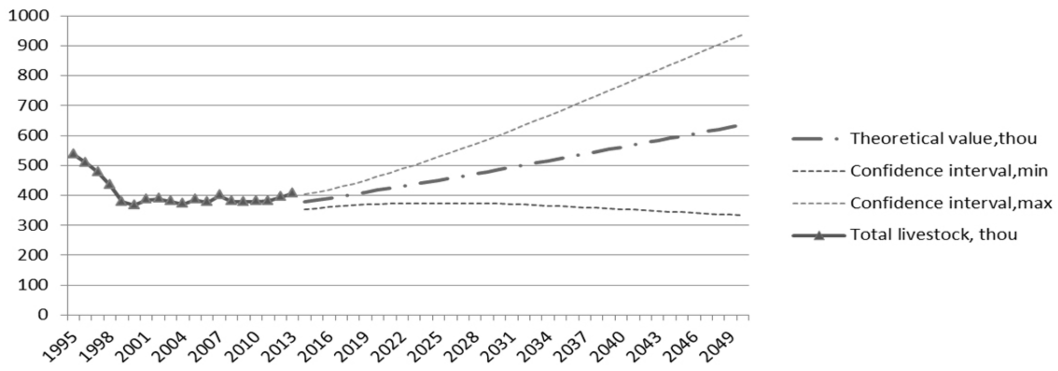

Figure 2. **Projections of changes in the number of livestock in Latvia till 2050**

After preparing the active data necessary for calculating GHG emissions by means of special models for forecasting emissions, based on the long-term macroeconomic forecasts, development strategies of and government policy documents for various industries produced by the Ministry of Economics, the calculation of GHG emissions is started. According to the forecast data on the development of the industry, the determination of GHG emissions is based on calculations in accordance with the guidelines developed by the Intergovernmental Panel on Climate Change (IPCC).

The IPCC guidelines for calculating GHG emissions set out methodologies of several levels: Tier 1, Tier 2 and Tier 3. Each next level means a more detailed and specific emission calculation methodology for every country as well as reduces the impreciseness of calculation results. The emission calculation methodology and the level are determined using decision-making trees. GHG emissions that may be characterised as the key emission source have to be mostly calculated according to the Tier 2 methodology. The methodology also specifies the recommended levels for calculating emissions from various sources, for example, the recommended levels for calculating methane emissions from intestinal fermentation processes are presented in Table 1.

Table 1

Methodology recommended for calculating methane emissions from intestinal fermentation processes [16]

Farm animal species	Recommended IPCC methodology level
Milch cows	Tier 2a/Tier 3
Other cattle	Tier 2a/Tier 3
Sheep	Tier 1/Tier 2
Goats	Tier 1
Horses	Tier 1
Pigs	Tier 1

Source: authors' construction based on the IPCC guidelines

The key factors determining emission calculation results are as follows:
1) active data for agricultural development (livestock and crop) indicators;
2) emission factor (EF).

For example, methane emissions from intestinal fermentation processes for each farm animal species are determined according to the equation:

$$Emission = EF(T) \cdot (N(T) / 10^6), \quad (8)$$

where: Emission = methane emission from intestinal fermentation processes, Gg CH_4 $year^{-1}$;
EF(T) = EF for each farm animal species, kg CH_4 $animal^{-1}$ $year^{-1}$;
N(T) = number of animals of each farm species (T);
T = farm animal species.

Agricultural production active data may be divided into primary data for calculating direct emissions and secondary data for calculating the EF according to the Tier 2 methodology. Amounts of GHG emissions may be forecasted depending on the values of agricultural production intensity and the effects of the technology chosen (for instance, the use of a certain manure management system). In calculating emissions according to the Tier 1 methodology, standard emission factors are employed; therefore, the final result is closely associated with the active data used. In calculating emissions according to the Tier 2 methodology, the effects of various production technologies on the size of GHG emissions are taken into account, thus, the emission factor is calculated using country-specific values of agricultural production indicators. In this case, agricultural production indicator forecasts may be attributed not only to active data but also to assessments of the effects of production technologies. A final forecast result can be also affected by development plans for some specific agricultural industry, which can qualitatively correct a forecast produced mathematically.

CONSLUSIONS

1. The long-term forecasting of agricultural indicators has to be linked to macroeconomic forecasts for the country and to the development of the world market of agricultural products.

2. The multifactor linear regression equation whose factors are output macro-model indicators for Latvia – GDP, share of agriculture in GDP, number of population, agricultural exports, price of agricultural products and consumption of agricultural products – may be successfully used for the long-term forecasting of agricultural indicators.

3. Forecasting GHG emissions is based on the IPCC guidelines and forecasts of agricultural indicators. The overall result may be adjusted to the specific development plans of some agricultural industry.

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