MODELLING AND FORECASTING OF GREENHOUSE GASES EMISSION IN LATVIA

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This paper presents a forecast analysis of production in different sectors of Latvia's manufacturing. It considers the results of investigation ordered by Ministry of Environment Protection. The forecasts of production growth in different sectors of manufacturing are calculated up to 2020. On basis of these forecasts by means of unified EU methodology the forecasts of CO_2 emission are calculated. The calculated CO_2 emission forecasts will serve for Latvia's emission quota demand from EU as basis.

Keywords: *"Greenhouse effect", greenhouse gases, CO_2 emission, production functions*

1. Introduction

In order to suppress the undesirable changes of world climate it is necessary to implement the requirements of United Nations Framework Convention on Climate Change, its Kyoto protocol, as well as European Union legislation acts on Climate changes. These requirements should be taken into account in development of Latvia's national economy. In accordance with this Latvia's Programme of Mitigation of Climate Changes in 2005-2010 [1], [2],[3] is elaborated.

It is expected that this Programme will positively affect the environmental situation, accelerate the structural changes in national economy and decrease the intensity of natural resources usage.

Latvia's long-term strategy of economic development considers four development scenarios: convergence scenario, slow convergence scenario, stagnancy scenario and divergence scenario. Each of them could be expected in longer period at definite inner and outer factors affecting the national economy. The desirable and, therefore, a supportable convergence scenario at favourable combination of inner and outer factors as well as at successful usage of Latvia's advantages in different areas of national economy provides the achievement of goals set in the National Development Plan [4], [5].

All these scenarios should be taken into account in forecasting the greenhouse effect. For this the medium-term and long-term prognosis of production sector development is necessary to know. Therefore, we calculated the production growth in main sectors of economy for two more probable development scenarios: convergence and slow convergence scenarios.

Forecast scenarios depend on fluctuations of outer and inner demand. These fluctuations are determined by several factors (structure and dynamics of investment, changes between trade and non-trade sectors mainly between manufacturing and services, an ability to penetrate new markets, etc.). In considered period of development the growth rate and its stability will depend on how Latvia's competition in EU market will be strengthened, how successfully EU structural funds will be used and on conditions of outer conjuncture. The elaborated concept of possible economics development in longer time period is based on assumption that growth of GDP and structure of economics sectors will be stabilised after 2012.

However the Ministry of Economy notes that in this period simultaneously with favourable conditions of economic development some risk factors also can appear – the growing investment favours the import and thus can increase the deficit of current account. These factors in their turn can significantly affect the inner demand.

In order to forecast the integrated emission of all sectors of economy it is necessary to take into account the long-term macroeconomics forecast developed by Ministry of Economy and covering time period up to 2025.

The elaborated macroeconomics development forecasts used in development of CO_2 emissions forecasts are characterised by the following parameters:

- High growth of GDP in the first half of development period (up to 8% yearly) which after 2010 can slow down up to 5% due to achieved high level of production.
- The growth of GDP will determine mainly the growth of productivity and not the increase of employment.

- The high inflation rate in 2004-2007 will decrease step by step up to 3% in the following years and will reach the level of 2% at the and of the considered development period. The inflation rate is relatively high due to relatively low prices and unavoidable increase of salaries and wages. It is expected that faster than prices of goods the prices of services will increase.
- The fast annual growth of export is necessary for growth of manufacturing.
- The part of import in economy is high and stable, the import is stimulated by inner demand, the investments of foreign countries and availability of EU structural funds, more tangible equalization of export and import is expected after 2010.
- The structural changes in economy will continue, the part of agriculture will go down and the part of services will go up.
- An increase of high technologies part in economy will suppress the necessity to intensify the branches of economy demanding natural resources.

In Table 1 there are shown the basic macroeconomic indicators used in forecasts.

Table 1. Basic macroeconomic indicators

	2000	2001-2005	2006-2010	2011-2015	2016-2020	2021-2025
Number of inhabitants (thousands)	2373,0	2298,9	2275	2222,5	2170	2063,6
GDP in real prices (million LVL)	4750,8	8937,3	16584,4	24102,6	34078,6	48190,2

2. Methodology of Forecasts

Forecasts are one of the most demanded and at the time one of the most complicated issues in the economics analysis. A forecasting basically is the prediction of present and forthcoming situation on the basis of indicators known from the past.

In order to make the forecasts of some economic indicators different methods of simulation can be used. Such are, for example, time series, models of macroeconomic (production functions) forecasts, models of variation (optimisation) theory, neuron networks, etc.

Firstly, the extrapolation method can be mentioned. Based on known relations among indicators of the past, present and future it allows finding the time series of process development. The method of time series can be applied when the dependence of future indicators on the past indicators is known and data in the past are given with small separation in time. When data step in time is a year the application of this method becomes doubtful. Time series practically are not applicable for long-term forecasts. Therefore, the method of time series is not used in the present investigation.

The state economy growth can be simulated also by means of production functions. In these models the economy growth is related to growth of different production factors (labour force and capital) and to technological progress. In economic studies and forecasting very widely the Cobb-Douglas production function (hereinafter C-D production function) is used, in order to analyse the return of the production factor (capital and the labour force), as well as to estimate the level of technological progress and the historical trends of production output in the country. It is a general practice to use linear design methods for assessing the C-D production function. In order to assess the production function the standard form of C-D function with constant returns of scale is frequently applied. It has the following presentation:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha},$$

where Y_t is GDP in comparable prices, A_t is the total productivity of factors or the technological progress, K_t is the actual volume of the accumulated capital, L_t is the labour force in the economy and α is the return on capital.

At testing of results, which were obtained using Latvian data for different sectors of national economy in order to determine the production functions for each sector of economy, the conclusion was drawn, that the C-D production function with constant return of scale cannot be applied. Better results were obtained when C-D production function with a variable return of scale was used. It is

$$Y_t = A_t K_t^{\alpha} L_t^{\beta},$$

where β is return of labour.

At simulation of C-D production function in linear form it is assumed that the total factors of productivity development in time or the technological progress are determined as follows:

$$A_t = A_0 e^{t\beta+\varepsilon_t},$$

where ε_t is the assessment error.

The application of the last approach would be more appropriate for the present investigation. Unfortunately, in order to use the production functions in different sub-sectors of distributed sectors of economy very detailed past data on sub-sectors capital, productivity and amount of investment are necessary. Because these data are not available at present the application of the last method in the present investigation is impossible.

Another possibility of outputs forecasting in different sub-sectors of manufacturing consists in application of input-output model. The application of this model would allow taking into account also the mutual influence of different sectors on their development. Unfortunately for full application of this method the necessary set of data in the past was not available

In the present forecast calculations the method of time series and method of impact of macroeconomics indicators iss used. At such combined approach it is assumed that each concrete sector of national economy will develop in accordance with national economy development forecasts made by Ministry of Economics. At calculation of production amount in each sub-sector the error corrections are taken into account. It is done in accordance with error correction model. The time series obtained are corrected taking into account the known and predicted technology changes in each sub-sector

$$Y_t^k = (1+\tau^k)Y_{t-1}^k + \varepsilon_t^k,$$

where Y_t^k is amount of product for each sub-sector k in year t, τ^k is rate of economic growth for sub-sector k and ε_t^k is error for sub-sector k in year t.

In forecast calculations the historical time series on production dynamics and international trade as well as data of Ministry of Economics on development of national economy in different sectors of economy and manufacturing are used.

Table 2. Growth rates for economy sectors

	2001-2005	**2006-2010**	**2011-2015**	**2016-2020**	**2021-2025**
Agriculture, fishing.	4,5	3,0	3,0	3,0	2,8
Manufacturing	7,6	8,4	7,0	6,5	6,5
Electricity, gas and water supply	4,4	3,1	5,0	5,0	5,0
Construction	11,8	13,5	8,0	7,0	7,0
Wholesale and retail trade	12,7	9,4	6,0	5,0	5,0
Transport, storage and communication	10,1	7,3	5,7	5,2	5,0
Public services	2,8	3,1	3,0	3,0	2,6
Other services	7,5	8,7	4,5	4,0	4,0
GDP	**8,1**	**8,0**	**5,5**	**5,0**	**5,0**

Table 3. Growth rates for manufacturing sectors

	Structure 2000	**2001-2005**	**2006-2010**	**2011-2015**	**2016-2020**	**2021-2025**
Manufacture of food products	31,4	5,1	5,7	3,1	2,2	2,0
Manufacture of textiles	9,4	1,1	5,8	2,7	2,0	1,0
Wood-processing	20,8	8,4	11,4	10,2	9,5	9,0
Manufacture of pulp, paper and paper products	1,8	5,0	3,4	2,7	3,2	3,0
Publishing, printing and reproduction of recorded media	5,1	6,2	7,7	6,1	6,2	6,0
Manufacture of chemicals and chemical products	4,0	10,6	12,3	9,1	5,5	5,0
Manufacture of rubber and plastic products	1,9	25,8	9,4	9,1	6,2	6,0
Manufacture of other non-metallic mineral products	2,9	21,0	8,3	9,1	9,0	8,0
Manufacture of basic metals	5,9	4,3	6,4	4,8	4,2	4,0
Manufacture of fabricated metal products, except machinery and equipment	3,5	11,2	13,9	10,3	8,3	8,0
Manufacture of machinery and equipment	8,6	9,0	8,2	7,2	8,0	8,2
Other manufacturing	4,7	8,9	7,7	6,1	4,2	3,9

Forecasts of direct greenhouse gases emissions in different branches of manufacturing are calculated taking into account the forecasts of production growth in different sectors of economy. Calculations are made taking into account the common report format of climate change intergovernmental board (CCIB) and improved in 1996 CCIB guidelines on preparation of inventory of national greenhouse gases emission effect as well as 2000 good praxis manual.

Conclusions

From analysis of forecast data obtained in frames of convergence scenario for output of manufacturing it follows that the largest output will be expected in sector of mineral (cement, lime, clinker) production. It is expected that the growth of produced cement will be almost 85% but growth of that of cement clinker approximately 92%. For common iron and steel production forecast predict approximately 50% growth, for steel itself – 32% growth.

Forecasts of manufacturing outputs to large extent are affected by quick development of construction. Consequently, this increases the demand of construction materials.

Due to the fact that in some sectors of manufacturing there are enterprises, which produce all amount of sector's output, the corresponding forecast data are confidential.

The largest part of emissions in manufacturing processes consists of CO_2 emission, small amount of CH_4 emissions appears in ferrous metallurgy.

Taking into account the quick growth of manufacturing outputs, 80.4% increase for greenhouse gases emission is predicted in 2020. In case of slow convergence scenario the increase of greenhouse gases emission is expected to be approximately 75.4% (in CO_2 equivalent).

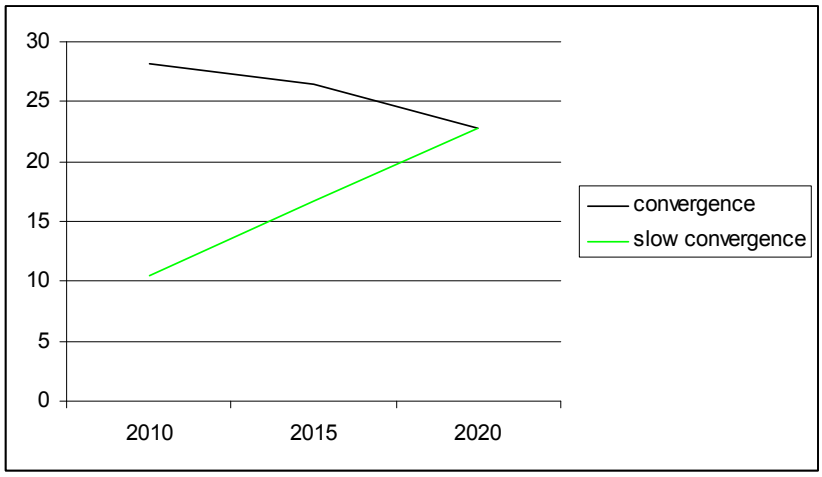

Figure 1. Growth changes of metal production

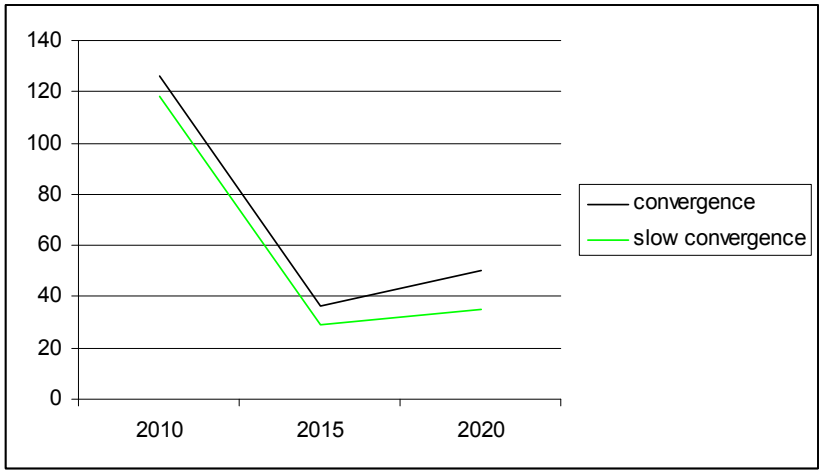

Figure 2. Growth changes of mineral production

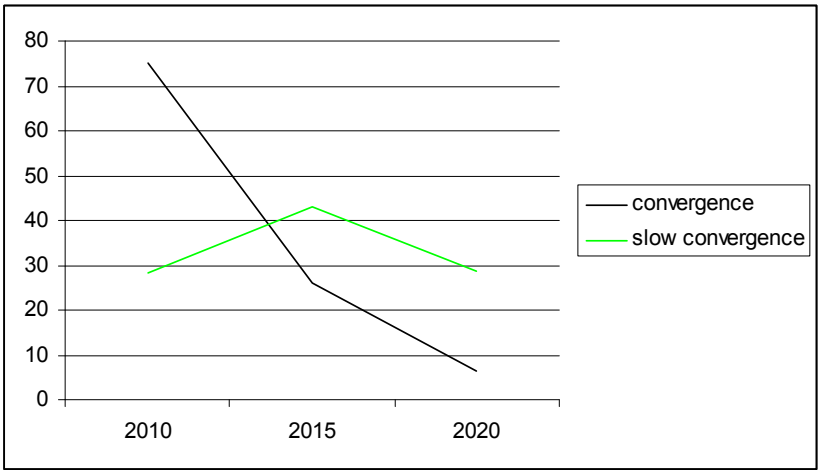

Figure 3. Growth changes of bricks production

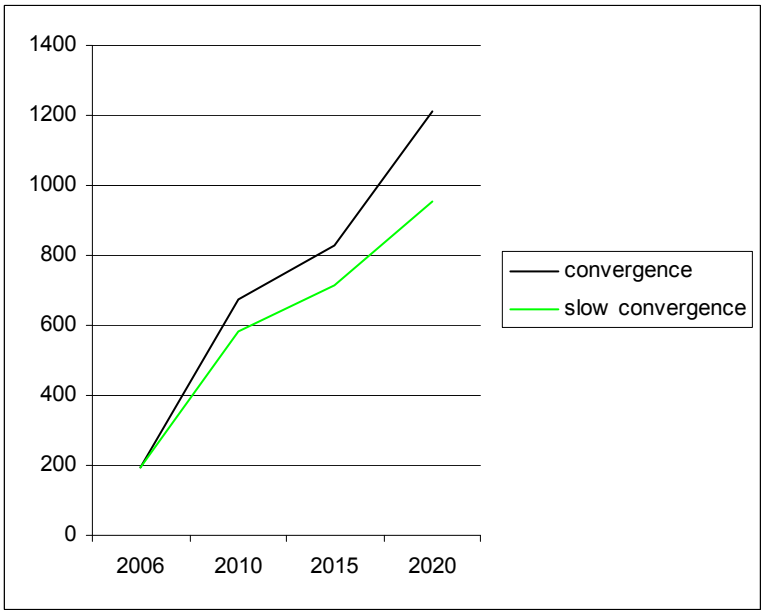

Figure 4. Calculated emission forecast of mineral production (Gg)

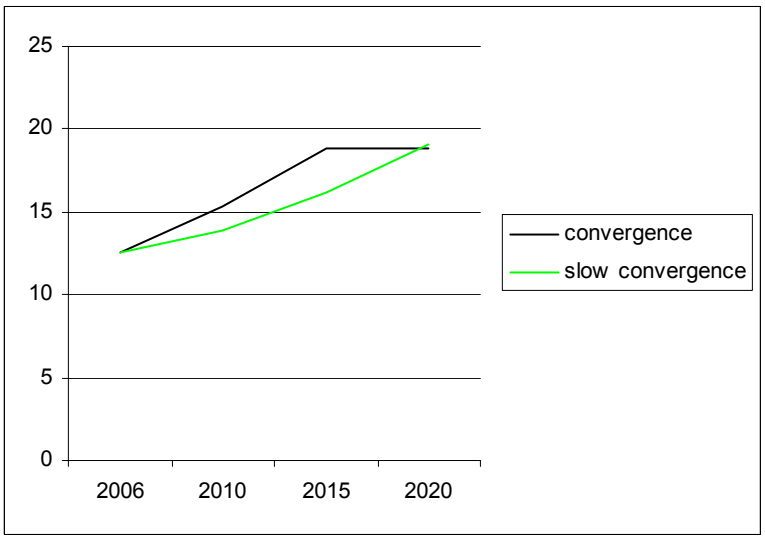

Figure 5. Calculated emission forecast of metal production (Gg)

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