Computable General Equilibrium Model as a Tool to Assess the Impact of Climate Policy in Latvia

Olegs Krasnopjorovs, Daniels Jukna, Konstantins Kovalovs, Rita Freimane

18.03.2022.

Macroeconomic impact of climate policy (literature findings)

GDP and productivity: ↓

Employment: ↓ (skill redistribution: ↑ high-skilled jobs; ↓ low-skilled jobs).

Inflation: ↑

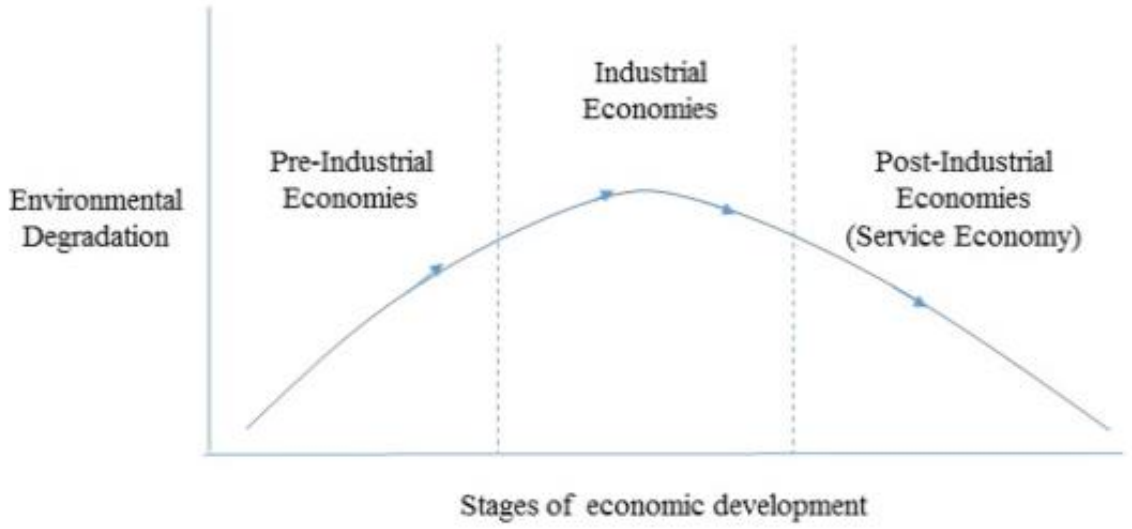
But:

- Impact of climate policy could be smaller than impact of climate change (global warming, natural disasters, more extreme weather events);
- Double-dividend hypothesis: wise climate policy could increase both:
  - welfare (taxes on pollution ↑ allow to ↓ taxes on labour income);
  - well-being (lower pollution => better health, longer life expectancy => ↑ happiness (and ↑ productivity));

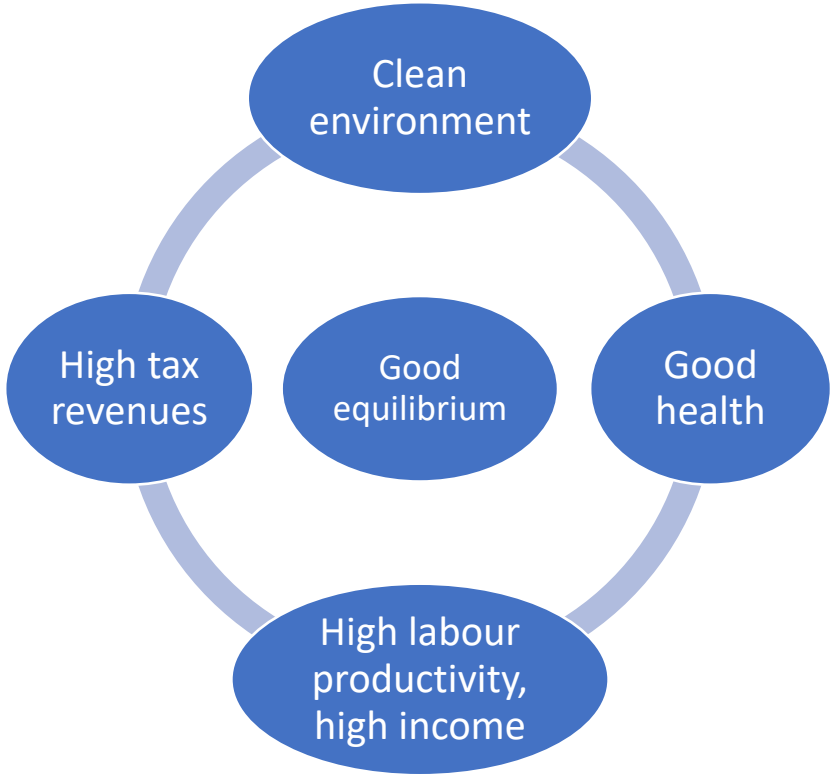
=> Design of climate policy is crucial: economic analysis needed => CGE model.

Economic development goes together with the environmental goals

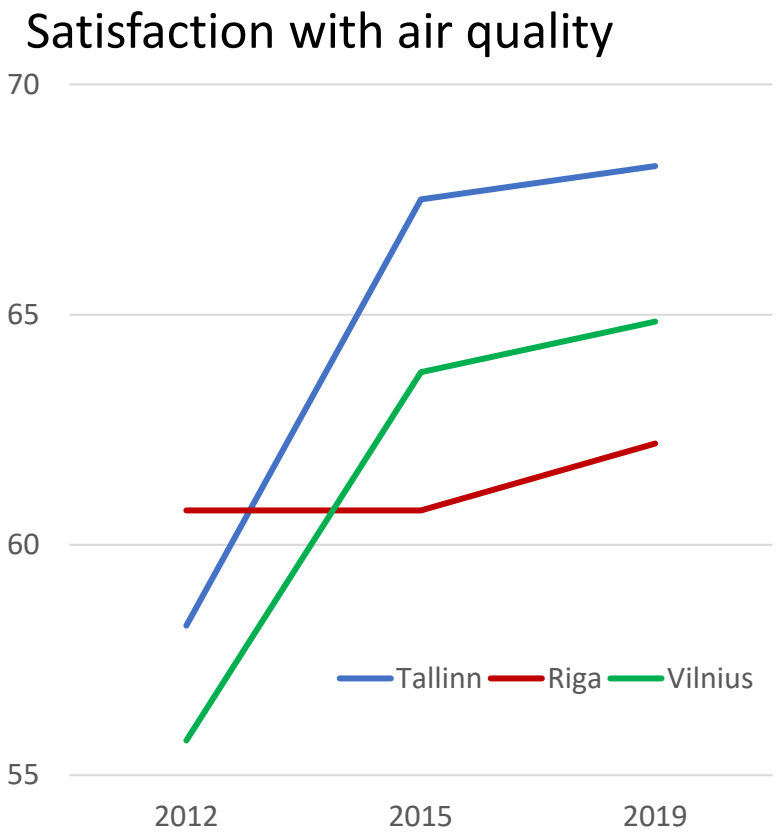
Environmental Kuznets curve

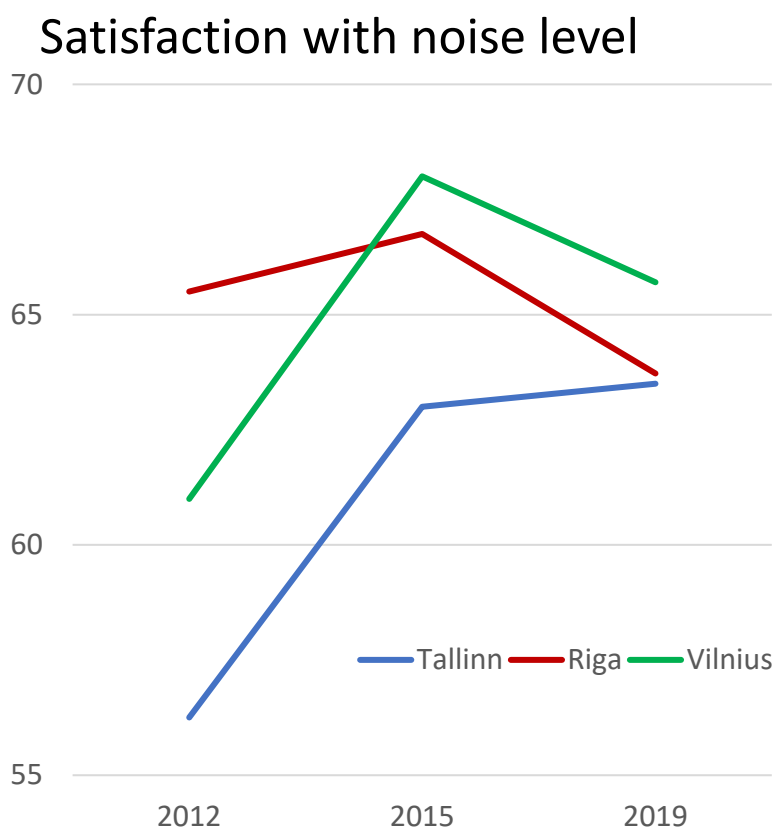


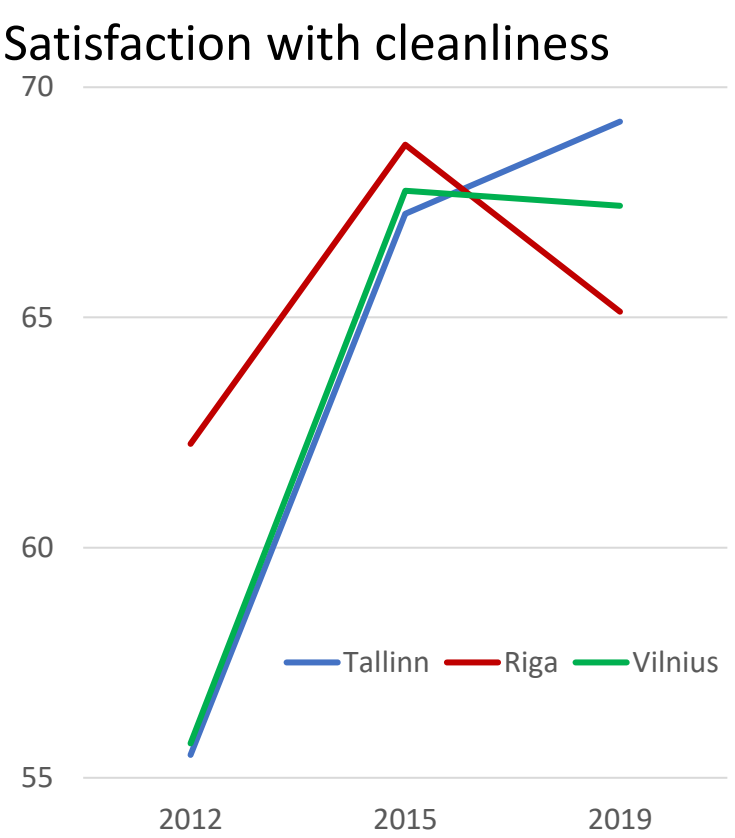
Theoretical model of environmental quality, population health and economic development



Large room to ↑ environmental quality also in Latvia







10 years ago, Riga was the leader of the Baltic capitals in terms of environmental quality.
Lack of progress => Riga is currently lagging behind

Source: author's calculations based on European Commission survey on the Quality of life in European cities.
Balance of replies was recalculated to 0-100 scale, 0 – not at all satisfied, 100 – very satisfied.

Why to use CGE (and not econometric) model?

- Diffenbaugh, Burke (2019) «Global warming has increased global economic inequality». *Proceedings of the National Academy of Sciences of the United States of America.*
- Finding: global warming is responsible for 25% increase of the income inequality between countries over the past half century.

$$\Delta \log(Y_{it}) = \beta_1 T_{it} + \beta_2 T_{it}^2 + \lambda_1 P_{it} + \lambda_2 P_{it}^2 + \mu_i + \upsilon_t + \theta_{1i} t + \theta_{2i} t^2 + \varepsilon_{it},$$

where Y_{it} is per capita GDP in country i in year t, T is the average temperature in year t, P is the average precipitation in year t, μ_i are country-fixed effects, υ_t are year-fixed effects, and $\theta_{1i}t + \theta_{2i}t^2$ are country-specific linear and quadratic time trends.

Or: GDP growth = f (Temperature, Rainfall)

- A critique by Rosen (2019) «Temperature impact on GDP growth is overestimated»:

«I believe that all of the numerical results cited in this article are wrong, because the methodology is not valid»

Excludes the main factors of economic growth: physical capital, population growth, technical progress, education, employment rate changes etc.

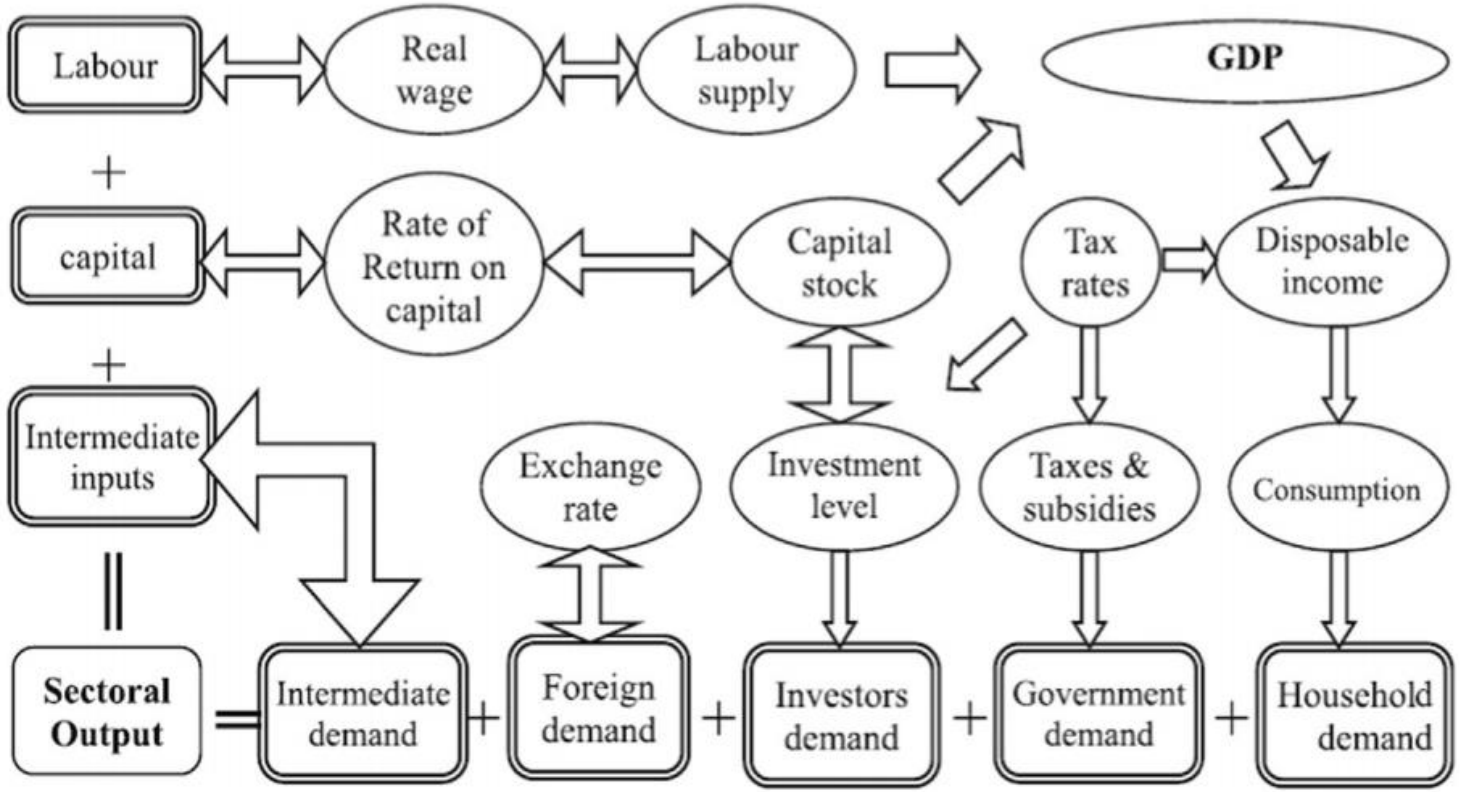
⇒Results based on one equation may be misleading.

It is not possible to describe all economic interactions in one equation.

CGE model is a computer simulation that uses a system of equations that characterises the interaction of all sectors of the economy. All these interactions should be considered to get reliable results.

CGE model consists of the 2 main parts:
(1) Model structure
(2) Database

CGE model structure:



CGE model database:

(1) income and expenditure flows in the economy (input-output tables, supply-use tables u.c.);

(2) parameter values.

Source: Babatunde, Begum, Said (2017). «Application of computable general equilibrium (CGE) to climate change mitigation policy: A systematic review». *Renewable and Sustainable Energy Reviews*, Volume 78, 2017, Pages 61-71, https://doi.org/10.1016/j.rser.2017.04.064.

Why one CGE model is not enough?

CGE model (E3M Modelling; University of Latvia)

«Top-down» approach:

- reflects the interaction of all sectors of the economy;
- assesses the impact of climate policies on non-energy sectors;

But does not pay attention to energy sector details:

- introduction of new technologies => Δ energy intensity;
- Δ energy demand => Δ energy mix;
- Δ competition => Δ electricity & heating prices.

Demand for energy

Energy prices, Energy mix

TIMES/MARKAL model (Institute of Physical Energetics; Riga Technical University)

«Bottom-up» approach:

- describes the energy sector in detail but do not include non-energy sector impacts.

Linking the two models would reduce shortcomings of each individual model.

«**Two-way soft-linking**»: each model works independently from each other (e.g., 1st model results are exogenous variables for the 2nd model). Two models are linked manually: information flows are controlled by researchers, in a form of multiple iterations.

How to link CGE with a Times/Markal model (how will the models exchange information with each other)?

Soft-linking

- Models work independently;
- Information flows are controlled by researchers, in a form of multiple iterations;
- Transparency, researchers' learning-by-doing;
- Researcher decides how to change inputs/assumptions to get consistent results;
- Easier to develop, may be harder to use.

Hard-linking

- Models work independently
- information is exchanged automatically, using computer programs;
- Efficiency / productivity;
- Model 1 is given control over specific results; Model 2 may reproduce these results with a different aggregation level;
- Harder to develop, may be easier to use.

Hybrid model / model integration

- Models depend on each other
- Model integration may need to simplify one or both models significantly;
- OK for looking at a global picture, but with less sectoral or technological details, it is less useful for public policy considerations.

=> What this project will do: soft-link first, then think about hard-link.

Some of the best practice examples

Examples of linking the CGE and TIMES models

Article	Data sent from CGE to TIMES	Data sent from TIMES to CGE	Linking
Böhringer & Rutherford, 2009	• Energy demand	• Net energy output • Inputs of non-energy goods to the energy system	Hard-linking
Fortes, et al., 2014	• Energy demand	• Energy prices • Energy consumption • Policy monetary values	Integration
Dai, et al., 2016	• Energy demand	• Energy consumption	Soft-linking
Holz, et al., 2016	• Energy demand	• Energy mix	Soft-linking
Abrell & Rausch, 2016	• Electricity demand and price • Input prices for fuel, capital, labour, goods and services	• Electricity dispatch • Input demand for fuel, capital, labour, goods and services	Hard-linking
Krook-Riekkola, et al., 2017	• Energy demand	• Energy intensity parameter • Energy mix • Energy prices	Soft-linking
Wiebe, et al., 2017	• Energy demand	• Energy mix	Hybrid-linking
Andersen, et al., 2019	• Energy demand • Fuel prices	• Energy prices • Energy mix	Soft-linking

Source: authors' elaboration based on academic literature.

A way forward

- Project began in September 2021;
- In cooperation with E3 Modelling, Ministry of Economics, Institute of Physical Energetics, Riga Technical University etc.;
- Aim is to develop a full-fledged dynamic CGE model with energy/environment sector, i.e. CGE model should be able to assess the impact of both carbon and non-carbon shocks; and soft-link it with Times/Markal model (which describes details of the energy sector);
- Analysis of how to achieve the maximum benefits of the climate policy, with the minimum costs;
- Take into account both economic and social impacts (e.g., income inequality).

Please address any comments and questions to:

Olegs.Krasnopjorovs@lu.lv