University of Regina

IEES

Institute for Energy, Environment and Sustainable Communities

ECONOMIC MODELING TO SUPPORT THE **DEVELOPMENT OF CLIMATE CHANGE REGULATIONS**

Background

Global climate change has emerged as one of the most challenging environmental issues and has gained considerable attention worldwide[1]. Greenhouse gases (GHG) in the earth's atmosphere are destabilizing established climate patterns and damaging the ecosystems on which all living beings depend[2]. Tremendous efforts are needed to avoid the increasing risks of climate change on the environment, human health, and the economy.

In Canada, a national target was set to reduce GHG emissions by 30 percent below 2005 levels by 2030[3]. In 2016, the Canadian economy was estimated to have nearly equivalent net exports of minerals and fuels (16 percent of GDP) and automobiles (16.4 percent of GDP)[4]. This is important when it comes to how carbon taxation affects jurisdictions across Canada. Mineral and fuel production tend to be concentrated in western Canada (Alberta, and Saskatchewan, and to some extent British Columbia), while Canadian manufacturing exports tend to come from central Canada (Quebec and Ontario). Manufacturing-based economies are able to adjust to carbon pricing and taxation by passing on costs to customers. On the other hand, natural resource-based economies are hard to adjust to carbon pricing and taxation as their revenues are determined by global commodity markets.

Saskatchewan's economy significantly relies on resource extraction[5]. A carbon tax may be detrimental to economic growth in Saskatchewan. It is crucial to systematically assess the numerous and cumulative effects of a carbon tax on the province's socio-economic system. This analysis will help enable an effective economic strategy for GHG emission reduction in Saskatchewan.

University of Regina

IEES

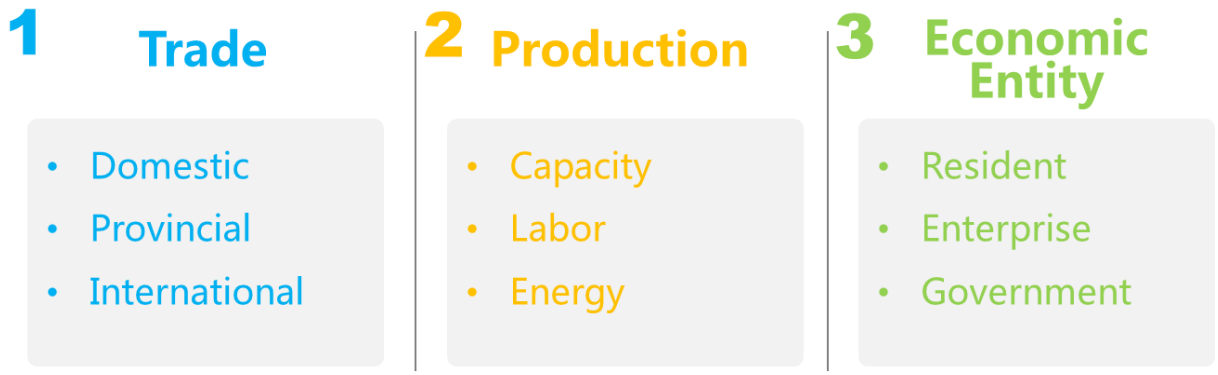
Institute for Energy, Environment and Sustainable Communities

Objective

The objective of this research is to develop a Saskatchewan Computable General Equilibrium (SK-CGE) Model and simulate a series of direct and indirect socio-economic impacts of a carbon tax. In detail, the energy sector is further disaggregated based on production structure and energy use patterns to obtain robust results. Different policy scenarios are simulated to quantify the interrelationships of a carbon tax, GHG emission reduction, and economic growth. In-depth examinations are conducted to investigate other macroeconomic impacts and responses from specific economic sectors. The results are expected to provide an evidence-based perspective on the Saskatchewan specific economy for exploring feasible GHG-emission reduction approaches.

Computable General Equilibrium Model

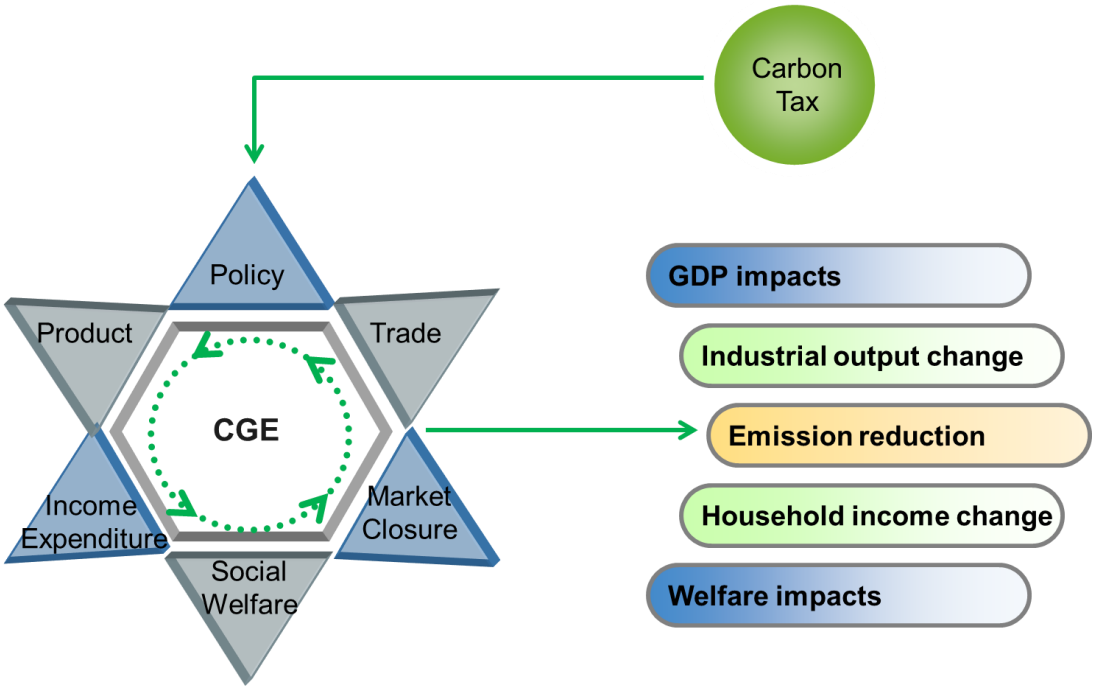
In economics, general equilibrium theory attempts to explain the behaviour of supply, demand, and prices in a whole economy with several interacting markets, by seeking to prove that a set of prices exists that will result in an overall equilibrium. Computable general equilibrium (CGE) models are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. The first CGE model was developed by Johansen in 1960, however little attention was paid to the model until there were great changes in energy prices and international monetary systems.



There are many successful CGE models, which have different areas of emphasis. In Canada, the CGE models have been applied to support climate change policy-making in Alberta, British Columbia, Ontario, Manitoba, and Quebec. It is important to note that a policy in one jurisdiction will have different impacts on different economies. Thus, a CGE model must be developed based on the actual economic structure of a jurisdiction or region.

SK-CGE Model

To begin the project, a CGE model for Saskatchewan was developed to describe the new equilibrium after an exogenous shock affects the province's economic system. The SK-CGE model can reflect the reactions of the province's economy at one point in time. Through the disaggregation of energy sectors, the model provides a full representation of the structure of production and consumption in the economy to analyze the aggregate and detailed implications of GHG mitigation policies.



The SK-CGE model has 6 modules:

- Production - describes the production activities of all commodities.
- Trade - reflects the trade behaviors of different agents, including exports and imports.
- Income and expenditure - aims to reveal income and expenditures of various economic entities. Each entity has many sources of income and expenditure.
- Social welfare - to calculate a households' utility change after policy implementation. A positive value denotes an improvement in social welfare and a negative one implies a decline in social welfare.
- Policy - to represent policies such as a carbon tax.
- Model closure and market clearing - different principles of closure have been adopted in this model.

The modules are linked together by the variables of price and quantity. When simulating the impacts of a policy, a new policy will be added into the model as a shock, which will break the equilibrium status. In this research a carbon tax has been introduced to the policy module. This will change the price of related factors, leading to price changes of related commodities. The entire model will reach a new equilibrium status. Finally, by comparing the two equilibrium statuses, comprehensive results can be obtained, including GDP impacts, industrial output change, emission reduction, household income change, welfare impacts, and so on.

Input data

- Input-output table of Saskatchewan (Statistics Canada)
- Social accounting matrix of Saskatchewan (Statistics Canada, national accounts data, other statistic data)
- Emission factors (Statistics Canada, Environment and Climate Change Canada)
- ...

Scenarios

1. Benchmark scenario

GDP continues to grow with a growth rate equal to 1%.
The model was calibrated based on the benchmark year (2011) following a standard calibration procedure. In 2011, the benchmark emission is 69.29 Mt and the benchmark GDP is $74.6 billion.

2. Carbon tax scenario

The carbon tax was applied to two sectors: transportation and building. According to the Government of Canada, the floor price will start at $10 a tonne in 2018, and go up by $10 a year for the next four years, and reach a minimum of $50 a tonne by 2022. In addition, revenue from the carbon tax will be transferred to households at the end of every year.

Both federal carbon pricing system and Saskatchewan climate change approach have covered large emitters in other industries except for building and transportation. Therefore, the PURE impacts of carbon tax can be obtained through the comparisons between scenario 1 and scenario 2.

Results

The results of the CGE modeling indicate that when the carbon tax reaches $50 per tonne, Saskatchewan's GDP will be reduced 2.43 percent, which equals to a $1.8 Billion economic reduction.

The carbon tax scenario in this research is based on fuel charge for heating (natural gas) and transportation (petroleum). This will increase the price of production factors and results in a production decrease.

The lowest consumption demand of a household is determined by income, which is mainly earned through labour inputs in production activities. Although carbon tax revenue is returned to household, household income will decrease along with an economic depression which will further lead to a consumption decline.

References

1. United Nations Framework Convention on Climate Change, The Paris Agreement, http://unfccc.int/paris_agreement/items/9485.php; 2016 [accessed 06 January 2017].
2. United Nations Framework Convention on Climate Change, Canada's 2017 Nationally Determined Contribution Submission to the United Nations Framework Convention on Climate Change, http://news.gc.ca/web/article-en.do?nid=1132149; 2017 [accessed 24 March 2017].
3. Canada's INDC Submission to the UNFCCC, http://www4.unfccc.int/submissions/INDC/Published%20Documents/Canada/1/INDC%20-%20Canada%20-%20English.pdf; 2015 [accessed 04 January 2016].
4. Statistic Canada, Trade by exporter characteristics: Godds, http://www.statcan.gc.ca/daily-quotidien/170502/dq170502b-eng.htm; 2016 [accessed 15 March 2017].
5. Government of Saskatchewan, Economic review 2016, http://www.stats.gov.sk.ca/stats/ER2016.pdf; 2016 [accessed 08 May 2016].