Energy Economics 57 (2016) 106–127

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Impact of a carbon tax on the Chilean economy: A computable general equilibrium analysis

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ARTICLE INFO

Article history:
Received 10 May 2014
Received in revised form 13 February 2016
Accepted 11 April 2016
Available online 2 May 2016

Keywords:
Applied general equilibrium
Climate change
Carbon tax
Chile

ABSTRACT

In 2009, the government of Chile announced their official commitment to reduce national greenhouse gas emissions by 20% below a business-as-usual projection by 2020. Due to the fact that an effective way to reduce emissions is to implement a national carbon tax, the goal of this article is to quantify the value of a carbon tax that will allow the achievement of the emission reduction target and to assess its impact on the economy.

The approach used in this work is to compare the economy before and after the implementation of the carbon tax by creating a static computable general equilibrium model of the Chilean economy. The model developed here disaggregates the economy in 23 industries and 23 commodities, and it uses four consumer agents (households, government, investment, and the rest of the world). By setting specific production and consumptions functions, the model can assess the variation in commodity prices, industrial production, and agent consumption, allowing a cross-sectoral analysis of the impact of the carbon tax. The benchmark of the economy, upon which the analysis is based, came from a social accounting matrix specially constructed for this model, based on the year 2010.

The carbon tax was modeled as an *ad valorem* tax under two scenarios: tax on emissions from fossil fuels burned only by producers and tax on emissions from fossil fuels burned by producers and households. The abatement cost curve has shown that it is more cost-effective to tax only producers, rather than to tax both producers and households. This is due to the fact that when compared to the emission level observed in 2010, a 20% emission reduction will cause a loss in GDP of 2% and 2.3% respectively. Under the two scenarios, the tax value that could lead to that emission reduction is around 26 US dollars per ton of CO_2-equivalent. The most affected productive sectors are oil refinery, transport, and electricity — having a contraction between 7% and 9%. Analyzing the electricity sector by energy source, the production of electricity from fossil fuels will decrease by 11%, but electricity from renewables will increase by 43%. Electricity producers will pass the cost of the carbon tax to the consumer by increasing the price of electricity by 8%.

The findings of this paper will allow policy makers to take better and more informed decisions, by providing a cross-sectoral analysis of the impact on the economy of reducing emissions by 20% by implementing a national carbon tax.

1. Introduction

Global warming has become one of the biggest issues of mankind, due to its high impact on a global scale. It affects several fields, such as economic development, population growth, and resource management, among others (UNFCCC, 2013a). In 2007, the Intergovernmental Panel on Climate Change (IPCC) ratified with over a 90% probability that global warming is caused by anthropogenic greenhouse gas (GHG) emissions to the atmosphere (IPCC, 2007). This strengthens the importance of countries' commitment to reduce GHG emissions and to shift towards a low-carbon economy. In 2009, at the COP-15,[1] Chile made official its commitment "to achieve 20% deviation below the business-as-usual emission growth trajectory by 2020, as projected from year 2007" (UNFCCC, 2013b, p.2). In 2009, the GHG emissions of Chile represented only 0.226% of the world's emissions (IEA, 2012a) and its abatement will not have a significant global impact. However, with Chile being a member of the OECD, it is important to show the willingness and the infrastructure to help tackle important issues of the world, such as global warming.

Although the Chilean government has committed to accomplishing this goal, it is not yet clear which mitigation actions will be taken and what would be the associated cost (Pizarro, 2013). In order to clarify these questions, the government has set up a 2-year program called "MAPS Chile" (Mitigation Action Plans and Scenarios), which seeks to estimate the GHG emissions growth trajectory and therefore set a BAU scenario, identify a portfolio of mitigation actions, and assess their costs (MAPSChile, 2012).

Apart from regulation of the command-and-control type, effective mitigation action can involve the more flexible use of economic

[1] COP-15: Conference of Parties of the UNFCCC which took place in Copenhagen in December 2009.

http://dx.doi.org/10.1016/j.eneco.2016.04.014
0140-9883/

instruments, such as carbon pricing, which can be based on price (e.g., carbon tax) or quantity (e.g., cap-and-trade schemes) (Hepburn, 2006). There are several places where carbon pricing is used or planned to be used in order to reduce GHG emissions. Some examples can be found in Australia, Canada, China, Denmark, the European Union, Finland, Japan, New Zealand, Norway, South Korea, Sweden, Switzerland, the UK, and the USA (Flannery et al., 2012).

As Sloman (2006) explains, welfare theory predicts that the taxation of goods will reduce the quantity produced as a consequence of increased consumer prices. The downside of taxation is the excess burden of the tax which is a deadweight loss in welfare for society. However, in case of 'green' taxation, the goal is to achieve environmental benefits that are not easily comparable with economic benefits and costs. In fact, before the green taxation is implemented, the environmental costs are external to the market and are thus not taken into account by producers and consumers, resulting in inefficient allocation decisions. Reducing GHG emissions requires growth of low-carbon production value and reductions in production levels of high-carbon industries, i.e., a fundamental restructuring of the economy.

As a carbon tax can be an effective instrument to regulate the emissions of a country and with Chile on the quest for different options to achieve its emissions reductions goals, the question asked in this article is, *what would be the impact of carbon taxation on the Chilean economy*?

Due to the fact that the business-as-usual emissions growth has not yet been defined, the reduction goal considered will be a 20% reduction from 2010's emissions. In order to assess the impact of policy measures that would meet this target, this paper aims to indicate answers to the following three questions:

1. What is the minimum carbon tax rate that would permit the achievement of the reduction goal?
2. What would be the change in the country's GDP?
3. Which economic sectors would be most and least affected by the implementation of the carbon tax?

To analyze these questions, the Chilean economy was modeled using a Computable General Equilibrium model, for which a dataset with energy and emissions detail was carefully compiled and with which the implementation of a carbon tax was simulated in order to analyze its impacts on each economic sector.

2. Methodology

2.1. Literature

In the specific field of carbon tax assessment, Computable General Equilibrium (CGE) has been proven to be an effective tool for policy analysis, as it shows both direct and indirect effects of the implementation of a tax, e.g., (micro-economic) changes in demand and supply due to price changes and interactions of different markets at the macroeconomic level. Beausejour et al. (1995) estimated the impact of a carbon tax on the Canadian economy in order to comply with the Bergen agreement, which stated that countries should stabilize their emissions at 1990 levels by 2000. In their study, they developed a static model which recreated the interactions of three regions: Canada, USA, and the rest of the world. In 1998, Zhang used a dynamic CGE model of the Chinese economy to estimate the impact of a carbon tax that will reduce CO_2 emissions by 20% and 30% of the emissions projected for 2010 in a business-as-usual scenario. In 2007, Wissema and Dellink analyzed the impact of a carbon tax on the Irish economy. They estimated that the necessary carbon tax to achieve 25% CO_2 emission reduction compared to 1998 levels was in the range of 10 to 15 EUR per ton CO_2 and it would result in a less than 1% reduction in GDP. They have made a complete description of the effects of the carbon tax by assessing macroeconomic index, production changes by economic sector, change in consumption behavior, energy commodities' price variation, and a sensitivity analysis of the model in order to assess the robustness of their findings. Other examples of carbon pricing assessments with CGE models are the work of Böhringer and Rutherford (1997), Devarajan et al. (2009), Siriwardana et al. (2011), Adams and Parmenter (2013), among others.

CGE analysis has also been utilized in Chile for economic–environmental studies. In 1990, Dessus and O'Connor used a dynamic CGE model with a time horizon of 18 years, from 1992 to 2010, in order to estimate the "no regret" abatement of particulate matter (PM10) by balancing the cost and the ancillary benefits (i.e., the reduction of morbidity and mortality) of implementing a carbon tax. A similar study was conducted by O'Ryan et al. (2003) who assessed the impact of reducing the emissions of pollutants such as PM10, NO_2 and SO_2 by implementing a tax on emissions. They estimated that with the achievement of a 10% reduction of PM10, GDP would drop by 0.2%. Even though both models are good examples of the application of CGE to the Chilean economy, the results are no longer representative due to the fact that none of the models included certain abatement technologies[2] which at that time were at a developmental stage, but which are now fully available on the market. The inclusion of those technologies will add other options to firms, rather than just reducing production or fuel-switching, impacting directly on the results of the model. In addition, the work of Dessus and O'Connor (1990) estimated a baseline scenario where, for 2010, the emissions would have been 78 million tons of CO_2-equivalent (M tCO_2e) whereas the actual data shows that emissions were 69.7 M tCO_2e for that year (IEA, 2012a). In a model that estimates the cost of 10–20% emission reduction, a difference of 10% in the baseline will bring highly significant uncertainties to the results. Moreover, the price of the carbon tax required was estimated at 120 USD/tCO_2e, which appears to be strongly overestimated compared with similar carbon tax assessments for other countries. For instance, a carbon tax ranging from 13 to 22 USD/tCO_2e would reduce South African emissions by 15% (Devarajan et al., 2009), 23 USD/tCO_2e would reduce Australian emissions by 12.4% (Siriwardana et al., 2011),[3] and 27.7 USD/tCO_2e would reduce Canadian emissions by 12.5% (Beausejour et al., 1995).

From the literature review presented above, it can conclude that CGE models are useful analysis tools for energy forecasting and policy assessment. Furthermore, CGE has been widely used for the assessment of carbon taxes, allowing not only the determination of the overall cost to an economy, but also deeper sectoral analysis. Finally, this assessment of a carbon tax and its implication in the Chilean economy contributes to the literature and allows policy makers to make better informed decisions.

2.2. Chilean energy-model

2.2.1. General features

In 2005, Dellink explained that a CGE model is a representation of an entire economy described as a group of consumers and producers (i.e., economic agents), both demanding and supplying commodities. The economic agents are assumed to behave rationally by optimizing their production (or consumption) for a given budget, while taking into account the market environment (e.g., government policies). In its original form, general equilibrium theory has three basic assumptions: zero profit conditions, market clearance in all commodities and services, and a balanced budget for each agent. The main characteristic

[2] NO_2 emissions can be reduced by increasing the quality of combustion; there are several techniques than can be used such as steam-water injection and post-combustion. SO_2 emissions can be reduced by treating the exhaust gases in Scrubber. PM emissions can be reduced by adding to the exhaust a gas system control: baghouses and filters, electrostatic precipitators, inertial impactors, among others (EPA, 2002).

[3] A more sophisticated study of carbon pricing in Australia, carried by Adams and Parmenter (2013), found that a 40% emission reduction below base case level by 2030 would require the price of emission permits to lie around 22 US dollars in 2015 to rise to 45 US dollar in 2030 (i.e., 50 AUD, currency at August 2013). The emission trading system will impact in just 1.1% of 203 GDPs. In case of the most simple models with all the standard assumptions in place, carbon taxation and emission trading would have the same economic impact if the emission price is the same as the tax level and the permits are auctioned.