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How do learning externalities influence the evaluation of Ontario's renewables support policies?

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ABSTRACT

Support programs for renewable electricity generation in Ontario have been in place since 2005, including feed-in-tariffs and a competitive procurement process. These programs have been criticized on a number of fronts. In particular, critics claim the level of support was excessive and creating surplus supply. However, prior studies have ignored one potential benefit of renewable energy support—that it can help to promote cost reductions in new technologies through learning-by-doing.

This paper uses a recursive-dynamic computable general equilibrium (CGE) model featuring learning-by-doing effects to assess the renewable support programs provided in Ontario. Our results, in line with previous studies, do not justify the high support rates paid in Ontario given our core range of assumptions. But our modeling approach allows us to identify the combination of key parameter values relating to learning effects and environmental damages that justify the observed rates. These parameters are hard to measure empirically, and our modeling approach introduces a new tool for examining the impact of variations in these parameters on policy analysis.

1. Introduction

Programs for renewable electricity support have a long history in Ontario. From about 2005–2008, the Ontario Power Authority procured renewable energy via a competitive process, by soliciting bids to supply renewable energy in response to calls for proposals. Then, starting in 2006, Ontario launched the Renewable Energy Standard Offer Program (RESOP). The RESOP was aimed specifically at encouraging participation by smaller providers, by providing standardized contracts for renewable energy that reduced transaction costs significantly. Like the European programs on which it was modeled, the RESOP also differentiated tariff rates by energy source to encourage generation from resources that were otherwise non-competitive. In 2009, following closely on the design of Germany's longstanding feed-in tariff program for renewable energy, Ontario announced a feed-in tariff (FIT) program as part of the Green Energy Act (GEA). The program built in important ways on the RESOP, enhancing the level of support and removing barriers to scaling up the volume of renewable electricity supply (Yatchew and Baziliauskas, 2011; Mabee et al., 2012).

Ever since coming into existence, support programs for renewable electricity in Ontario have been accused of incurring excessive costs. Although these policies have, as intended, transformed the province's electricity system (Ontario is now the leading jurisdiction for wind and solar energy in Canada), in particular the FIT program included in the GEA has been subject to more or less scathing criticism (Yatchew and Baziliauskas, 2011; McKitrick, 2013). The program, responsible for adding about 6000 MW of new capacity of renewable energy (contracted or in service), has been criticized for being excessive and for generating economic burdens by leading to surplus supply of costly renewable energy.[1] Responding to critiques, major revision of the FIT rules in 2013 has severely cut the program's scope, in particular, by moving large projects out of the FIT program and into a new competitive procurement process and by capping new development of small projects. The first round of the competitive procurement process was

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[1] Many critics of Ontario's supports for renewable electricity focused on the contribution of renewable electricity to the Global Adjustment (a cost spread over most electricity users in Ontario). The Ontario Energy Board notes that wind and solar electricity supports contributed about 33% to the Global Adjustment compared to 38% for nuclear energy alone (Ontario Energy Board, 2016). See also Winfield (2016).

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concluded in April 2016. Only a few months later, the Ontario Ministry of Energy cancelled the second procurement round "in the interest of maintaining an affordable electricity system" (Ontario Ministry of Energy, 2016). Ontario's decade-long experience with aggressively promoting renewable energy seems to have come to a halt.

Interestingly, none of the economic studies scrutinizing Ontario's renewable energy policy address questions that require accounting for the possibility of learning-by-doing related to the increase in renewable electricity production. In particular, McKitrick (2013) investigates the effects of the GEA on employment using an econometric model. Changes in productivity within the renewable electricity sector due to learning would only be relevant to this question if learning externalities reduced the observed electricity price. The qualitative studies by Yatchew and Baziliauskas (2011) and Mabee et al. (2012) do not focus on the implications of learning effects either. The present article explicitly addresses this gap in existing research, drawing on the well-established literature on learning-by-doing in the application of renewable energy technologies (Nemet, 2006; Berry, 2009). In cases where investors in renewable energy technology are unable to fully appropriate the benefits from learning spillovers between generators, this is a market failure warranting government intervention (Jaffe et al., 2005; Fischer and Newell, 2008). Hence, even in the absence of environmental externalities, non-appropriable learning may justify public support programs for renewable electricity. As learning effects diminish over time, so does the efficient subsidy (Melitz, 2005; Neuhoff, 2005; Kverndokk and Rosendahl, 2007).

While there is a large literature about the choice among different policy instruments to support renewable electricity, many studies assume a uniform level of support or a given target level of renewable electricity (for example, Menanteau et al., 2003; Requate, 2015). In contrast, this paper considers the second-best[2] support profile over time for renewable electricity, which in turn determines the corresponding expansion of renewable electricity.

The present paper examines for the first time how the economic assessment of Ontario's renewable energy policy changes when learning externalities are taken into account. We use a recursive dynamic computable general equilibrium (CGE) model featuring learning-by-doing effects to evaluate a second-best profile of support for renewable electricity in Ontario. We then compare these findings to the actual renewable support provided in Ontario.

We find that the support for renewable electricity in Ontario provided under the FIT program and the competitive procurement process diverges significantly from the second-best support profile in our central case. Even assuming moderately higher environmental damages and/or stronger learning effects, our results do not justify the rates observed in Ontario. Only when we assume very high environmental damages ($225/t CO_2e) and very strong learning effects (a learning rate of 20%) come the second-best support profiles close to the actual support levels in 2010. While our results largely support previous studies on the issue, our methodology allows for valuable new insights. In particular, given the difficulties related to empirically measuring learning effects and the large uncertainty about the regional costs of climate change, our modeling approach allows for determining the effect of alternative assumptions about these parameters on policy analysis.

Generally, our findings crucially depend on key parameters relating to both learning effects and to environmental damages. This conclusion is somewhat at odds with van Benthem et al. (2008) which finds that for California, the size of learning effects alone is the key determinant to the assessment of support for solar electricity.

The paper is structured in the following way. In Section 2 we provide a brief overview of the support programs for renewable electricity in Ontario. Section 3 focuses on findings from the empirical literature on learning externalities and, in particular, research on the temporal structure of renewable industry support policies. In Section 4 we present the dynamic CGE model used for this analysis and Section 5 informs about the simulations we run. Next, in Section 6 we discuss our findings in terms of aggregate impacts (Section 6.1), the profiles of support (Section 6.2) and the comparison with Ontario's program rates (Section 6.3). We provide a limited sensitivity analysis in Section 6.4. Finally, Section 7 concludes.

2. Ontario's renewable electricity support

This paper focuses on the second-best schedule of renewable power support for Ontario including an assessment of how recent history of the program aligns with the simulated optimal paths as well as the implied future path of feed-in-tariffs. This section briefly describes the various support programs for renewable energy implemented by the Ontario government since 2005.

From around 2004–2007, Ontario developed a new Integrated Power System Plan (IPSP), a 20-year plan to refurbish existing generating assets, invest in new assets, overhaul governance, and modernize the grid. Of particular note was the plan to dramatically increase the contribution of renewable energy sources to electric supply in the province. By 2025, the IPSP aimed to have about one-third of total capacity, or roughly 15,700 MW, met by renewables. This commitment was augmented in the 2013 Long Term Energy Plan (LTEP), which aims to have 20,000 MW of renewable generation capacity on-line by 2025, including over 10,000 MW from non-hydro sources (primarily wind and solar). In response to these targets, the Ontario Power Authority began an ambitious program to source new renewable energy supply. From about 2005–2008, it procured renewable energy via a competitive process, by soliciting bids to supply renewable energy in response to calls for proposals. Then, starting in 2006, Ontario launched the Renewable Energy Standard Offer Program (RESOP). By offering standardized contracts the goal of RESOP was to reduce transaction costs for small providers; by offering differentiated rates by energy source, RESOP aimed at rendering renewable energy technologies competitive.

In October 2009, Ontario announced a feed-in tariff (FIT) program, the core legislation of the province's *Green Energy and Green Economy Act*. The FIT program built on the RESOP by providing transmission system access (the RESOP provided access to the distribution grid only), removing caps on project size (the RESOP capped projects at 10 MW), and enhancing tariffs for renewable energy (Yatchew and Baziliauskas, 2011; Mabee et al., 2012). Under the FIT program, renewable energy generators enter long-term power purchase agreements, with the Ontario Power Authority (OPA). The OPA guarantees a fixed price for every kWh generated from eligible renewable electricity technologies over a time period of 20 years (40 years for hydropower). Tariff rates vary by technology, project size, and ownership. Eligible technologies include bioenergy (including on and off-farm biogas, biomass, and landfill gas), solar photovoltaic (with project capacity below 10 MW), waterpower with project capacity below 50 MW per project; and wind. A separate program exists for small-scale project, called micro fit.

As intended, these programs have quickly transformed the province's electricity system. From a small base at the end of last decade, new renewable electricity generating capacity in Ontario has grown to nearly one quarter of total capacity.[3] Ontario is now the leading jurisdiction for wind and solar energy in Canada, both in terms of the share of total capacity as well as in absolute terms. While all three renewable

[2] The support profile is not optimal because we are assuming that we are constrained from using the optimal policy instruments tied directly to pollution damages and the learning effects.

[3] The IESO reports that as of the first quarter of 2017, 6056 MW of wind capacity and 2785 MW of solar capacity were either in operation or under development (with a contract secured). Thereof, 7072 MW of wind and solar capacity are in commercial operation. As of June 2017, the IESO reports that total system capacity installed is 36,563 MW. See http://www.ieso.ca/Pages/Power-Data/Supply.aspx#TCG.