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Effects of consumer subsidies for renewable energy on industry growth and social welfare: The case of solar photovoltaic systems in Japan☆,☆☆

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ABSTRACT

The primary goal of policies to promote renewable energy is to correct for the unpriced pollution externalities from burning fossil fuels. It is, however, difficult to assess whether and to what extent these policies enhance industry growth and economic welfare, especially when no comparable data on a proper control group are available. This paper provides an empirical framework to tackle such a problem with a particular focus on the use of consumer subsidies for installing residential solar photovoltaic systems in Japan. The presented estimates show elastic demand, and small learning by doing along with modest learning spillovers in production. Our simulations show that, while the subsidies are an effective instrument to encourage the greater use of solar panels, they would exacerbate social surplus unless the value of mitigating CO_2 emission is well above the ongoing market price.

1. Introduction

Policies to increase electricity generation from renewable energy have been widespread all over the world. All 138 countries listed in Renewable Energy Policy Network for the 21st Century (2013, hereafter REN21) adopted some form of renewable energy support policies as of 2013. The primary goal of these policies is to correct for the unpriced pollution externalities from burning fossil fuels (Borenstein, 2012).[1] A variety of different policies have been adopted by many governments. One such initiative taken place in Japan was Residential Solar Photovoltaic Dissemination (RPVD) Program. The Program, implemented nationwide in the period from 1997 to 2005, provided per kW subsidies for households who installed solar panels on top of their roofs. This subsidy program appears to have had a considerable impact on the solar energy industry; the installation volume of roof-top solar photovoltaic (PV) panels had increased more than tenfold over the implementation period (see Fig. 1). This trend changed, however, when the RPVD Program was terminated in 2005; the Japanese market declined from 260 MW in 2005 to just 180 MW in 2007, below the level of the EU market, with the decrease in new installations flagged as the main driver of this decline (see Fig. 2).

The correlation observed in Figs. 1 and 2 informs us little of the causal inference between the subsidy policy and PV deployment. Since the subsidy was provided across the nation, we do not have the controlled experiments that would allow us to assess what would have happened in the absence of the subsidy. Furthermore, it remains unanswered whether and to what extent the subsidy policy approached closer to the goal mentioned above; namely, how much the subsidy corrected for the unpriced pollution externalities, and thus improved the social welfare. Such questions must be an interest for those who manage public money designed to reduce greenhouse gas emissions, or to encourage the greater use of renewable energy.

This paper attempts to answer such questions by presenting an empirical analysis to identify the effects of the renewable subsidy policy on growth and welfare, with a particular focus on solar energy in Japan. Since there are no obvious way in which to perform controlled experiments regarding the RPVD Program, we instead conduct counterfactual simulations in the following two steps. First, we use an

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[1] Other goals often mentioned are, for example, to reduce dependence on foreign energy sources, and to create jobs in a new green industry.

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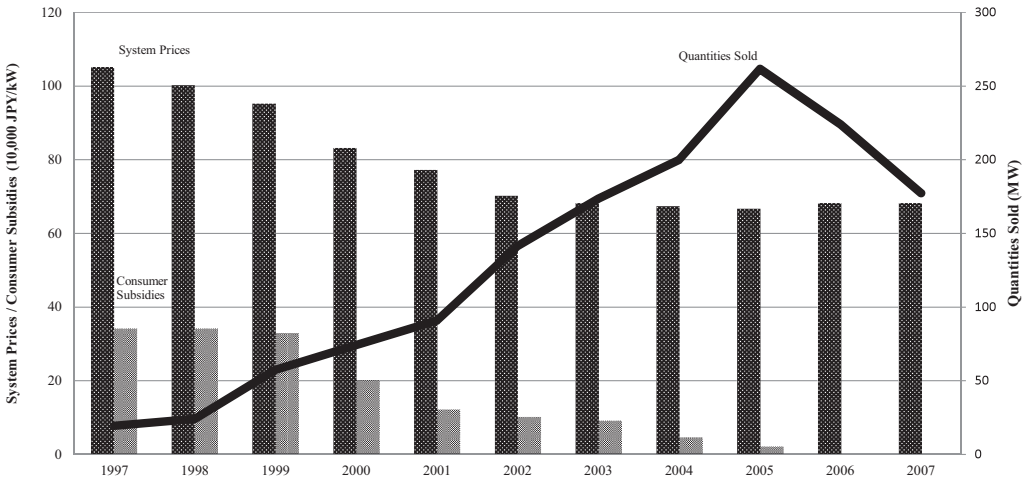

Fig. 1. System prices, consumer subsidies and quantities sold for Japanese residential solar PV, 1997–2007.

Note: Residential solar PV consists of hardware (panels and inverters) and non-hardware (site visits, labor, and marketing).

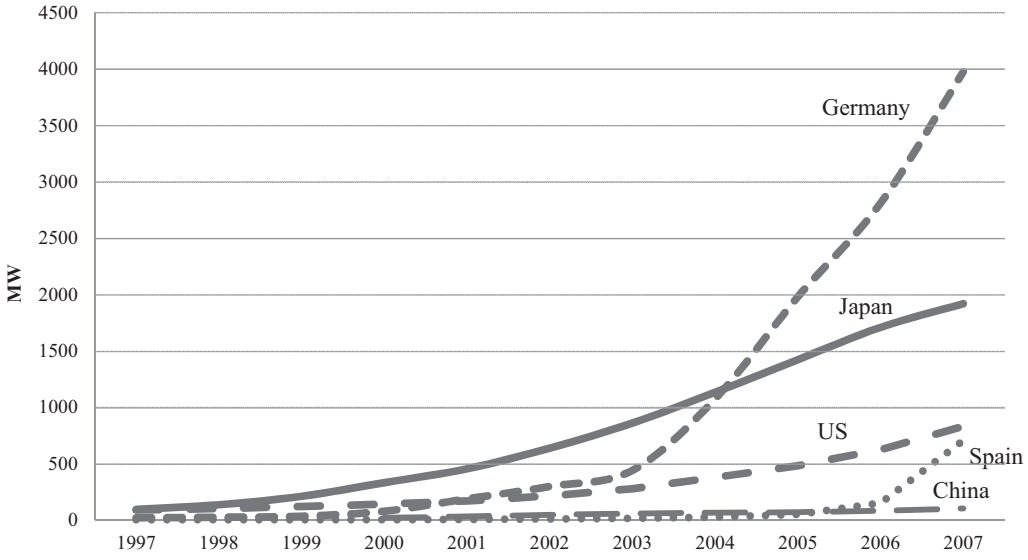

Fig. 2. Cumulative solar PV adoption for major countries, 1997–2007.

economic model to recover the estimated parameters of the underlying economic primitives invariant to the policy environment. In our application, we estimate the parameters of household demand for residential solar panels and then derive firm marginal costs of production under an assumed mode of competition. The second step involves using the model to simulate the change in equilibrium outcomes that result from a change in the provision of the subsidy. By using this simulation method, we evaluate how the RPVD Program affected the market outcomes of residential solar energy. The proposed structural estimation method allows us to perform a cost-benefit analysis of the program with an explicit understanding of the environmental externalities attributed to carbon emissions. For this simulation approach to be successful, however, the adopted model must closely approximate the economic environment under study, while the subsidy program of interest (i.e., the RPVD Program) must be exogenous to the environment. Note that the simulation method used in the second stage is not limited to the assessment of the RPVD Program, but also applied to the evaluation of alternative subsidy policies more broadly. As discussed shortly below, this study assesses as an alternative subsidy policy, the Feed-In Tariff (FIT) Program, in a counterfactual environment.

The simulation results, based on estimates from 1997 to 2007, demonstrate that the RPVD Program increased residential installations of solar panels by an additional 350 MW, leading to a reduction of carbon emissions of approximately 2.8 million tons. This emission reduction, however, accounts for a mere third of one percent of annual emissions in Japan. Moreover, whether the program improved social welfare depends upon the external social costs associated with this reduction. The study finds that in order for the RPVD Program to have improved welfare, the economic value of carbon dioxide should have been well above the then ongoing market price (i.e., the transaction price in Japan's voluntary emissions trading scheme) at that time; thus the amount of the subsidy provided through the Program would have been excessive in light of social welfare.

While the available data period is short and does not cover the implementation period of the FIT Program, we use the obtained structural estimates of demand and supply in the Japanese residential PV market to simulate how this program affected the equilibrium market outcomes, under the assumption that the structural estimates are invariant throughout the period. The simulation results indicate that the FIT Program could be an effective instrument to facilitate the spread of PV in the market, and even more so if the production costs of PV system would further decrease. In the meantime, the rapid PV diffusion would raise the buyback expenses, which outweighed other benefits accrued by the FIT Program. The paper's simulation exercises on the two Programs witness that those policies effective for diffusion need not necessarily improve social welfare; they sometimes provide excessive incentives for households to adopt solar PV, just like the RPVD and FIT Programs.