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Testing Diffusion of Innovations Theory with data: Financial incentives, early adopters, and distributed solar energy in Australia

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ABSTRACT

Policies promoting the adoption of residential solar photovoltaic systems often include financial incentives. This research uses Diffusion of Innovations Theory to assess the effects of incentives on the adoption of residential solar systems based on three previously defined conclusions: that incentives increase adoption; that incentives promote adoption by a group of consumers different to those who would otherwise adopt; and that adoption to access incentives may reduce the likelihood of re-adoption. A mail-out survey of 338 householders who purchased a solar system was undertaken in Western Australia in 2013, followed by 26 interviews during 2013–2015. Financial incentives were prioritised in the decision-making process by 70% of survey respondents. Incentives promoted adoption by reducing the payback period of systems and also acted as a 'cue-to-action' for those who were considering adoption. The vast majority of survey respondents (82%) installed their solar system for financial reasons, representing a change in motivation away from the 'early adopters' who prioritise the technical and environmental aspects of solar. Survey respondents who educated themselves about solar and/or installed solar for environmental or technical reasons were more likely to readopt. 85% of survey respondents indicated that education is needed to understand the costs and benefits of solar.

1. Introduction

A growing awareness of the harmful impacts of greenhouse gas emissions has led to investment in renewable energy technologies to replace fossil fuel-based electricity generation. While the majority of installed capacity of all renewable energy, including solar, is utility-scale, distributed smaller-scale generation has a role to play in increasing the penetration of renewable energy on electricity networks. Importantly, residential householders are in a position to invest in small-scale electricity micro-generation units, typically in the form of solar photovoltaic systems (solar systems).

To date, much of the academic literature considering the adoption of residential solar energy has focused on the potential impact of peer-to-peer interactions on the adoption of solar, predominantly from a geographical point of view [1–4], and consumers' motivations and barriers for adoption of solar energy [5–9]. In particular, Rogers' [10] 'Diffusion of Innovations' theory has been employed to determine whether the widely applied categories of adopters relate to those adopting residential solar systems. Rogers' [10] theory hypothesises that an innovation will diffuse through society via different groups of adopters, each with a specific set of characteristics and role in the adoption process. Innovations are first adopted by 'innovators' and 'early adopters' (together representing the first 15% of adopters) before being adopted by the 'early majority' (35% of adopters). In the case of research into adoption of residential solar systems, the findings have confirmed the presence of early adopter characteristics, with early adopters or those intending to install solar systems being educated [11–14], interested in the technical attributes of solar [15–17], and coming from high socioeconomic groups, with disposable income available to invest in innovative technologies [6,11–14,18]. Additionally, early adopters are concerned with the environment, choosing to install systems in part to reduce their greenhouse gas emissions [9,15,17,19]. Research into a potential early majority group of adopters has identified that the financial attributes of solar are the most significant barrier to adoption, with the capital cost of systems perceived as outweighing the financial benefits of installing a solar system [6]. This is consistent with Moore's [20] theory on a 'chasm' that exists between the innovators/early adopters and the early majority, which often prevents an innovation from diffusing through society. The chasm is caused by a lack of acceptance of the relative advantage of a technology by the early majority, with early adopters often interested in the technical aspects of an innovation whereas the early majority are

Abbreviations: SCM, Solar Credits Multiplier; kW, kilowatt; kWh, kilowatt hour

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concerned with the benefits (typically financial) they will receive from adoption.

Governments have established a range of policies to assist with the adoption of solar systems by residential householders. The extensive implementation of such policies by governments has resulted in a stream of literature examining the costs and benefits of incentives. In particular, studies focus on the relative benefits of different incentives, for example the merits of up-front subsidies that reduce capital costs [21] and feed-in tariffs that reduce payback periods [22]. Additional support mechanisms, such as information campaigns [16,23], establishing social learning activities [24], development of solar community organisations [2] and different market-mechanisms such as leasing options [25] have also been assessed. The literature identifies a number of potential negative outcomes of incentives, with studies showing that incentives are typically accessed by higher income earners [26] and that funds used to pay for incentives are often regressive forms of taxation [27], where lower socioeconomic groups contribute a higher proportion of their income to pay for incentives. Alternatively, research has found that residential householders support the subsidisation of residential solar systems, although levels of support are lower in lower income groups [28].

One aspect of Rogers' [10] 'Diffusion of Innovations' theory that has not received attention in the residential solar academic literature is the effect of incentives on the diffusion process. Based on his work on family planning innovations, Rogers [10] suggests that the availability of incentives has three likely impacts on the diffusion process. First, 'incentives increase the rate of adoption' (p. 238) as they act to increase the relative advantage of the innovation or can act as a 'cue-to-action' for those considering adoption. Second, 'incentives lead to adoption of an innovation by individuals different from those who would otherwise adopt' (p. 238), given the improved relative advantage of a technology makes it attractive to the financially motivated early majority. Finally, Rogers [10] suggests that incentives may have a negative impact on the continued diffusion of an innovation given that 'although incentives increase the quantity of adopters of an innovation, the quality of such adoption decisions may be relatively low' (p. 238) because decision-making is heavily influenced by the availability of an incentive rather than an informed understanding of the innovation.

Rogers' [10] theory on the 'Diffusion of Innovations' suggests that where an innovation has financial benefits for the adopter there is the potential that the diffusion process could increase inequality because 'individuals or other units in a system who most need the benefits of a new idea (the less educated, less wealthy and the like) are generally the last to adopt an innovation' (p. 295). Therefore, if Rogers' [10] second effect of incentives proves accurate and generous incentives can encourage a different, potentially more disadvantaged, group of adopters to install systems there is the potential for a reduction in inequality. Alternatively, if Rogers' [10] third conclusion proves to be accurate, a period of generous incentives and coincident low quality in decision-making may be followed by a decline in enthusiasm for installing systems. The impact of public approval on an innovation's adoption process is demonstrated by 'Gartner's hype curve' [29].[1] Although the authors interpret this model as being developed in relation to media communication of expectations around a new technology, the authors believe its depiction of a rapid deterioration in levels of acceptance of a technology if unrealistic expectations go unmet is transferable. In the case of 'Gartner's hype curve' this is referred to as the 'trough of disillusionment' (Fig. 1), which states: 'Because the technology does not live up to enterprises' and the media's overinflated expectations, it is rapidly discredited' (p. 8). Rogers' conclusions on the effects of incentives therefore have potential equity outcomes and implications for the success of policies to promote ongoing adoption of solar systems.

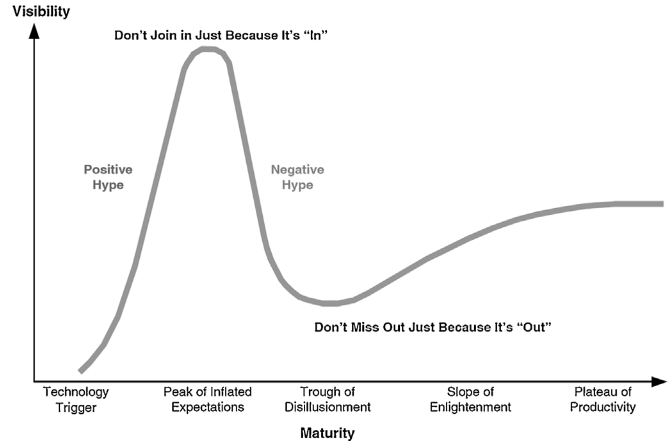

Fig. 1. Gartner's hype curve, developed by Gartner Research, May 2003, demonstrating the 'trough of disillusionment' that can occur after unrealistic expectations of an innovation are communicated through society [29].

At the time of writing Australia had the highest level of installed small-scale solar capacity in the world [30], with householders installing residential solar systems in Western Australia having had access to both state and federal incentive schemes. Discounts on the purchase price of systems have been available through the Australian Government for over a decade, including under the Photovoltaic Rebate Program, the Solar Homes and Communities Grant [26] and most recently through the Renewable Energy Target. The Renewable Energy Target allows for renewable energy certificates to be generated based on an approximation of the electricity produced by a small-scale system over a 15-year period [31], with a specific incentive for the promotion of residential-scale solar systems, the Solar Credits Multiplier (SCM). The SCM multiplied the number of certificates that could be generated for small-scale systems, starting with a multiplier of five in June 2009 with stepwise reductions on 1 July 2011 (three times multiplier), 1 July 2012 (two times multiplier), and finally to one (no multiplier) by 1 January 2013 (six months ahead of schedule given oversubscription to the scheme [31]). Under the assumption residential householders would purchase an approximately 1.5 kW system it was expected that the SCM would initially provide a subsidy of AU$7500; around the value of the Solar Homes and Communities Grant it was intended to replace. During the period the SCM was active most Australian states and territories also introduced feed-in tariffs. In Western Australia a 'premium net feed-in tariff' was introduced alongside the pre-existing standard net feed-in tariff that paid for the wholesale value of electricity fed into the grid [32]. Together these feed-in tariffs paid approximately AU47cents per kWh, compared with the residential retail tariff of approximately AU21cents per kWh. The scheme was open to new entrants on 1 July 2010 and closed to new entrants on 1 August 2011 [33]. Therefore, the period 2010–2012 represents an incentive-intensive period for the promotion of residential solar in Western Australia and a useful example for testing Rogers' [10] 'effects of incentives' conclusions. It should be noted that there has only been one period during which access to financial incentives for solar adoption has been means tested (available to lower income households only), from May 2008 until June 2009 [34], when approximately 5000 systems were installed out of a total of more than 175,000 systems installed in Western Australia (to end 2014).

The objective of this research is to consider the extent to which Rogers' [10] conclusions on the effect of incentives accurately describe the process of adoption of solar systems by residential householders in Western Australia. The findings assist in developing an understanding

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