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# Shotgun or snowball approach? Accelerating the diffusion of rooftop solar photovoltaics through peer effects and social norms

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ABSTRACT

In the last decade, feed-in tariffs have been the method of choice for policymakers trying to accelerate the diffusion of solar photovoltaics (PV). Despite the overall effectiveness of feed-in tariffs, actual adoption rates have shown surprising regional differences, pointing to the presence of peer influence and regional spillover effects. For future diffusion of photovoltaics, understanding these social influences on the decision to adopt is key. Several studies have used revealed preference approaches to discern peer effects in PV adoption, proving their existence but leaving open questions about underlying psychological mechanisms. We close this gap by conducting a survey among potential PV adopters in one of the top three fastest-growing European solar markets and find that two types of social norms, descriptive and injunctive norms and their underlying interplay, play an important role in explaining PV adoption decision and diffusion patterns. Our findings have significant policy implications – as an alternative to following the shotgun approach of uniform nationwide incentives, policymakers should consider inducing snowball effects by facilitating the creation of regional hot spots. Such programs, which may be supported through co-investments between federal and local authorities, would effectively complement existing policy approaches.

## 1. Introduction

Installations of solar photovoltaics (PV) have shown significant growth worldwide. The initial wave of PV market diffusion was driven by strong policy incentives in countries like Germany, Spain and Italy (Antonelli and Desideri, 2014; Jacobsson and Lauber, 2006; Luethi, 2010; Wüstenhagen and Bilharz, 2006). With the cost of solar technology approaching grid parity, policy is no longer the only driver of PV diffusion (Karneyeva and Wüstenhagen, 2017). The urgency of global climate change may still motivate policymakers to accelerate the deployment of solar PV, but effectively doing so in a post-grid parity age will require a deeper understanding of the decision processes of PV adopters. There is an increasing consensus in the literature that the decision to invest in PV, especially in the case of distributed rooftop PV, is driven by a combination of financial and non-financial (also referred to as "behavioral") factors (Jager, 2006; Korcaj et al., 2015; Schelly, 2014; Sigrin et al., 2015). One of the behavioral factors that has received particular attention in recent literature is social contagion or peer effects. A number of studies have shown that peer effects exist in the diffusion of PV, leading to geographical clustering of adoption rates (Bollinger and Gillingham, 2012; Graziano and Gillingham, 2014; Linder, 2013; Rai and Robinson, 2013; Richter, 2013). However, despite the increasing empirical evidence, there is still a scarcity of detailed investigations of *how* and *why* peer effects influence the decision to adopt. One reason is that the prevalent methodological approach to investigating social contagion has been using market data reflecting revealed preferences, which inherently limits the ability to understand what is going on in investors' minds.

We contribute to closing this gap by conducting a stated preference survey among potential PV adopters in one of Europe's top three solar markets, Switzerland. In 2016, the Swiss market has been almost on par with the Netherlands and the UK in terms of newly installed PV capacity per capita (see Fig. 1), and the current installed base of approximately 1.7 Gigawatts is expected to double in the next four years (SolarPowerEurope, 2016). Our study sample consisted of Swiss homeowners who intended to renovate their roof within the decision

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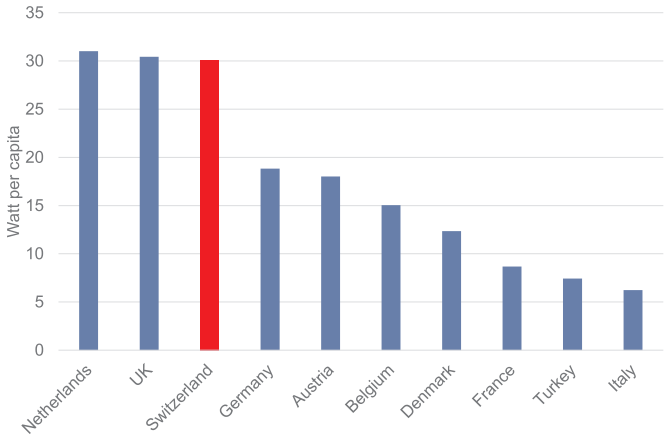


**Fig. 1. :** Fastest-growing European photovoltaics markets in 2016 in terms of newly installed PV capacity per capita.
Source: Own calculations based on [dataset] IEA PVPS (2017) / [dataset] UN (2015).

period of interest (PV installation within next 10 years). Thus, this sample constitutes a promising target group for the adoption of PV systems in general and building-integrated PV (BIPV) systems in particular that require a comprehensive renovation of the roof.

In our analysis of behavioral factors driving PV diffusion, we confirm the existence of peer effects and draw on the social psychology literature to investigate how two types of social norms shape homeowners' intentions to install solar panels. We find that both *descriptive norms* (referring to what other people do; to be considered as typical or normal) and *injunctive norms* (referring to what other people approve or disapprove; to be considered as socially expected) play a role in potential PV adopters' decision-making, and discuss how post-grid parity PV policy can be designed to facilitate an accelerated diffusion of solar photovoltaics.

The rest of our paper is structured as follows. Section 2 provides a short literature review. Section 3 describes the methodology. Section 4 presents the results of our empirical analysis. Section 5 is a discussion of our findings, and Section 6 concludes the paper with implications for policymakers.

## 2. Background and Literature Review

### 2.1. Social contagion and the diffusion of PV

Social contagion or peer effects have been a longstanding phenomenon in research on the diffusion of innovation (see e.g. Berger, 2008; Burt, 1987; Iyengar et al., 2011; Levy and Nail, 1993; Peres et al., 2010; Van den Bulte and Lilien, 2001). Social contagion refers to a spread of affect or behavior from one person to another (Marsden, 1998), and is influenced not only by the strength of interpersonal ties but also by geographical proximity. For instance, peer effects have been investigated in the diffusion of drugs (Manchanda et al., 2008), residential air conditioning systems (Noonan et al., 2013), organic farming (Bjørkhaug and Blekesaune, 2013), and car purchase (McShane et al., 2012). Bollinger and Gillingham (2012) were the first to demonstrate the existence of peer effects in the installation of PV systems in California, showing that the likelihood of adoption increases with the existence of previous installations at the street or zip code level. Along similar methodological lines, Richter (2013), Müller and Rode (2013), Rode and Weber (2016) and Graziano and Gillingham (2014) confirmed the existence of peer effects for the UK, Germany and other parts of the U.S. (Connecticut), respectively. The geographical distance in which these studies identified peer effects ranges from 1 km (Rode and Weber, 2016) to 4 miles (Graziano and Gillingham, 2014), and most authors agree that the effects diminish with distance and over time. They also converge in demonstrating the existence of significant peer effects even after controlling for a wide range of other variables (such as housing density, income and irradiation). A common feature of previous studies is that they take a revealed preference approach, drawing conclusions from large datasets of tens or even hundreds of thousands of PV installations (For an overview of further spatial econometric analyses of PV adoption see: Dharshing (2017)). Despite their large number of observations, those studies tend to be relatively light on underlying mechanisms of adopters' actual decision process. One of the few studies that have taken a stated preference approach to overcome this shortcoming is Rai and Robinson (2013) survey of Texan households. They found that experiencing spatial neighborhood effects led to shorter decision processes, and the likelihood to adopt increased with the number of perceived PV systems in the neighborhood.

Previous studies lead us to expect that PV adoption is indeed influenced by prior adoption of the systems in the neighborhood, therefore:

**Hypothesis 1:.** The number of PV systems in the neighborhood increases homeowners' intention to install PV.

### 2.2. Social norms and PV adoption

Given the rich empirical evidence for the existence of peer effects in PV adoption, there is a surprising scarcity of research that has investigated the underlying psychological foundations of peer effects in the PV domain. Research in psychology has long recognized that humans tend to imitate the behavior of others (Asch, 1956), which is argued to have had benefits in evolution (Griskevicius et al., 2012). Imitation can be beneficial as others' behavior may convey pertinent information (Aronson et al., 2005). This provides an explanation for the effectiveness of *descriptive norms* indicating what behaviors are typically performed (Cialdini et al., 1991). A large body of research has shown that social norms conveyed by reference groups such as neighbors have a powerful effect on people's behavior in a range of domains, including energy conservation (Nolan et al., 2008) and recycling Schultz (1999). According to Cialdini (1983), people conform to descriptive norms in particular under conditions of high uncertainty. The decision to install a PV system involves substantial investment, and occurs in changing policy and market conditions. Conforming to descriptive norms may be a way of coping with this uncertainty.

A second form of social norms are *injunctive norms*, which refer to the behavior commonly approved or disapproved of by a person's reference group (Cialdini et al., 1991; Steg et al., 2012). Korcaj et al. (2015) investigated whether descriptive norms (the perceived peer behavior) and injunctive norms (the perceived expectations of others towards one's own behavior) determine behavioral intentions to purchase PV systems, and confirmed the influence of both. Building upon our Hypothesis 1 and previous research on the effectiveness of injunctive norms we hypothesize:

**Hypothesis 2.** The perceived expectation of others to install a PV system (injunctive norm) increases homeowners' intention to install PV.

Although previous research has provided evidence for the influence of descriptive and injunctive norms on purchase decisions in the realm of PV adoption, only little is yet known about *how* the two norms eventually impact purchase decisions. Potential insights were provided by Rimal (2008) who has shown that descriptive norms had an influence on injunctive norms, which in turn affected behavioral intentions. Applying these findings to the PV sector, we expect that a higher number of PV systems in the neighborhood concomitantly increases homeowners' perceived pressure to conform with the behavior of others, thus eventually impacting purchase decisions. That is, we hypothesize:

**Hypothesis 3.** The perceived expectation of others to install a PV