# Photovoltaic installations diffusion: modeling and analysis

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The need for an energy transition has led to an increase in renewable energy installations in recent years. We analyzed the self-consumption register of Catalonia [1], particularly, we studied the spreading of photovoltaic installations, using the framework of diffusion of innovations and methods from statistics and data analysis.

To describe the observed temporal evolution, some widely used models and some variations were fitted, considering different types of interactions between agents. One of them has been the mean field Bass model [2]:

$$\frac{dS_B(t)}{dt} = \left(p + \frac{q}{N}S_B(t)\right)(N - S_B(t)) \tag{1}$$

$$S_B(t) = N\frac{1 - \frac{p}{q}e^{-(p+q)(t-t_i)}}{1 + e^{-(p+q)(t-t_i)}}. \tag{2}$$

It led to a good fit of the data, although it is equally well in the limit $p \to 0$, when the model simplifies into a logistic one:

$$\frac{dS_L(t)}{dt} = \frac{q}{N}S_L(t)(N - S_L(t)) \tag{3}$$

$$S_L(t) = \frac{N}{1 + e^{-q(t-t_i)}}. \tag{4}$$

The logistic model, whose fit is shown in Fig. 1, assumes a rate of installations proportional to the fraction of neighbors that already have adopted the technology, although the interpretation of the underlying mechanisms can be discussed. Installations also seem to be influenced by the *impuesto al sol*. Other deviations from the expected evolution were studied by applying an original method that allowed us to identify potential influences of some subsidies and tax bonuses.

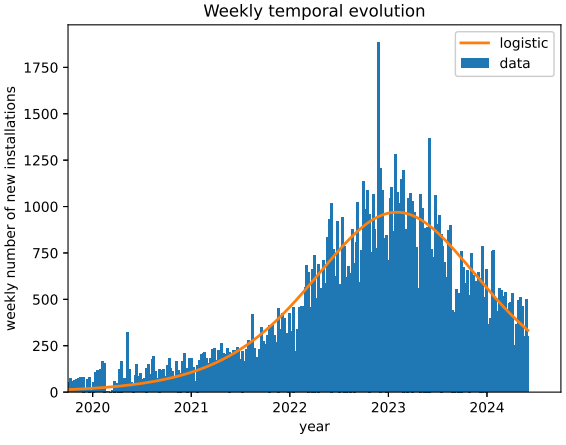


Fig. 1. Weekly number of new installations as a function of time and the corresponding logistic derivative fit.

The spatial distribution of installations per inhabitant reveals lower values in, among other regions, metropolitan areas, as observed in Fig. 2. Installations per inhabitant also exhibit a higher correlation with the fraction of low-height buildings, compared with other variables, what indicates there is probably an influence of the housing typology on the decision to install.

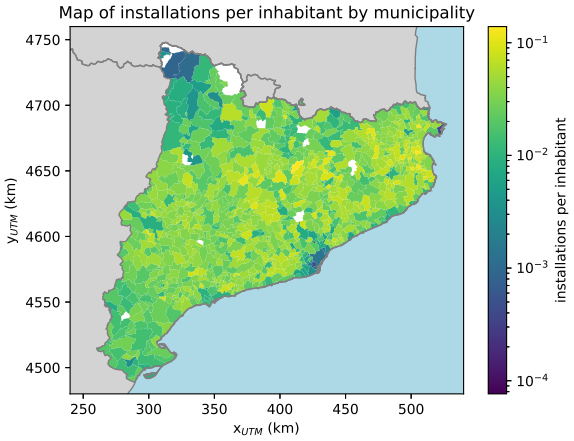


Fig. 2. Installations per inhabitant by municipality in UTM coordinates, and with a logarithmic color scale. The municipalities with no installations are displayed in white.

Interactions between agents happen to be not much different than the expected by null models. This is a surprising result, since the logistic model use to suppose a word-of-mouth propagation, which can hardly be considered to be all-to-all. Since the mean field logistic fits the data well, but with no clear reasons of why, possible alternative explanations to the traditional interpretation are discussed.

To sum up, the study of photovoltaic self-consumption installations let us understand better various features of their evolution, and even if the main mechanisms driving said evolution are still unclear, now we have a big picture of the potential ones and their properties. Furthermore, the analysis can help the design of policies that foster the spread of installations, and allowing to focus in areas where there is more photovoltaic potential yet to use.

[1] https://mediambient.gencat.cat/ca/05_ambits_dactuacio/energia/installacions-domestiques/autoconsum/registre-autoconsum-catalunya/

[2] Bass, Frank M., *A New Product Growth for Model Consumer Durables*, Management Science **15**, 215-227 (1969).