

# ***THE PRICE-CONCENTRATION RELATIONSHIP IN EARLY RESIDENTIAL SOLAR THIRD PARTY MARKETS***

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## **Overview**

The market for residential solar photovoltaic (PV) systems in the United States has experienced tremendous growth over the past decade, with installed capacity more than doubling between 2014 and 2016. The residential PV market's continued growth prompts new questions about the nature of competition between solar installers and how this competition, or lack thereof, affects the prices consumers pay. It is often assumed that more competition leads to lower prices, but this is not universally true. For example, some studies have shown that factors such as brand loyalty could lead to a negative relationship between concentration and price in imperfectly competitive markets (Borenstein 1985; Holmes 1989). As such, the relationship between prices and market concentration is an open empirical question because theory could predict either a positive or negative relationship.

In this paper, we study the relationship between solar PV TPO prices and market (installer) concentration (i.e., market competitiveness). To do this, we build a novel dataset of TPO contract terms for the residential solar PV market in the San Diego Gas & Electric service territory. This allows us to construct the net present cost (NPC) of each system based upon the leasing terms. We combine numerous public and proprietary datasets that allowed us to match solar PV system-level data to TPO contract prices and to construct eight different variables that measure market structure.

Determining a relationship between prices and installer concentration is challenging for several reasons. Most significantly, prices and market structure are simultaneously determined by each other—the amount of competition a seller faces influences the price they can command, while prices determine a seller's market share. Previous studies have examined recent solar PV pricing trends over time and between markets (Davidson et al., 2015; Nemet et al., 2016, Gillingham et al., 2014; Barbose and Darghouth, 2015; Davidson and Margolis, 2015). While these studies of solar PV pricing are able to determine correlations between prices and market factors, they have not proven causation. Our study aims to fill that gap by focusing on identifying the causal relationship between market structure and prices paid by consumers.

We contribute to the growing literature on solar markets by addressing two key missing pieces. First, we study TPO system pricing as measured by the contract terms agreed upon between the consumer and the third party. This is different from studying the host-owned (HO) market in which the residential customers own the solar system. In the case of TPO, a third-party owns the solar system and leases it to the residential customer, resulting in a different pricing structure and business model. Other studies to date have focused on the HO market because of data limitations. Our access to and evaluation of proprietary contracts obtained through a non-disclosure agreement allows us to overcome the barrier of TPO pricing data availability.

Second, while previous studies reveal interesting insights about the correlations between market structure, technology, and policy with system prices, we show that there is a bias associated with ignoring the endogeneity of market structure. We use an instrumental variables (IV) approach in an attempt to remove this bias.

## **Methods**

We use an instrumental variables (IV) approach to study how market competition (i.e., installer concentration) impacts solar PV system pricing in early residential TPO markets. We construct and employ eight different market structure measures for robustness purposes (the Herfindahl-Hirschman Index, number of installers, a “monopoly” indicator, and others). Each market structure variable is measured by census tract (which we define as a “market”). Our IV approach aims to address the endogeneity of market structure. We isolate exogenous variation in concentration by using the percentage of single-family homes within a census tract that are owner-occupied as an IV. The first stage results and F-statistics suggest that our IV is consistently strong across the eight measures of market structure.

## Results

We find that firms charged higher prices in more competitive markets in our sample. The finding is robust across multiple definitions of market structure.

We also conduct a number of robustness checks. We show that our findings are not sensitive to the choice of discount rate used when calculating the NPC of TPO contract terms. Furthermore, we searched for additional IVs in case our original IV in case our IV is correlated with the error term. We use the median of weekly for-sale homes within a zip code for a given month as an additional IV and show that our results hold. The first stage results and F-statistics suggest that both IVs are consistently strong across the eight measures of market structure.

There are at least two potential explanations for our findings. First, firms could be conducting entry deterrence strategies. It is possible that firms are acting in a non-competitive and setting prices lower than they would otherwise. Setting low prices that are below potential competitors' marginal costs could deter entrants and ensure a larger market share. Second, there could be a group of dominant firms (with a competitive fringe), and the dominant firms may occasionally engage in price wars. If this is true, prices might be lower in more concentrated markets during price wars.

## Conclusions

As the rooftop solar PV market continues to grow, market structure will remain a relevant policy issue in consideration of the potential for rooftop solar to contribute to decarbonisation efforts or other policy objectives. This paper adds to the understanding of supply-side factors in scaling up solar markets in the residential sector. Generally, solar markets have become more competitive over the same time period that solar technology costs decreased. While solar system hard costs have come down, our research suggests that total costs are more nuanced in early solar system TPO markets. Policymakers and industry stakeholders can consider these findings when operating within and designing markets and use data to make informed decisions.

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