Deconstructing Solar Photovoltaic Pricing: The Role of Market Structure, Technology, and Policy

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EXECUTIVE SUMMARY

Overview

Installations of solar photovoltaic (PV) systems have expanded rapidly over the past decade, with continued growth anticipated over the near- and longer-term. Along with this growth has been a substantial decline in PV system prices. Amid this decline, however, there remains considerable heterogeneity in PV system pricing. For example, among residential and small commercial systems installed in the United States in 2013, roughly 20 percent were sold for less than $3.90/Watt (W), while a similar percentage was priced above $5.60/W.

This paper empirically examines observed heterogeneity in PV prices in the United States. We explore different plausible sources of price variation, including characteristics of the PV systems and household demographics, as well as measures of installer competition, installer experience, demand for PV, and public policy. A rich dataset of nearly 100,000 PV systems over the 2010-2012 timeframe was analyzed, focusing on systems under 10 kW for which a non-appraised value price is observed.

Methods and Data

The approach used in this study follows an extensive literature on price dispersion, and estimates the reduced-form relationship between PV prices and a wide variety of supply and demand factors that may impact those prices. The study relied on LBNL's sizable Tracking the Sun dataset of system-level PV prices. Additional data were compiled from SEIA/GTM, DSIRE, IREC, and the U.S. Census Bureau. Only system-level installation prices between $1.5/W and $20/W were retained, system size was limited to 1 kW to 10 kW, and only PV systems installed between 2010 and 2012 were included. Appraised-value TPO systems were excluded from the analysis, but other TPO systems for which prices reflect transactions between installers and finance providers were retained. The final sample contains 98,586 PV systems across 14 states.

Results and Conclusions

The results demonstrate that a wide variety of factors can and do impact PV system pricing. Even after controlling for many plausible price drivers, however, much of the variation in prices remains unexplained. This suggests that highly installation-specific (unobservable) characteristics, such as the suitability of the roof or the willingness of the consumer to search for a lower price, may impact prices.

Key findings from the study include (see Figure 1):

• PV system characteristics have a strong influence on pricing: larger PV systems, even within the narrow range of 1 kW to 10 kW, are associated with lower prices per W; tracking, thin-film panels, building integrated panels, and batteries all increase prices; and systems installed as part of new home construction or that were self-installed have lower prices.

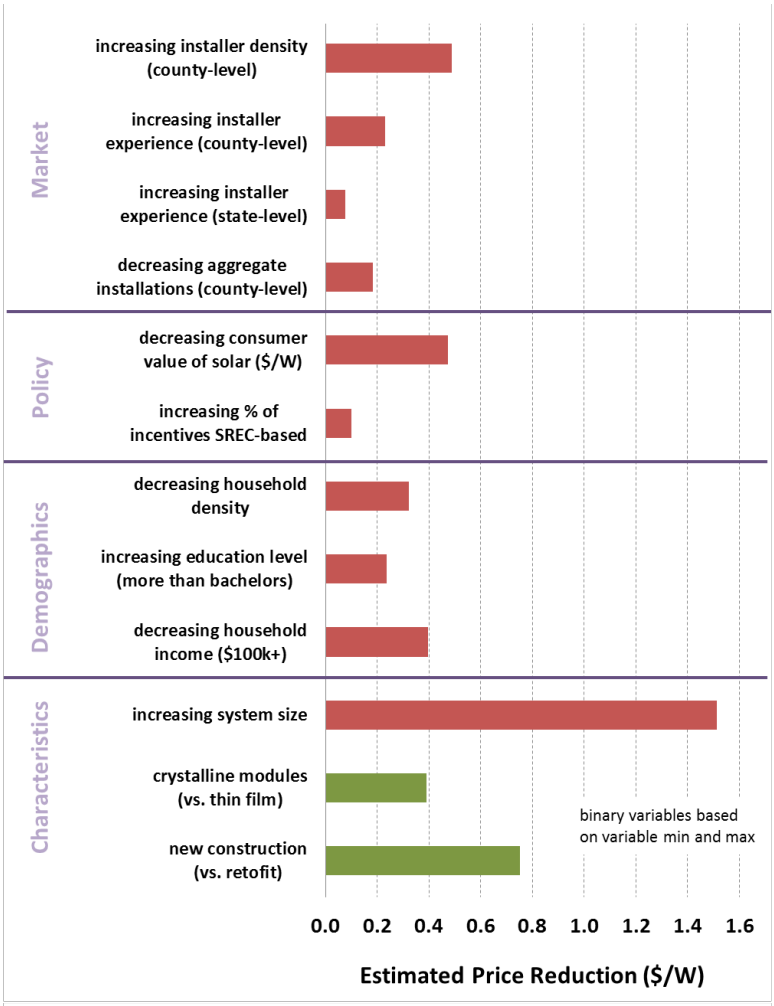
• Installer competition and consumer search costs affect pricing; for example, as the density of installers active in a local market increases, PV system pricing declines.

• Installer experience and economies of scale at the state and especially at the county level are found to reduce prices, consistent with a large literature on learning-by-doing in new technologies.

• Policy variables influence prices, as regions with a higher "consumer value of solar," which accounts for utility bill savings and incentives, tend to experience higher prices; these results may stem from a demand shift due to the higher incentives, or alternatively, may be a symptom of imperfect competition whereby installers are able to "value-price" systems based on consumer willingness to pay.

• Demographic factors influence prices: greater regional household density and household income increase prices, whereas greater levels of education in the region decrease prices.

• Factors that increase demand for or willingness to pay for PV, including many noted above and also including the aggregate number of PV systems in the local market, are found to increase system prices.



Notes:
The bars present the pre-incentive price reduction (per watt) from moving from the 5th to 95th percentile of each variable. For green bars , the range reflects the minimum to maximum as these are binary variables. Not all variables are presented in this figure; results for variables on HHI, sales tax, interconnection score, other educational and income variables, local labor cost, customer segment, third-party-owned, tracking, BIPV, battery, inverter and module are found in the full report.

Figure 1. Impact of Various Drivers in Reducing PV Prices

These results have several implications for policy. They provide a broad view of the factors influencing PV pricing, which is valuable given that price reduction is a stated policy objective. Many of these factors, such as the level of competition and experience, also relate closely to market failures that may be justification for government intervention. Finally, the results provide evidence of how policy actions, such as changes in the magnitude of financial incentives for PV may directly influence prices. Attention may therefore be required when designing and evaluating deployment policies aimed at achieving cost reductions, given the potential for such policies to elevate prices in the short-term.