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How price spikes can help overcome the energy efficiency gap

Johannes Mauritzen*

Center for Sustainable Energy Studies (CenSES), Department of Business and Management Science
NHH Norwegian School of Economics, Helleveien 30, 5045 Bergen, Norway
IFN Research Institute of Industrial Economics, Stockholm, Sweden

HIGHLIGHTS

- Electricity price spikes may have an informational effect on energy efficiency.
- Price spikes are associated with increased Google searching for heat pumps in Norway.
- I devise a novel method of decomposing prices into smoothed and spiky components.

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ABSTRACT

Using data on Google searches, I suggest that the spiky nature of electricity markets has a strong effect on searching for information on energy efficiency goods. I identify the informational effect by decomposing prices into smoothed and deviation components.

1. Introduction

An important and often contentious issue in energy market research has been what has been referred to as *the energy efficiency gap*. This is the phenomenon that both consumers and businesses do not seem to invest in energy efficiency despite seemingly ample returns. A large literature spanning the engineering, economics and psychology literature has grown around the question. For recent overviews with special attention paid to policy implications see Gillingham and Palmer (2013) or Brennan (2013). Behavioral and psychological aspects have recently come to the forefront. Allcott and Greenstone (2012) provide a review of recent empirical research on the energy efficiency gap, noting "[i]mperfect information is perhaps the most important form of investment inefficiency that could cause an Energy Efficiency Gap".

This article attempts to connect the energy efficiency literature, especially its focus on information frictions and behavioral considerations, to characteristics of deregulated electricity market. In particular, deregulated electricity markets tend to experience occasional price spikes and high short-term volatility (Weron, 2006).

Price spikes are often seen as an unfortunate but hard to avoid aspect of electricity markets.

In this paper I argue that price spikes may also have a silver lining. When price spikes occur, it can generate publicity on TV, radio and in newspapers. Such news coverage can sometimes include, among other things, information and estimates of price savings from investing in energy efficiency. A price spike then can have the effect of ameliorating the under-provision of information on energy efficiency goods as well as acting as a behavioral nudge for inattentive consumers.

* Correspondence to: NHH Norwegian School of Economics, Helleveien 30, 5045 Bergen, Norway. Tel.: +47 55 95 92 69.
E-mail address: jmaurit@gmail.com.

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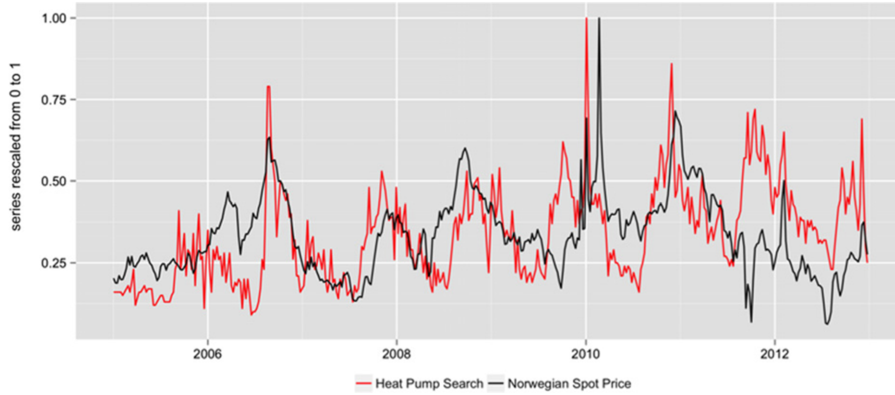

Fig. 1. Norwegian wholesale electricity prices and heat pump searches. The series appear to be correlated.

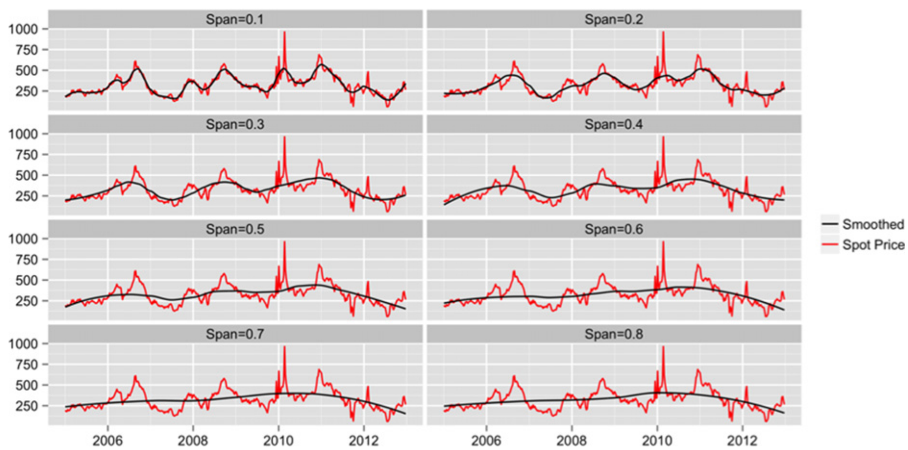

Fig. 2. Loess smoothed price series. Span indicates the level of smoothness with larger values signifying more smoothing.

I use search data from Google to estimate the informational effect of price spikes. I compare jumps in the price of electricity and Google searches in Norway for heat pumps ("varmepumper"). The inspiration for choosing this particular case came from Pauchon (2012) who noted a correlation between periods of high electricity prices and investment in energy efficiency. He argues that the variable market prices in Norway is likely one reason why incentives for energy efficiency investments have been relatively successful compared to countries like France.

The vast majority of Norwegian households have market contracts for their electricity, giving them an incentive to pay attention to market movements. However, these market contracts are based on averages of wholesale prices—nearly 60% of households have contracts where their bill is based on an average of the monthly wholesale price plus a given mark-up where just under 40% have variable contracts that partially hedge price moments on the wholesale market. Less than 5% have contracts that are fixed for a year or more (NVE, 2011). In other words, the real prices that retail customers face are smoothed versions of the wholesale prices. This makes it possible to try to identify the informational and behavioral components from the real price mechanisms by decomposing prices into smoothed and spiky components.

A cleaned data set as well as the complete code for my analysis can be found on my website http://jmaurit.github.io#price_spikes.

2. Material and methods

Fig. 1 shows a plot of the weekly average of Norwegian wholesale electricity prices against the Google search index for heat pumps from 2005 through 2012. Each series has been rescaled to be between 0 and 1. Both series are quite noisy, however a relationship appears to exist between jumps in price and searches for heat pumps.

Instead of providing an arbitrary definition of price spikes, I attempt to provide results for a range of *spikiness*. I smooth the price series using a locally weighted regression—or Loess of varying neighborhood sizes as shown in Fig. 2.

More formally, define the weights as in Eq. (1).

$$W_k(z_k) = \begin{cases} \left(1 - |z_k|^3\right)^3 & \text{for } |z| < 1 \\ 0 & \text{for } |z| \geq 1 \end{cases} \tag{1}$$

where $z_k = \frac{t_k - t_i}{h}$ and h is the half-width of the window containing the observations. This means that for each price at time, t_i, observations close in time are weighted heavier than those farther away. For each t_i a quadratic regression with weights as calculated above is run to give the fitted price, $\hat{p}_{t_i}$. The level of smoothing can be adjusted by including a fixed proportion or span of the data, s.

Taking the difference of the price series from the smoothed counterparts, at varying levels of span, s, I get a set of series representing a range of deviances as represented by Eq. (2).

$$d_{t,s} = p_{t_i} - \hat{p}^s_{t_i}. \tag{2}$$

Having calculated the deviances of prices from a set of smoothed series, I then run a simple regression repeatedly over the various spans, s. The regression can be written as in Eq. (3).

$$\begin{aligned}\log(g_t) &= \alpha_s + \beta_s^+ \log(d_{t,s}^+) + \beta_s^- \log(d_{t,s}^-) \\ &\quad + \beta^{smooth} \log(smooth_{t,s}) + \beta_{hdd} OsloHDD_t \\ &\quad + \beta_{mag} Magazine_t + \epsilon_{t,s}\end{aligned} \tag{3}$$

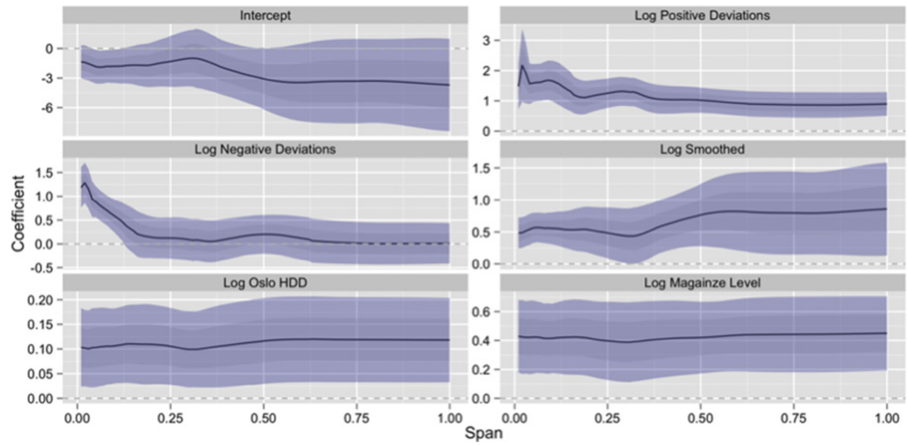

Fig. 3. Results. Series of estimated coefficients over varying span. Shaded areas indicate 95% confidence intervals.

g_t represents the Google search index for heat pumps in Norway at time t. Heat pumps are not only energy efficiency goods but also heating goods. Presumably cold weather and seasonal change could both lead to higher electricity prices as well as increased interest in heat pumps without there necessarily being any causal connection between the two factors. To deal with this I include measures of temperature and seasonality in the regression. Here $OsloHDD_t$ represents heating degree days in Oslo in week t while $Magazine_t$ represents the fill level in percent of Norwegian hydropower plant magazines in week t. α_s represents the intercept term while $\epsilon_{t,s}$ represents the error term.

$d^+_{t,s}$ and $d^-_{t,s}$ represent positive and negative deviances from the smoothed series, $smooth_{t,s}$ at varying levels of the smoothness parameter, s. The smoothed series is also included in the regression to control for the real price–demand effect.

3. Results

Fig. 3 shows the estimated coefficients, $\hat{\beta}^s_d$, for a range of regressions where the span, s, of the smoothing algorithm is allowed to vary between 0 and 1 in 0.01 increments. The bans represent approximate 95% and 70% confidence intervals.

The results of this model are consistent with the idea that price spikes are providing an informational or behavioral effect. Even with very small span – where price spikes are defined in the narrowest sense and the smoothed series includes most of the variation – the coefficient is estimated to be large and significant. In fact the point estimate actually becomes larger at the lower levels of span. In contrast, a price–demand effect would imply that the coefficient on the deviations would go towards zero as the span approached zero since the averaged price effect of the price deviations becomes negligible.

As a robustness check, I run a regression where searches for heat pumps are replaced by searches on key words that can be expected to be seasonal and correlated with weather but have no other direct connection with electricity prices. I test a model where the left-hand side variable is searches for winter tires ("vinterdekk"), which are required by law in Norway during the winter. No significant effect of price spikes on searches for winter tires is estimated. The same holds when searches for winter jacket ("vinterjakke") are used.

One feature that has appeared in all the results so far has been a spike in the estimated coefficient on price deviations at span values close to zero. At these span values just a few price spikes dominate the total variation in the deviation series, as the top panel in Fig. 4 show.

I went through the archive of the largest Norwegian newspaper, "Aftenposten"[1] and counted the number of articles that mentioned electricity prices, differentiating between those that spoke of high and low prices. The results are shown in the lower panel of Fig. 4. From the figure it is apparent that a few price jumps—in particular those in the winter of 2006–2007 and those in 2010 generated a large part of the news coverage. Thus the jump in the coefficient series on the price deviations at very low span does appear to be real in the sense that it reflects that the largest informational effects come from the few but large and sharp price deviations.

4. Discussion and conclusion

The arguments and methods of this article are relatively straightforward, yet the results demonstrate an important but largely overlooked point. By drawing attention to electricity prices – for example through news reports – spiky electricity markets can play an important informational role. The results of this article indicate a clear connection between price spikes and searches on Google for heat pumps in Norway. This correlation is especially strong where price spikes are defined most narrowly as sharp deviations from the overall movement of prices.

Throughout this article I have suggested two distinct mechanisms for the observed results that are in practice difficult to pull apart. The first is a mechanism based on under-provision of information and other information frictions. Because information has public good properties then, by definition, it is not optimally provided under normal market conditions. Price spikes then have the effect of increasing information provided on prices through news coverage and, potentially, other avenues. The other mechanism is behavioral. Consumers may be aware of electricity prices, but it takes some mental effort to make the necessary calculations involving yearly consumption and in turn energy savings from appliances. Price spikes may then be interpreted as giving a nudge to consumers to undertake this mental exertion.

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[1] http://a.aftenposten.no/kjop/article2853.ece.

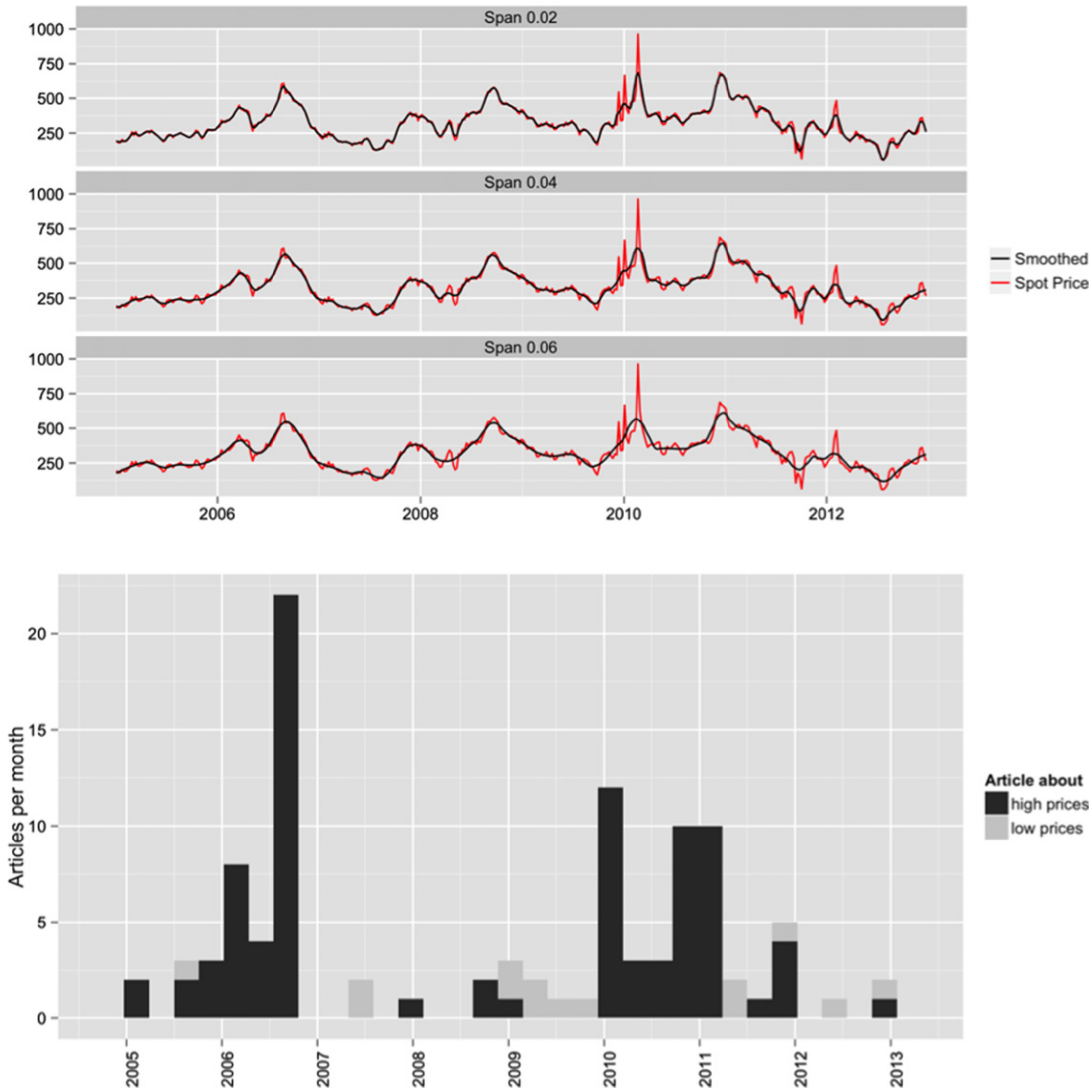

Fig. 4. Price deviations at very small span and frequency of news articles. The frequency of news articles coincides with sharp deviations from the smoothed price series.

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