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The Effect of HVTLs on Property Values: An Event Study

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We present empirical results for the effect on residential property values from the construction of high voltage transmission towers on an existing utility right of way. The event window consists of a period of two and a half years during which non-operational 500 kV towers were in place, after which they were taken down. When comparing the proximate transactions within the window to those outside, relative to the same difference for distant transactions, we find a negative effect on valuation during the presence of the towers, which is most significant for encumbered and abutting properties, and vanishes quickly with distance from the right of way or nearest tower. An event window that corresponds to widespread public knowledge of the pending construction leads to an insignificant effect, which suggests that the price formation process is possibly ineffcient.

Keywords

Hedonic Pricing, High Voltage Transmission Lines, Event Study, Market Efficiency

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1. Introduction

Beginning January 2011, sixteen 200 ft 500 kV non-operational double-circuit transmission towers were constructed on an existing 150 ft wide, 4 mile long utility right of way (ROW) through a residential part of the City of Chino Hills, California. Before this date, there were approximately ten 70-100 ft 220 kV towers in place that had last been used 40 years earlier. In September 2013, the new 500 kV towers were removed and the transmission lines were placed underground. This set of circumstances allows us to revisit the question of the impact of upgraded transmission lines on property values in a hedonic regression analysis by using the event window to control for non-high voltage transmission line (HVTL) local market conditions. Furthermore, since court testimony makes it reasonably clear when residents became widely aware of the construction plans, we use a second window to test for price impact before the new towers were in place and examine the efficiency of the price formation process at an hedonic level.

Extremely high voltage transmission lines are generally considered to be a negative amenity since they are visually not appealing, cause noise pollution (both aeolian and corona noise), and may be perceived as a health threat. The focus of this study is on a particularly onerous configuration in that the new six-arm towers were very tall and the ROW is relatively narrow. Studies suggest that a price effect diminishes with time, and the smaller preexisting towers let us reexamine this finding. The installation of the new towers, on the other hand, should have maximal impact, although they, like the old towers, were not operational.

To our knowledge, this is the first regression event study for transmission line impact on residential properties.[1] First, we find no marginal effects from the extant, non-operational 220 kV towers. Second, double differences show a significant negative impact on price when the 500 kV towers were present for properties that abut or are encumbered by the ROW. The effect diminishes rapidly with distance from the easement or nearest tower, which points to the importance of the interplay between proximity measures. Third, we find that price and transaction volume are unaffected during a preceding window that corresponds to concrete and widely known plans for the new tower configuration. This suggests that price formation is inefficient in our sample (Simons and Saginor 2006).

We review the existing literature in the next section, followed by a discussion of the model and data. The results are presented in Section 5, and Section 6 concludes.

[1] There have been some appraisal studies for new and upgraded transmission lines. See Kroll and Priestly (1991).

2. Literature Review

There is rich empirical literature on the impact of negative amenities on the value of residential real estate. Simons and Saginor (2006) review 75 articles and case studies of loss in value that stems from a wide range of individual contaminants, including power lines, and combine these into a meta-data set with added covariates, such as study type, contamination source and distance, geographic region, market conditions, and rural setting. They find that regression studies show systematically lower losses in value compared to survey results, which suggest that revealed preference is weaker than stated preference. Of particular interest to our study, they conclude that the "announcement of a bad thing" does not have a significant effect on value, while instead an "announcement of a closing [of a negative amenity]" is significantly positive.

Turning to transmission lines in a residential setting, several comprehensive reviews (Kinnard and Dickey 1995, Kroll and Priestly 1991, Jackson and Pitts 2010) break the empirical literature down into three categories: surveys, regression analyses, and a catch-all category that includes traditional appraisal techniques, such as paired sales, case-based, and sale-resale studies. This latter group also includes studies of court rulings (Bryant and Epley 1998, and Rikon 1996) and an analysis of perceived health risks (Priestly and Evans 1990).

Survey research generally indicates that while homeowners might consider the power lines a health risk and an eyesore (Kung and Seagle 1992, Priestly and Evans 1996), they do not view them as having a significant impact on property values (Kinnard 1967, Solum 1985, Kung and Seagle 1992). The work of Priestly and Evans (1996) is of particular interest here since it involved a survey of residents after an upgrade to an existing transmission line. Respondents that had lived in the neighborhood before the upgrade viewed it in the most negative light, consistent with the results that indicate price impact diminishes over time (Ignelzi and Priestly 1991). Chalmers and Voorvaart (2009) summarize the survey literature as being consistent and point out a puzzle from the general findings: most buyers knew of the power lines at the time of purchase, and a majority of the owners had negative feelings about them, but most of these in turn stated that the transmission lines did not factor into their decision to buy the property or the price that they paid. In contrast, a survey of appraisers by Delaney and Timmons (1992) revealed an average estimate of the negative impact on value to be 10%, with only 10% and 6% of the respondents believing there to be no effect or a premium, respectively.

The second strand of the empirical literature deals with regressions that predict price based on hedonic characteristics, including terms for the level of negative amenity, such as encumbrance, adjacency, or distance to an easement or a tower. Generally, these studies find a small effect, with the loss in value varying from no effect, to 2–10% (Kroll and Priestly 1991, Jackson and Pitts 2010). Colwell and Foley (1979), and Hamilton and Schwann (1995) find a significant price impact close to transmission lines, but it disappears rapidly with distance. Colwell (1990) considers encumbered property and adds distance to towers as an explanatory variable to find similar results and that the impact tends to diminish over time (see also Ignelzi and Priestly 1991). Des Rosiers (2002) uses detailed micro-spatial data to find a ∼ 10% drop in value if the property is abutting or facing a tower, and a premium once it is 1–2 lots away from the easement. Chalmers and Voorvaart (2009) similarly observe that once the level of visibility of the tower is controlled for, only encumbrance has a significant but small effect on value while mere proximity does not. Bottemiller and Wolverton (2013) find weak negative effects for abutting properties, but that these are more significant for higher-priced homes. They caution that studies are not easily generalizable to other markets because of differences in terrain, vegetation, and local attitudes. Kroll and Priestly (1991) summarize these results: effects are generally limited to 10% of the value and most evident for encumbered property; proximity effects vanish rapidly with distance; when a new line is constructed, the negative effects are initially large, but attenuate over time; the tower height has little impact on loss in value, but visibility plays an important role; and proximity may even lead to a premium, presumably because the ROW can provide recreational amenities and added privacy (Rhodeside and Harwell 1988, Des Rosiers 2002, but see Peiser and Schwann 1993).

Turning to market efficiency, there is a large body of literature that investigates the centralized and homogeneous securities markets.[2] By "efficient", one generally means the extent to which relevant public (weak-form) or private (strong-form efficiency) currently available information is impounded in the price of an asset, so that an investor cannot derive economically significant excess returns.

For real estate markets, there is rather less research, but efficiency is tested in broadly three different ways: research that examines if the present value of future rents matches price in the long run; whether excess returns exhibit serial correlation and might thus be forecasted; and tests of whether prices match their underlying determinants, such as income and employment. Meese and Wallace (1994) find that the present value relationship is violated in the short–term, but holds over the long–run. They also remark on the importance of considering transaction costs before concluding that the market is inefficient. Linneman (1986) and Case and Shiller (1989) find evidence of serial correlation in house prices, which implies that future prices are predictable. Guntermann and Smith (1987), however, conclude that the market is weak-form efficient once transaction costs are incorporated. They examine the serial correlation of excess total returns for 57 individual real estate markets versus the market as a whole for the period 1969–1982. At 1-3 year lags, they find no effect, and although serial correlation is observed at 4-10 year intervals, it is not economically significant. They also investigate "trading strategies", and find that a mean-

[2] A classic overview is provided by Fama (1970); see also Dimson and Mussavian (1998).

reversion strategy would be profitable, but only in the absence of trading costs. Rosenthal (1994) finds that shocks to prices relative to construction costs disappear faster than construction lags, which implies that the market for improvements is efficient, and that any remaining inefficiency must be derived from the land market.

3. Background and Time Line

The Tehachapi Renewable Transmission Project (TRTP) was a Southern California Edison (SCE) program to construct and upgrade 173 miles of HVTLs to deliver 4,500 MW of power from wind farms near Tehachapi in eastern Kern County, California, to the Antelope Valley and Los Angeles Basin. The project contributes toward compliance with California state law with regard to the proportion of power consumption that must be derived from renewable resources, and helps attain the greenhouse emission caps in California under the Global Warming Solutions Act of 2006.

SCE divided the transmission line project into segments. The last of these in the Los Angeles Basin is Segment 8, and runs from Monterey Park to the city of Ontario. The part of this segment that traverses our study area in the city of Chino Hills was to involve the construction of a double-circuit,[3] 500 kV line from the Mesa substation in Monterey Park to a substation in the City of Chino.[4] In Chino Hills, the project would place roughly 200 ft tall tubular and lattice steel towers on the 150 ft-wide utility ROW (see Aabo 2013). The ROW existed well before our study period with approximately ten 50–100 ft unused 220 kV towers placed on it prior to the upgrade.[5]

SCE announced[6] its intention to construct the TRTP in late 2004 when it applied to its regulator, the California Public Utilities Commission (CPUC), for permission to construct Segments 1–3. Plans for Segment 8 in Chino Hills were made public in the second quarter of 2007 when SCE distributed comprehensive information packages, and advertised open houses in local newspapers, on its website and mailed invitations to property owners within

[3] With a 3-phase system, “single circuit” means three cables, a “double circuit,” six cables.
[4] Chino Hills is about 50 km east of downtown Los Angeles, in San Bernardino County. Monterey Park is west of Chino Hills, and the City of Chino is the immediate eastern neighbor of Chino Hills, roughly divided from it by the Chino Valley Freeway (CA 71).
[5] Starting at the Chino Valley Freeway on the eastern border of Chino Hills (33.986466^{o}/-117.713386^{o}), the ROW runs directly west for 1.75 km (to 33.986697^{o}/-117.732786^{o}), and then in a south-westerly direction for about 4.5 km before entering the relatively unpopulated hills that form the western border of the Chino Hills. The western-most tower location that we consider is at 33.969762^{o}/-117.776489^{o}.
[6] The following time line is a summary of court documents, records and information pamphlets from SCE, and articles in the local press.

300 ft of the ROW. Later testimony by representatives of a local citizens group ("Hope for the Hills") before a CPUC administrative law judge indicates that this is when the residents of Chino Hills first became widely aware of the plans of SCE (Goodwin 2013, Genis 2013).

A formal project application for construction was submitted in June 2007, and the City of Chino Hills immediately filed a complaint to the San Bernardino County Superior Court that the planned transmission line would overburden the easement over city property (Fleager 2013). On December 17, 2009, the CPUC approved the SCE plan, and four months later, the San Bernardino County Superior Court ruled that the CPUC had exclusive jurisdiction with regard to ROW issues. Tower construction began on January 17, 2011.[7]

During this time-frame (mid-2007 through 2011), political pressure mounted against the project as proposed, and the City and Hope for the Hills campaigned for alternate routing and design of the transmission line. On October 19, 2011, after 16 towers were completed, and no cables had yet been strung, the CPUC ordered a stay of construction and asked SCE to provide five alternative proposals for routing and design. Among the alternatives that SCE submitted in January 2012 was a plan to place the cables underground, but it continued to advocate for the tower approach. By March 2012, mediation between the City and SCE had ended in failure and proceedings were moved before a CPUC administrative law judge in April 2013.[8] By then, however, the CPUC had sided with the City and in July voted 3-to-2 in favor of placing single–circuit cables underground. The towers were removed beginning September 24, 2013, and civil construction for underground transmission lines on the ROW commenced soon thereafter.

4. The Model and Data

The time line described above leads us to consider two event windows. The first is a simple "hard" window, from January 17, 2011 to September 24, 2013, during which the new 200 ft towers would have been visible and possibly influenced even uninformed buyers.[9] We shall call this period EW_1 and designate prior transactions (January 2001–December 2010) as "untreated" subjects, during which the much shorter, unused 220 kV towers were in place. EW_1 covers only a part of the time during which public information about the

[7] In September 2011, the Court of Appeal affirmed the Superior Court ruling that the CPUC had exclusive jurisdiction in the matter. A subsequent petition to the California Supreme Court was denied in December 2011.
[8] See Fleager (2013), Lombardo (2013), Aabo (2013), Goodwin (2013), and Genis (2013).
[9] Sellers within a 300 ft distance from the easement would have been notified by SCE around the second quarter of 2007. In principle, brokers would have disclosed project plans to buyers as part of their fiduciary duty.

pending transmission lines was available.[10] We choose not to include the period after September 2013 when construction for underground cables began since it is not directly comparable to the prior two periods. We cannot yet consider the (potentially positive) impact from underground cables as construction is ongoing and there are insufficient transactions proximate to the ROW.[11]

As a second test, we investigate if there was any announcement effect. We choose to start this window, EW_2, when SCE began its notification campaign in March 2007 because this is when residents first became aware of the plans of SCE (Goodwin 2013 and Genis 2013). The window ends at the commencement of tower construction in January 2011. If the market incorporated publicly available information to any degree, one would expect some negative effect on property values and/or sales volume proximate to the ROW during that time.

The transactions data were obtained from PropertyRadar (2015), a firm that specializes in data for real estate professionals. To reduce heterogeneity whilst keeping a sufficiently large control group at distances where the potential negative price effects from the towers and transmission lines are negligible, we restrict transactions to within 1 km of the ROW, between January 2001 and November 2013.[12] Within this band and time frame, there were 2,735 transactions.

To the hedonics in the data set, we add the latitude and longitude of each parcel as obtained from county records, along with tower locations from SCE. We use four distance indicators as a proxy for the level of negative amenity: (1) distance levels to the center of the ROW, d_{TL};[13] (2) distance to the nearest tower, d_{TW}; and, from an inspection of the proximate parcel maps, whether (3) the property abutted the ROW; and (4) whether it was encumbered.

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[10] December 2009 (when the CPUC approved tower construction), or March 2007 (when SCE publicized the project), though July 2013, (when the CPUC voted to underground the transmission line).
[11] See McNair and Abelson (2010) for an empirical study of the economic impact of placing utility cables underground.
[12] We include a one month lag between the date of the sales contract and transfer of ownership.
[13] Closest distance to a "path" was computed brute force by placing a latitude/longitude marker every 10 m or so on its centerline, and then finding the distance of the property to the closest point on the path.

The model that we use is motivated by a standard double difference setup, and restricted by the available characteristics, significance, and collinearity tests:[14]

$$\begin{aligned}\ln PRICE = {} & LIVINGAREA \times \beta_{LA} + LOTSIZE \times \beta_{LS} + AGE \times \beta_{A} \\ & + BEDS \times \beta_{BD} + BATHS \times \beta_{BT} + D_{UNITS} \times \beta_{U} \\ & + D_{STORIES} \times \beta_{S} + D_{SFR} \times \beta_{SFR} + D_{POOL} \times \beta_{P} \\ & + \ln HPI_{t} \times \beta_{HPI} + D_{CLOSEQTR} \times \beta_{CQ} + D_{ZIP} \times \beta_{Z} \\ & + D_{ELEMENTARY} \times \beta_{E} + D_{SALETYPE} \times \beta_{ST} \\ & + [D_{EW_i} \times \beta_{EW_i} + D_{ABUTS} \times \beta_{A} + D_{A \times EW_i} \times \beta_{A,EW_i}] \\ & + [D_{EW_i} \times \beta_{EW_i} + D_{ABUTSONLY} \times \beta_{AO} + D_{AO \times EW_i} \times \beta_{AO,EW_i}] \\ & + [D_{EW_i} \times \beta_{EW_i} + D_{ENCUMBERED} \times \beta_{EN} + D_{EN \times EW_i} \times \beta_{EN,EW_i}] \\ & + [D_{EW_i} \times \beta_{EW_i} + D_{TL} \times \beta_{TL} + D_{TL \times EW_i} \beta_{TL,EW_i}] \\ & + [D_{EW_i} \times \beta_{EW_i} + D_{TW} \times \beta_{TW} + D_{TW \times EW_i} \beta_{TW,EW_i}], \qquad (1)\end{aligned}$$

where D indicates a dummy variable. Terms of primary interest are enclosed in brackets "[...]", and we refer to all other terms as the base regression model. *ENCUMBERED* is an indicator for whether the lot is encumbered by the ROW. This portion is taxed, owners must maintain it, and may not improve it without permission from SCE. Owners can, however, use encumbered land for coverage restrictions on improvements. *ABUTS* here will mean that the lot shares a border with (or is also encumbered by) the ROW. In an alternate definition, we use *ABUTSONLY* to exclude properties with an easement. *TL* and *TW* are distance indicators to the center of the ROW and nearest tower, respectively. The interaction between these four proximity measures and EW_i allows us to control for local market conditions unrelated to transmission lines: the effect on price for proximate transactions during EW_i compared to the period when the new negative amenity (or threat of one) was absent, relative to the same difference for distant properties. The house price index (HPI) (see below) serves as a further control for the wider market.

Sales with missing living area, year built, bed/bathroom count, or lot size were dropped. A small number of (non-abutting) properties have a bed and bath count that is incongruous with the living area and were removed. We assume that any property construction was completed midyear, and dropped any observation for which age at time of sale (AGE) was less than negative 0.5 years.[15] Four non-abutting properties with ages that exceed 50 years significantly contribute to non-linearity in *AGE*, and were also removed.[16]

[14] We return to the issue of a log-linear specification later.
[15] There are 22 such excluded observations, none of which abut the ROW. Our findings do not change if we keep these observations instead. Some of them could, of course, correspond to pre-sales.
[16] AGE-squared was not considered as the VIF tests show it to be highly collinear with AGE; dwellings in Chino Hills are relatively new, with only few exceptions.

We note that Hamilton and Schwann (1995) advocate the use of logarithms of independent variables to capture nonlinearity. Given that there are only very few properties that cause the nonlinearity in our sample, none of which are proximate to the ROW, we choose instead to drop these observations and forego the added complications of a full translog specification.

There were six properties that transacted a total of seven times with a living area of more than 4,500 sq ft. None abut the ROW and they are more than 400 m from any tower. Most belong to a non-contiguous cluster of very large luxury homes about 500 to 1,000 m south-west of the western-most tower. Local regression indicates that they would be responsible for inducing large non-linearity in *LIVINGAREA*, which we do not cure with higher order terms because the variance inflation factor (VIF) tests show strong collinearity effects. Given that these homes are qualitatively different from the bulk of the sample and none abut the ROW, we dropped all properties with a living area greater than 4,500 sq ft. Similarly, we cut *LOTSIZE* at one acre.

SALETYPE is a PropertyRadar indicator for the type of transaction, identified through the use of official records from the office of the county recorder, and matched with assessor records, geographic information systems (GIS) data, and trustee sale results. The levels of *SALETYPE* in our data set are: "Market", for which none of the attributes listed next apply; "3rd Resale", purchased by a 3rd party at a trustee sale and resold; "Market Flip", sold in a "market" transaction if the prior purchase was "market" less than 180 days ago; "REO Resale", purchased from a bank as a real estate owned (REO) property; "REO Flip", the sale of a property if it was purchased REO less than 180 days prior; "Short Sale", sold at a price less than the outstanding mortgage (and requiring bank approval unless the seller made up the difference in cash); "Short Sale Flip", a sale that was preceded by a short sale within 180 days; and "Short Sale Foreclosure", which corresponds to a short sale during an active foreclosure.

"Non-Market" transactions[17] make up about 25% of the total sample and we choose to keep them in the estimation, and return to this issue below. Additionally, we kept only one of any ``double transactions": if all attributes, including price, transfer date, and transfer type were identical, one observation was dropped. For same-day sales with differing transfer types, we removed the non-market transaction, or kept the higher-priced sale. There are a total of six same-day transaction pairs, none of which abut the ROW.

ln HPI is the (log) quarterly Zillow all-property price index level for Chino Hills (zip code 91709), and accounts for general market conditions. We have also considered our own quarterly date-of-sale dummies, and the resulting

[17] In this discussion, we label all transactions with special qualifiers as "non–market" and those without as "market." A more usual industry practice would be to refer only to transfers such as inter-spousal deeds, transfers into a trust, or upon the death of a joint tenant, etc. as "non-market". There are no such transactions in our data set.

index well reproduces that of Zillow, albeit with added noise. To account for any seasonal variation and the fact that about 2% of the raw sample (5% of the final sample) has a Chino postal address (zip-code 91710), we include dummies for quarter of transaction (*CLOSEQTR*) and zip-code (*ZIP*), respectively.

Finally, the other factor variables in Eq. (1) are: detached or duplex (*UNITS*), one or two stories (*STORIES*), single family or condominium (*SFR*), pool (*POOL*), and elementary school district (*ELEMENTARY*).[18]

An estimation of the base model Eq. (1) reveals no multi-collinearity issues via VIF tests, and local regression analysis indicates linearity in all continuous variables. A Breusch-Pagan test shows that the data are strongly heteroscedastic and scatter plots indicate 36 observations with studentized residuals less than -2.5 (none greater than +2.5), mostly at mid-range fitted log-price. One of the outliers abuts the ROW, but outside either event window. A further 55 observations exhibit a Cook's *D* greater than the cut-off value of *4/N*, of which six abut the ROW and one abuts inside EW_2 (none in EW_1).[19] These outliers and influential observations are dropped – they do not significantly affect our results, presumably since they are not proximate transactions during either event window (see below). The residuals remain heteroscedastic, so we shall use Huber-White standard errors in what follows.

The summary statistics are presented in Table 1. For EW_1, there are 2,569 transactions with 97 that abut the ROW, 21 of which are in EW_1. For EW_2, sales after January 2011 were dropped and the counts are 2,115, 76, and 17, respectively.

Finally, we note that our results are robust to reinstating the outliers and influential observations that we dropped above. Relaxing the cuts and removing instead only the 15 observations with $r_{st} < -4$ (keeping all Cook's *D* otherwise) leaves 2,631 observations, of which 20 have $r_{st} < -2.5$ (none of which abut) and a further 75 exhibit Cook's $D > 4/N$ (one of which abuts, but outside both EW_1 and EW_2). The base regression adjusted R^2 drops marginally to 93.7%, and we find that the double difference log price effects are qualitatively identical to the results that we report below, albeit with a slightly lowered significance. Similar results are found if we drop all non–market sales.

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18 The ROW runs roughly east-west, approximately perpendicular to Freeway 71. Since Chino Hills property values tend to rise toward the west, an alternate specification to school district that we considered uses levels of distance to the freeway, *dHW*. *dHW* is highly significant when *ELEMENTARY* is excluded, but becomes insignificant when it is included. In particular, even immediate proximity to the freeway was no longer significant. We chose the more customary school district co-variate, and dispensed with *dHW* altogether.

19 Roughly one-half of these outliers and influential observations are market transactions, compared to 75% in population.

Table 1 Summary Statistics for the Transaction Data

	EW_1		EW_2	
	Mean SD.	Min Max	Mean SD.	Min Max
Observations	2569		2115	
Transfer Date (Y.Q)	2006.66 3.85	2001.25 2014.00	2005.35 2.88	2001.25 2011.25
Price per sq ft	232 62	95 442	231 66	95 442
Living Area (sq ft)	1951 635	974 4500	1933 632	974 4500
Lot Size (acres)	0.154 0.087	0.022 0.849	0.152 0.086	0.022 0.849
Age (yrs)	19.2 10.1	-0.3 49	18.1 9.6	-0.3 47
Beds	3.57 0.79	2 6	3.54 0.78	2 6
Baths	2.52 0.52	1.5 5	2.50 0.52	1.5 5
Units (1 or 2)	1.0012	–	1.0009	–
Stories (1 or 2)	1.701	–	1.707	–
SFR [Condo]	0.854	–	0.845	–
Pool	0.171	–	0.165	–
Chino Zip	0.048	–	0.042	–
Market	0.764	–	0.810	–
3rd Resale	0.020	–	0.010	–
Market Flip	0.007	–	0.008	–
REO Flip	0.004	–	0.001	–
REO Resale	0.106	–	0.098	–
Short Sale	0.068	–	0.054	–
Short Sale Flip	0.002	–	0.001	–
Short Sale Forecl.	0.030	–	0.018	–
Elem. Sch. Cntry Springs	0.102	–	0.111	–
Hidden Trails	0.324	–	0.326	–
Litel	0.337	–	0.317	–
Glenmeade	0.171	–	0.179	–
Oak Ridge	0.049	–	0.049	–
Chaparral	0.018	–	0.018	–
Abuts	0.0378	–	0.0359	–
Abuts Only	0.0230	–	0.0213	–
Encumbered	0.0148	–	0.0147	–
Dist. ROW d_{TL} (m)	492 277	16 999	494 275	16 999
Dist. Tower d_{TW} (m)	519 278	18 1342	521 277	18 1342
EW	0.177	–	0.252	–
Abuts × *EW*	0.00817	–	0.00804	–
Abuts Only × *EW*	0.00545	–	0.00378	–
Encumbered × *EW*	0.00273	–	0.00426	–

5. Results

We begin with the results for EW_1, as discussed in the previous section. Table 2 shows the coefficients from an estimation of the base model, Eq. (1), without the terms of final interest (those in square brackets). We find a small but significant seasonal effect, with prices in the third quarter exceeding the first quarter prices by 2.2%. The Chino postal addresses in our sample are 9% lower-priced when compared to Chino Hills properties. Living area is highly significant, and once this is controlled for, bedroom and bathroom counts add very little to price since they are correlated with living area. Lot size is highly significant at about 40% of price per acre. Condos and duplexes are 20 and 16% cheaper than single family residences, all else equal, while pools add 2% to the value. Transfer types vary in significance, but Wald tests indicate that they are highly significant as a group. Properties purchased as REO and in short sales transfer are 3.8% and 2.9% less than market transactions, respectively. The corresponding flips are significantly positive, 4.1% and 2.3%, respectively, thus indicating that any upgrades are reflected in price, relative to market sales.[20] Third party resales and market flips are insignificantly different from market sales, while short sales during an active foreclosure sell at a 10% discount. Elementary school catchment areas are individually significant; the Chaparral district straddles the freeway, which might account for its large discount. The adjusted R^2 is high at 95.05%, which is not surprising since the study area is small (roughly 13 km^2), relatively homogeneous, and we have removed outliers.[21]

We now add the event window dummy EW_1, a proximity measure, and its interaction with EW_1. The levels for the distance to the center of the ROW (d_{TL}) are 0–100 m, 100– 200 m, and 200-1000 m, and the same for the distance to the nearest tower (d_{TW}). To examine the price impact from the transmission lines, first consider the more usual average marginal effect:

$$\Delta_{im,jn}(\log Price) = \log Price(P = i, EW_1=m) - \log Price(P =j, EW_1 =n), \quad (2)$$

where log Price is the predicted price, *(i, j)* indicate the level of proximity *P*, and *(m, n)* are 0 or 1 for outside and inside the event window, respectively. $\Delta_{11,01}$ and $\Delta_{10,00}$ are thus between-subjects estimates – the predicted price effect from "moving" a transaction from far ($P = 0$) to near ($P = 1$), within the event window and outside of it, respectively. Similarly, $\Delta_{11,10}$ and $\Delta_{01,00}$ are within-subject estimates of the effect of moving near and far transactions, respectively, from outside to inside the event window.

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[20] Note that the results do not reflect excess returns for "insiders", as we have not controlled for purchase price, extinguished option value, and costs. However, the pairing of sales with flips suggests a 7–8% capital gain (excluding costs).

[21] The adj. R^2 is 88% when all transactions are utilized.

Table 2 Base Price Regression, Eq. (1), without the Terms Enclosed in "[...]"

ln Price	Coef.	*t*
ln HPI	1.05317**	142.57
Closing Qtr: [1st]		
2nd	0.02079**	4.23
3rd	0.02225**	4.55
4th	0.01397*	2.70
Chino [Chino Hills]	-0.09083**	-10.41
Living Area (1,000 SqFt)	0.28717**	43.96
Lot Size (acres)	0.39251**	11.20
Age (yrs)	-0.00633**	-20.43
Beds	0.00400	1.16
Baths	0.00711	0.96
Units: 2 [1]	-0.16363**	-4.77
Stories: 2 [1]	0.00521	0.94
Type: Condo [SFR]	-0.20183**	-24.33
Pool	0.02101**	4.21
Transfer Type: [Market]		
3rd Resale	0.00704	0.63
Market Flip	0.01554	1.15
REO Flip	0.04081*	2.89
REO Resale	-0.03792**	-6.03
Short Sale	-0.02949**	-4.11
Short Sale Flip	0.02306	1.47
Short Sale Forecl.	-0.10267**	-9.98
Elementary School [Oak Ridge]		
Country Springs	-0.12214**	-12.63
Hidden Trails	-0.03932**	-4.74
Litel	-0.05690**	-6.82
Glenmeade	-0.05527**	-5.40
Chaparral	-0.34503**	-20.33
Intercept	-1.18332**	-12.52

Note: The data correspond to the EW_1 estimation, with 2,569 transactions. Base levels are shown in square brackets. The adjusted R-sq is 95.05%, and Huber-White *t*–statistics are reported. $*p < 0.01$, $**p < 0.001$

The results are summarized in Tables 3 and 4. Abutting properties are predicted to suffer only a very small and insignificant loss in value when compared to otherwise similar non-abutting properties, provided that the sale took place outside the event window: with the old 220 kV towers in place, prices are not affected by the abutting ROW, consistent with findings by other authors that impact diminishes with time. For the new and taller towers, on the other hand, there is a loss of about 6.0% for abutting properties, and this result is significant at the 99.9% level. An abutting sale inside the event window loses 4.6% in value (with 98% confidence) compared to the same sale outside the window, while non-abutting properties suffer no such loss.

A similar set of results is obtained for encumbered sales: on average, an encumbered property sold for 9.6% less (at 99% CL) than its unencumbered twin inside EW_1, while outside of the window there is no discernable effect. Market participants did not discount the loss of rights with the old towers on the easement, but significantly so once the new towers were constructed. The loss from moving the transaction from outside the event window to inside is 8.1% when encumbered, and insignificant otherwise.

Table 3 The Average Marginal Effect on Log Price for Abutting and Encumbered Variables, and EW_1, Relative to The Indicted Base Value

	Ref.	$EW_1 = 0$	$EW_1 = 1$
Abuts	[Not]	-0.0104 (0.91)	-0.0595*** (3.45)
Not Abutting	[$EW_1 = 0$]		0.0029 (0.52)
Abuts	[$EW_1 = 0$]		-0.0463** (2.28)
Encumbered	[Not]	-0.0128 (0.64)	-0.0957*** (2.59)
Not Encumb.	[$EW_1 = 0$]		0.0021 (0.39)
Encumbered	[$EW_1 = 0$]		-0.0808* (1.95)

Note: Huber-White *t*–statistics in parentheses below the coefficient. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Turning to the distance indicators, d_{TL} and d_{TW} (Table 4), we find that up to 100 m inside the event window, the loss in value is 3.4%, and 3.6% when compared to sales more than 200 m from the ROW or nearest tower, respectively. Outside EW_1, the small loss is insignificant – the old and shorter towers did not matter. Corresponding results are obtained if we switch the most proximate sale into the event window. However, the effects already vanish at 100–200 m in distance (Colwell and Foley 1979, Des Rosiers 2002, Chalmers and Voorvaart 2009).

Assuming that the unrelated local effects over time are identical for both groups far and near,[22] the transmission line effect can be isolated by removing the estimate of the between– subject difference outside the event window ($\Delta_{10,00}$) from the between–subject difference inside the window ($\Delta_{11,01}$)

$$\Delta^2 = \Delta_{11,01} - \Delta_{10,00}. \qquad (3)$$

[22] After testing this parallel trend assumption, we find that the covariance of EW_i, P, and $P \times EW_i$ with the residuals in our regression are zero with p-values near 100%.

In our setup, this double difference is simply the respective coefficient β_{P,EW_1} in Eq. (1). The results are collected in Table 5. For EW_1 (Case A), being encumbered induces the largest loss of value, 8.3%. Abutting properties (which include encumbered ones) lose a smaller, but significant 4.9% of value as a result of the presence of the new towers. As before, distance to the ROW and nearest tower matters only within the first 100 m (about 3% in each case), but not particularly significantly so.

Table 4 The Average Marginal Effect on Log Price in EW_1 for Distance Indicators *d*: 0=(0,100 m], 1=(100, 200 m], and 2=(200, 1000 m]. Relative to the Indicted Base Value.

	Ref.	Dist. ROW d_{TL}		Dist. Tower d_{TW}	
		$EW_1 = 0$	$EW_1 = 1$	$EW_1 = 0$	$EW_1 = 1$
$d = 0$	$[d = 2]$	-0.0024	-0.0340**	-0.0093	-0.0363**
		(0.33)	(2.46)	(0.73)	(2.10)
$d = 1$	$[d = 2]$	-0.0114*	0.0077	-0.0033	-0.0038
		(1.86)	(0.63)	(0.57)	(0.30)
$d = 0$	$[EW_1 = 0]$		-0.0301**		-0.0252
			(2.04)		(1.21)
$d = 1$	$[EW_1 = 0]$		0.0206*		0.0013
			(1.66)		(0.10)
$d = 2$	$[EW_1 = 0]$		0.0015		0.0018
			(0.25)		(0.30)

Note: Huber-White *t*–statistics in parentheses below the coefficient. * $p < 0.1$, ** $p < 0.05$.

The results for abutting and encumbered sales immediately raise the question of whether abutting properties that were not encumbered suffered a significant loss in value during EW_1. There are 62 non-encumbered transactions that abut, and 14 of these fall in EW_1. The double difference in log price with this redefined abutting indicator is added as Regression B in Table 5. The price effect declines to a loss of 3.1% (vs. 4.9% before) and it is not quite significant at the 90% level (p = 12.7%). Abutting-only does result in a loss in value, albeit by a lower amount unless the property is encumbered. The results for d_{TL} and d_{TW} at 0-100 m become insignificant when abutting properties are excluded. This could be interpreted as meaning that the visual effect from the towers was not very important,[23] but is also likely the result of the low transaction count.[24]

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[23] Either because buyers did not discount it, or because one lot in the visual impact is hidden by landscaping and/or unimportant because of the orientation of the house.

[24] Conservatively assuming average 6,500 sq ft ~ $(80\text{ ft})^2$ lots to be square, the ROW plus abutting properties (150 ft + 2 × 80 ft ~ 310 ft ~ 100 m) leaves little room for non-abutting sales within a 200 m diameter of any tower. In fact, the number of sales within 100 m of any tower drops from 90 to 39 when abutting properties are removed and there are only 6 within EW_1.

Finally, we turn to the second event window, EW_2, which starts when SCE began its information campaign and ends with the commencement of the tower construction. Results C in Table 5 show the difference–in–differences: none of the negative amenity variables are significant during the time that public information about the towers was available. This is in stark contrast to the price effect when the new towers were in place.

Table 5 The Double Difference Log Price, Δ^2 (log Price), for Various Measures of Proximity to the Transmission Lines

	A	**B**	**C**
Abuts × *EW*	-0.0492**	-0.0310	-0.0149
	(2.38)	(1.52)	(0.49)
Encumbered × *EW*	-0.0829**	-0.0829**	0.0263
	(1.99)	(1.99)	(0.67)
d_{TL} × *EW* [200 m+]			
0-100 m	-0.0316**	-0.0313	-0.0091
	(2.04)	(1.57)	(0.54)
100-200 m	0.0191	0.0189	0.0133
	(1.42)	(1.40)	(1.05)
d_{TW} × *EW* [200 m+]			
0-100 m	-0.0270	-0.0282	-0.0213
	(1.26)	(1.02)	(0.70)
100-200 m	-0.0004	0.0053	0.0125
	(0.03)	(0.36)	(0.98)

Note: Case A: event window EW_1. Case B: EW_1, "abuts" excludes encumbered properties, and d excludes all abutting properties. Case C: EW_2, announcement window. Omitted levels in square brackets. Huber-White *t*-statistics in parenthesis below the coefficient, $*p < 0.1$, $**p < 0.05$.

Of course, the announcement effect could have manifested itself in quantity rather than price, so it is instructive to test for a structural break in abutting (V_A) versus non-abutting (V_{NA}) sales volume during EW_2. Consider the simple time-series regression (Hansen 2000):

$$V_A(t) = \beta V_{NA}(t) + \theta V_{NA}(t) \times EW_2 + e(t) \quad (4)$$

The errors are serially correlated but normal, so we use Huber-White standard errors and a standard Wald test. We find $\beta = 0.0385 \pm 0.0044$ and an insignificant $\theta = 0.0020 \pm 0.0098$, so that we cannot reject the null of no structural break in sales volume during EW_2. A more sensitive test might be to examine time–on–market, for which we currently have no data.

6. Discussion

We have used an event study to examine the revealed price effect on residential properties from an upgrade to high voltage transmission towers that were constructed on an existing ROW. The transaction data cover the periods before and during this window, and allow us to obtain not only a between–subjects comparison (proximate versus not), which is used in most studies in the literature, but also a within–subjects difference (inside versus outside the event window) and therefore a double-difference to control for non-transmission line local effects. From the time line for the project, we can also investigate a potential announcement effect: does public information about construction plans affect value, as opposed to the physical presence of the towers?

We find a significant loss in value from the upgrade for encumbered (8.3%) and abutting (4.9%) properties, and insignificant losses when the older towers were present, even for lots with an easement. These results are consistent with previous studies that show that the price impact is initially large, but diminishes over time. Properties that abut the ROW, but not encumbered by it, suffer a smaller and less significant loss from the construction of the new towers (3.1%). Sales within 100 m of the ROW or nearest tower experience a 3% drop in value which vanishes beyond that distance. However, the result for the most proximate sales is weaker (1-2%) and insignificant if one excludes abutting sales. This illustrates the importance of distinguishing between adjacency or proximity, and a rights taking. Broadly speaking, our results are consistent with findings by other authors: (i) over time, price impact is diminished; (ii) effects vanish beyond about 100 m; (iii) the proximate sales results are largely driven by abutting lots; (iv) encumbered sales are significantly negatively affected; and (v) abutting properties somewhat less so.

We further find no evidence that public information prior to the construction of the towers affected sales prices, even if the property abutted or was encumbered by the ROW: market participants did not impound available information in price over the 3-4 year announcement interval. The information-only window (March 2007 – January 2011) is well defined by court testimony, and also squarely falls in the downturn when seller concessions would have presumably been more easily obtainable. While this result is consistent with the finding of Simons and Saginor (2006) that announcement effects have no significant price impact, it is nonetheless somewhat surprising in light of the large effect from encumbrance during the presence of the new towers, and because many studies suggest that the real estate market is weakly efficient, at least in an economic sense.[25] Before concluding that our results point to inefficiency, more study is needed to determine if they could be explained by a drop in sales volume during the announcement window. While we did not find any evidence of a structural

[25] A subset of market participants do seem to be able to extract excess returns locally, as hinted at in an examination of non–market sales.

break during EW_2, our sample probably contains too few abutting transactions to draw a definitive conclusion. A better test may be to examine the difference in time–on–market compared to distant properties, for which we currently have no data.

The burying of 500 kV cables requires periodic vaults for cooling and venting which are disruptive to immediately proximate home owners, but presumably at a much lower level than towers. A potential future avenue of study would be therefore to examine the price impact of the positive announcement of tower removal (see Simons and Saginor 2006 and McNair and Abelson 2010). Current ongoing construction of the underground transmission line complicates the study, but eventually, transaction volume in the post tower period will be sufficient to investigate the apparent asymmetry between “bad” and “good” announcements as noted by Simons and Saginor (2006).

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