A ground breaking paper: the effect of earthquakes on housing prices in the north of the Netherlands

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Abstract

The largest natural gas field in Europe is located in the north of the Netherlands. Extraction from it has taken place since 1963 at an increasing rate (Bourne et al., 2014). It is well understood that this extraction has induced many small earthquakes in the region due to the soil subsidence it elicited (Ellsworth, 2013). Although they were foreseen to occur with fair certainty before extraction began, to what extent have they affected households in the region has not been convincingly determined yet.

A straightforward way in which earthquakes affect households is through damages they inflict on their houses. This increases housing maintenance costs and induces their market values to drop. Additionally, more frequent and stronger earthquakes could make households feel uneasy given the increasing risk of the house structure becoming compromised. The effect on housing prices can therefore be sourced on both, the anticipation of increasing maintenance costs and the reduced willingness to pay for living in a prone to earthquakes area. In principle, the gas-extracting company (NAM[1]) should compensate for visible damages done to the house's structure, as it is stated in the Mining Act of 2003 (Roggenkamp, 2016). Consequently, anticipating an increase in maintenance should at most partially affect the price due to transaction costs.

Homeowners in the region have as well put forward the claim that housing prices have dropped due to how unappealing living in the area has become. In September 2015, a Dutch court ruled for around 900 private households and 12 housing corporations to be compensated by NAM for the drop in the market value of their houses. The company is supposed to have started compensation schemes for reduced housing prices since then. Moreover, compensations are payed by the Dutch Ministry of Economic Affairs who then holds a claim against the NAM for each compensated household. Therefore, an accurate estimate of the impact of these earthquakes on houses sold in the three northern provinces of the Netherlands is a particularly relevant policy issue.

[1]Nederlandse Aardolie Maatschappij.

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We take on the challenge and estimate the effect that earthquakes have had on housing prices in the region employing space-time specifications of hedonic models for real estate markets. Hedonic models identify the marginal willingness to pay for each characteristic of the house and local amenity provided at its location (Rosen, 1974). Seismic activity associated to a particular area would be considered a price-reducing dis-amenity. Given that compensation for damages has already been in place for many years, any effect found for houses sold before 2015 would be sourced on the reduced willingness to pay by households for living in a riskier place.

This paper contributes to the literature in several ways. Firstly, our econometric models are specified according to the spatio-temporal structure inherent to the data and its consequent cross-sectional dependence. We account for submarket heterogeneity, both discrete (neighborhood level fixed effects) as well as continuous (weights matrix indicating closer and similar houses). Moreover, we explicitly mimic the procedure by which asking prices are set by realtors in the Netherlands, thought to be one of the sources for spatial dependence in housing markets, weighting houses according to their similarity.

Secondly, we explicitly account for the endogenous effects of both, declining population in the region and the time the house has spent on the market. Thirdly, we propose a new continuous measurement for the impact of earthquakes on houses improving on earlier approaches. And finally, we provide with an estimate and measurement procedure to assess the impact of earthquakes on the price of any given house sold within the three northern provinces of the Netherlands, which can readily be employed in compensation schemes for households affected in the region.

Every house is sold within a specific spatial and temporal context. Spatially, it is embedded within a specific neighborhood and surrounded by a particular set of houses. Most differ from each other, but they nevertheless might share some characteristics that arguably make them part of the same sub-market. Moreover, spatial proximity makes them direct competitors for searching buyers which suggests that weak cross-sectional (or spatial) dependence should be present in the data (Pesaran, 2015; Bailey et al., 2015). Accounting for these market segmentations is very important for estimation and prediction in real estate markets (Pace et al., 2000; Smith and Wu, 2009; Füss and Koller, 2016).

Additionally, the time dimension puts the house transaction in a particular set of market conditions which may affect every house price within a certain time frame. This points to strong cross-sectional dependence (common factors), which can be better accounted for by cross-sectional yearly averages for housing price as shown in Halleck Vega and Elhorst (2016). Most hedonic approaches to housing markets, however, aggregate the data by its cross-sectional or time dimension, failing to account for its space-time structure. Moreover, most make no approach to the segmented nature of the market and its consequent spatial dependence, nor the common factors inherent to its time dimension.

We explicitly model the effect on prices of space lagged and predated sales of similar nearby houses. Most realtors in the Netherlands set asking prices by fitting a hedonic model with data on previously transacted houses (Op't Veld et

al., 2007). This is one of the typically argued sources of spatial dependency in the housing market (LeSage, 2014). We therefore construct a spatio-temporal-similarity weights matrix (W_a) that mimics this asking price setting procedure and employ it to structure our econometric specifications, in order to account for the effect of these lagged observations on the transaction price of the focal house.

Additionally, we construct another spatio-temporal-similarity matrix (W_{tr}), which structures observations so that the model accounts for the effect of spatially lagged houses sold between the date in which the focal house was put for sale and before it was sold. Spatio-temporal lags of housing characteristics impact the setting of the asking price, and we distinguish this effect from spatial dependence from spatio-temporally lagged transaction prices. Houses weighted by both W_a and W_{tr}, we define as the focal house's continuous sub-market limited by no artificial boundary. We also control for discrete sub-market heterogeneity by means of neighborhood level fixed effects. We account for common factors (strong cross-sectional dependence) by means of 4 in-sample yearly averages: the average price for houses sold in any of the largest cities in the region (Assen, Groningen, and Leeuwarden); and price averages for houses sold in each of the country-sides of the provinces in the sample namely, Drenthe, Friesland, and Groningen.

We make use of very detailed data on nearly 250.000 transactions spanning between 1993 and 2014 in the three northern provinces of the Netherlands. Besides transacted prices, we have data to control for several characteristics of the house and neighborhood. Additionally, we attempt to control for the endogenous population decline at the neighborhood level, which is a very distinctive feature of this northern region, as well as the time spent on the market employing as instruments their lags in space and time.

As in previous studies, the measure on which we rely to approach an earthquake's effect is its Peak Ground Velocity (PGV) at each house's geographical location (latitude and longitude). However, we depart from previous literature by accumulating the PGV received from every earthquake prior to the house sale, rather than counting those that could be felt as recently done by Koster and van Ommeren (2015). In practice, we construct a continuous variable that identifies the intensity with which each earthquake has reached any house in the region until its transaction date.

We find very significant and negative effects for the total PGV received by the house from every earthquake occurring previous to its sale, as well as for the total PGV hitting the house during the year prior to its sale, as well as for the historical average PGV received by houses previously sold in the same neighborhood. The latter measure provides the best fit and hence, we determine that an increase of 1% in the neighborhood's historical average PGV reduces the house price in around 4%, ceteris paribus. Additionally, we find significant spatial effects in the form of global spillovers from prices at which similar houses were previously sold, which increase the overall earthquakes' effect. On average, these continuous sub-market spillovers add a 0.5% marginal reduction to the house price.

Our estimations are robust to a series of different spatial hedonic specifications. Moreover, we find that effects from earthquakes that can be felt at the house location, as studied by Koster and van Ommeren (2015), are much smaller once spatial effects are accounted for.

Keywords: Housing prices, spatial hedonic model, earthquakes.
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