

Earthquakes and Property Prices: a Literature Review

Extended abstract

The province of Groningen in the Netherlands suffers from earthquakes caused by the production of natural gas. One important consequence may be a negative effect on house prices. This paper presents an international literature review on the effects of (the risk of) earthquakes and other natural disasters on house prices.

Selection of studies

In the literature, a large number of studies on effects of earthquakes, other natural disasters and risk of natural disasters on house prices can be found. Not all this literature seems equally relevant for answering the question what the effects are of earthquakes and earthquake risk on house prices in Groningen. Therefore, there is a need to restrict the literature review in several respects. First, the study only reviews empirical results. The most relevant research pertains to (the risk) of earthquakes. Other natural disasters are interesting if they are also caused by human actions, like the earthquakes in Groningen. Research in the Netherlands is – *ceteris paribus* – more relevant than research in other countries because housing markets may vary considerably across countries. However, this does not imply that it is not possible to draw lessons from other countries. A criterion is that the situation in these countries (for example, with respect to the housing) is comparable to a sufficient degree to that in the Netherlands. Finally, the quality of the research is of interest. Publications in peer reviewed journals are preferred over research reports.

In summary, the ‘ideal’ empirical study has the following characteristics:

- A study of effects of (risk of) earthquakes ...
- caused by human activity ...
- on house prices ...
- in the Netherlands ...
- published in a peer reviewed journal.

If we apply these criteria simultaneously, only one study remains (Koster and Van Ommeren, 2015). For this review studies have been selected that differ by no more than two of the criteria mentioned. Studies published until February 29, 2016, are included. This provides a selection of 24 studies.

Results

In the paper, each study is summarized briefly. The emphasis is on effects on house prices in the period following a natural disaster or after a related event such as the introduction of government measures. We provide information about the severance of the natural disasters involved, the types of effects that have been estimated, and the size and (statistical) significance of the effects. Also, attention is also paid to limitations mentioned by the authors of the publications.

In an Annex (included in this abstract), we provide an overview of the studies, including key characteristics and findings including the type of natural disaster, the country where it occurred, the observed effect and the research method.

Findings

House prices in earthquake zones are strongly affected by (subjective) perceptions of earthquake risks. These perceptions are not only determined by the actual (objective) risks but also by information provision and earthquakes that have occurred in the past.

The international literature shows that especially subjective perceptions of the earthquake risks affect house prices. Earthquakes that occur or have occurred recently may affect risk perception. Research in Japan shows that owners estimate the effect of earthquakes on house prices as being twice as high as before after a (heavy) earthquake in a nearby area (Naoi et al., 2009). Research into advertised property prices in Istanbul suggests a similar effect after an earthquake in eastern Turkey in 2011 (Keskin & Watkins, 2014). Beron et al. (1997) show that the perceived (subjective) risk declined after an earthquake occurred in California.

Another study on house prices in California shows that the negative impact of earthquake risks in prices occurred only after active communication that the location of the property was in an earthquake risk area (Brookshire et al., 1985). Later research in the same region provides a similar conclusion (Bernkopf et al., 1990). According to this study, warnings from the government about earthquake risks had an impact on the perception of risk, and thus on the property values estimated by homeowners.

Both the perceived risk of earthquakes and its impact on the development of land and house prices fluctuates over time.

According to a study on the effects of (heavy) Wenchuan earthquake in China, the effect of an earthquake on the risk perception disappears completely over time (Deng et al., 2015). This conclusion is reached by mapping price differences between homes in different floors of residential towers. After the earthquake the relative price of top floor houses dropped. However, this effect disappeared after a year. The researchers compare this effect to reactions seen in stock markets after an unexpected event. In the Netherlands Bosker et al. (2015) estimate a negative impact of 3 percent on house prices of earthquakes after a relatively large earthquake. However, after government pledges to compensate the region, no significant effect could be found any more.

Media attention can affect the perceived risk of earthquakes and (therefore) house prices.

Beron et al. (1997) analyse the effects of the (heavy) Loma Prieta earthquake in California in 1989. They conclude that both the earthquake itself and media coverage that followed had implications for risk perception. People were initially inclined to overestimate the risk, but over time they adapted their views on the basis of new information.

Other researchers observe an increase in risk consciousness under the influence of media coverage. For example, a study of advertised house prices in Istanbul in the period 1995-2000 indicates that the negative impact of earthquake risks on the risk perception increases as the media report about an earthquake (Önder et al., 2004). Apparently, under the influence of media coverage a (heavy) earthquake in 1999 in a nearby province has increased awareness of the risks of earthquakes.

Risk-reducing measures and financial compensation result in higher house prices. Additional employment opportunities in the area can also positively affect house prices.

Nakagawa et al. (2009) show that measures against physical risks (collapse) reduce price differences between areas of high and low earthquake risk in Tokyo between 1980 and 2001. These differences went up in periods in which a lot of people indicated in surveys that they were worried about

collapse. These differences decreased when anxiety stabilised. The researchers suspect that this effect was due to preventive measures following a major earthquake in 1995.

Other research shows that risky human actions may also cause positive effects on house prices. Muehlenbachs et al. (2015) investigate shale gas drilling in Pennsylvania, causing a risk of groundwater pollution. On the other hand, home owners can claim royalties and gas drilling increases employment. These positive effects appear to have a dampening effect on the negative effects of shale gas drilling on house prices. Another study on shale gas extraction attempts to measure the effects of employment separately (Bennett & Loomis, 2015). This leads to indications that extra employment increases house prices.

Relatively large effects of earthquake risks on house prices are found in studies using survey data or other estimated house values. If realized sales prices are being used, the effect is usually smaller.

In Iran a survey among real estate brokers showed a 15 percent price difference between new homes with and without earthquake mitigation measures (Willis and Asgary, 1997). The effect of risks of strong earthquakes on house prices in Japan and California was estimated in surveys among owners to be minus 8.2 percent to minus 13.5 percent (Naoui et al., 2009; Bern Knopf et al., 1990). These effects are large compared to studies that measure the impact of risks of similar-size earthquakes on actual sales prices. These effects range from minus 2 percent and minus 6 percent (Beron et al., 1997; Brookshire et al, 1985. Murdoch et al., 1993; Deng et al, 2015.). The large effects in surveys also again underline the importance of subjective perceptions in assessing the effects of earthquakes.

The earthquakes in the northern Netherlands are relatively light compared to the earthquakes in other countries in the literature. Accordingly, measured price effects in the Netherlands are smaller (approximately 2 percent) or not statistically significant. The price effects of earthquake risks seem to be smaller than those of the risk of flooding.

International research is focused on areas which face (the risk of) much more severe earthquakes than Groningen in the Netherlands. Almost all studies pertain to tectonic earthquakes, not earthquakes by gas drilling. The price effects measured in Groningen are at the lower end of the spectrum of estimates in the literature. Bosker et al. (2016) estimate a net average price effect of about minus 2 percent. Statistically insignificant effects emerge in Francke and Lee (2013, 2014) and CBS (2015). According to CBS (2015) it cannot be said with certainty that house prices in the risk area have developed less favourably than in a reference area without earthquakes.

In the Netherlands, the risk of flooding may have a much greater impact on house prices than the risk of earthquakes. The price effect of floods risk varies from about minus 1 percent (Bosker et al., 2013) to minus 9 percent (Daniel et al. 2009).

Conclusion

International literature shows that the risk of earthquakes and actual earthquakes may have a measurable negative impact on house prices. This effect seems to be related to the size of the risk, but is moderated by pre-emptive measures to reduce risks, mitigating measures, media attention, the passage of time and in some cases by other, positive economic effects of risky activities.

Annex 1 Summary table (this table will be translated in English)

Studie	Effect van	Ernst van de beving(en) ¹	In land	Effect op	Grootte effect	Methode	Overige bevindingen en opmerkingen
Aardbevingen: Artikelen in wetenschappelijke tijdschriften							
Koster en Van Ommeren (2015) (VU)	Aardbevingen	Licht	Nederland	Woningprijzen	min 1,9%	Gerealiseerde verkoopprijzen	Het betreft het effect per aardbeving. Tot 2001 is het effect 0%, 2002-2007 min 1,7% en 2008-2013 min 1,9%.
Koster (2016) ² (VU)	Aardbevingen	Licht	Nederland	Woningprijzen	min 1,6%	Gerealiseerde verkoopprijzen	Het betreft het effect per aardbeving. Het effect op de woningprijzen van één procentpunt meer woningen met schade in het postcode-4 gebied waar de woning in ligt is min 0,2%.
Deng et al. (2015)	Aardbeving 2008	Zwaar	China	Prijzen appartementen	4,4%	Gerealiseerde verkoopprijzen	Prijsverschil (van 4,4%) tussen appartementen op 1 ^e of 2 ^e verdieping versus 7 ^e verdieping op hoger. Prijsverschil verdwijnt ongeveer een jaar na de aardbeving.
Nakagawa et al. (2009)	Aardbevingsrisico	Krachtig	Japan	Grondprijzen	0 tot min 11%	Gerealiseerde verkoopprijzen	Prijsverschil hoog/laag risico grond. In 1980 nog geen effect, min 11% voor hoogrisico grond in 1994. Min 7% in 2001, mogelijk als gevolg van preventie.
Naoi et al. (2009)	Aardbevingsrisico (na aardbeving dichtbij)	Krachtig	Japan	Woningprijzen	min 13,5%	Door woningeigenaren ingeschatte waarde	Aardbevingsrisico werd in eerste instantie overschat door consumenten. Na aardbeving weegt aardbevingsrisico zwaarder in de woningprijs.
Önder et al. (2004)	Afstand tot breuklijn (na aardbeving)	Zwaar	Turkije	Woningprijzen	Niet bekend	Geadverteerde verkoopprijzen	Negatief effect van aardbevingsrisico (afstand tot breuklijn en bodemtype) is na de aardbeving toegenomen. Beperkte set controlevariabelen.
Beron et al. (1997)	Aardbevingsrisico (na aardbeving)	Zwaar	Californië	Woningprijzen	min 4,1 tot min 6,4%	Gerealiseerde verkoopprijzen	Aardbevingsrisico werd in eerste instantie overschat door consumenten. Na aardbeving weegt aardbevingsrisico minder zwaar in de woningprijs.
Willis en Asgary (1997)	Aardbevingsrisico reducerende maatregelen	Zwaar	Iran	Woningprijzen	15%	Enquête onder makelaars	Betreft nieuwbouwwoningen met en zonder aardbevingsrisico reducerende maatregelen. Met aardbevingsrisico reducerende maatregelen is de geschatte prijs 15% hoger
Kawawaki en Ota (1996)	Aardbevingsrisico	Krachtig	Japan	Woninghuren	Plus 11%	Geadverteerde huur- en verkoopprijzen	In de maanden na de aardbeving is een stijging waarneembaar van woninghuren, na een jaar verdwijnt dit effect. Geen effect gevonden op woningprijzen.
Murdoch et al. (1993)	Lokaal risicolabel	Zwaar	Californië	Woningprijzen	min 3,7%	Gerealiseerde verkoopprijzen (met referentiegebieden)	De Loma Prieta aardbeving leidde tot een gemiddelde woningprijsdaling van ongeveer 2%.
Bernknopf et al. (1990)	Waarschuwingen aardbevings- en vulkaanrisico	Krachtig	Californië	Woningprijzen	min 8,2 tot min 11,4%	Door woningeigenaren ingeschatte waarde	Waarschuwingen hebben niet alleen invloed op woningprijzen, maar ook op de risicoperceptie.
Brookshire et al. (1985)	Lokaal risicolabel	Zwaar	Californië	Woningprijzen	min 3 tot min 5,5%	Gerealiseerde verkoopprijzen (met referentiegebieden)	Het effect is pas zichtbaar na actieve communicatie over het risicolabel.

¹ In deze notitie duiden we aardbevingen tot kracht 3,9 aan als licht, van 4,0 tot 4,9 als gemiddeld, van 5,0 tot 5,9 als vrij krachtig, 6,0 tot 6,9 als krachtig en 7,0 tot 7,9 als zwaar.

² Deze studie is niet gepubliceerd in een wetenschappelijk tijdschrift maar is op deze plaats opgenomen in verband met de relatie tot Koster en van Ommeren (2015).

Aardbevingen: Onderzoeksrapporten							
Bosker et al. (2016) (Atlas voor gemeenten)	Aardbevingsrisico	Licht	Nederland	Woningprijzen	min 2%	Gerealiseerde verkoopprijzen (met referentiegebieden)	Betreft het netto effect van imago, bevingshistorie en schadecompensatie tezamen.
Bosker et al. (2015) (Atlas voor gemeenten)	Aardbevingsrisico	Licht	Nederland	Woningprijzen	min 2%	Gerealiseerde verkoopprijzen (met referentiegebieden)	Periode tot januari 2014 is het effect min 3%. Periode na januari 2014 geen significant effect.
Groetelaers en De Wolff (2016) (OTB)	Risico's vergelijkbaar met aardbevingsrisico	n.v.t.	Wereldwijd	Woningprijzen	n.v.t.	Diverse methoden	Betreft een literatuurstudie. Relevante conclusies voor de Groningse situatie met betrekking tot verschil tussen risico en risicoperceptie, het feit dat de prijsdaling groter kan zijn dan schade alleen en de impact van herhaaldelijke rampen (in contrast tot eenmalige rampen) op de prijsvorming.
CBS (2015)	Aardbevingsrisico	Licht	Nederland	Woningprijzen	Niet significant	Gerealiseerde verkoopprijzen (met referentiegebieden)	Alternatieve indicatoren wijzen op een ongunstigere woningmarkt ontwikkeling in risicogebied.
Francke en Lee (2014) (Ortec)	Fysieke schade door aardbevingen	Licht	Nederland	Woningprijzen	Niet significant	Gerealiseerde verkoopprijzen (met referentiegebieden)	Alternatieve indicatoren wijzen op een ongunstigere woningmarkt ontwikkeling in risicogebied.
Francke en Lee (2013) (Ortec)	Aardbevingsrisico	Licht	Nederland	Woningprijzen	Niet significant	Gerealiseerde verkoopprijzen (met referentiegebieden)	Geen aanwijzingen dat de woningmarkt zich in het risicogebied anders ontwikkelt.
Keskin en Watkins (2014)	Aardbevingsrisico	Zwaar	Turkije	Woningprijzen	Niet bekend	Geadverteerde woningprijzen	0,16 tot 0,20% lagere woningwaarde per extra procent kans op (ernstige) aardbevingsschade. Effect groter na aardbeving in een ander deel van Turkije.
Andere door menselijke activiteit veroorzaakte natuurrisico's: Artikelen in wetenschappelijke tijdschriften							
Muehlenbachs et al. (2015)	Schaliegasboringen	n.v.t.	Pennsylvania	Woningprijzen	min 6,5% tot min 13,9%	Gerealiseerde verkoopprijzen	Effect geldt voor woningen die grondwater gebruiken, geen leidingwater. Er zijn ook positieve effecten door royalty's, werkgelegenheid, bestedingen, uitbreiding van voorzieningen en verbetering van de lokale overheidsfinanciën.
Bennett en Loomis (2015)	Schaliegasboringen	n.v.t.	Colorado	Woningprijzen	min 1%	Gerealiseerde verkoopprijzen	Het effect doet zich voor in de periode dat de bron wordt geboord en verdwijnt vrijwel geheel zodra de bron in productie is. Er zijn indicaties dat additionele werkgelegenheid een positief effect heeft op de woningprijzen.
Gopalakrishnan en Klaiber (2013)	Schaliegasboringen	n.v.t.	Pennsylvania	Woningprijzen	min 2,1%	Gerealiseerde verkoopprijzen	Betreft het effect van een boorput binnen 0,75 mile van de woning. Voor woningen afhankelijk van grondwater loopt het effect op tot min 20 procent.
Andere natuurrisico's in Nederland: Artikelen in wetenschappelijke tijdschriften							
Bosker et al. (2013)	Rivieroverstromingen	n.v.t.	Nederland	Woningprijzen	min 1%	Gerealiseerde verkoopprijzen	Het effect is groter (min 2%) voor gebieden die daadwerkelijk ervaring hebben met (concrete dreiging van) overstromingen en gebieden met risico op een overstromingsdiepte van meer dan 50 centimeter.
Daniel et al. (2009)	Rivieroverstromingen	n.v.t.	Nederland	Woningprijzen	min 9%	Gerealiseerde verkoopprijzen	Mediane effect in wetenschappelijke literatuur is circa min 7,5%. Ligging nabij water heeft los van overstromingen een positief effect van 3%.