# Environmental Hazards: The Micro-Geography of Land-Use Negative Externalities

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**Abstract**

The decisions on the siting of hazardous facilities and compensation for nearby landowners depends on an accurate estimation of the negative externalities these facilities place on proximate land uses, primarily residential properties. In this paper we highlight the sensitivity of these estimates to the treatment of distance from the hazard and to the presence of other nearby land uses identified at a highly granular geographic level. Recent opposition to the expansion of North American pipeline capacity has been intense, mixing concerns about climate change, environmental damage, and local opposition to the physical presence of pipelines in their neighbourhoods. This paper studies the disamenity effects associated with the last factor. In doing so we generate results that more broadly address the specification and left out variable bias challenges of measuring the capitalization of negative location-specific environmental externalities. The key contributions of this paper are first showing that disamenity effects can be highly localized and easily susceptible to errors with parametric specifications. Second, that the magnitude of the effect on house prices arising from proximity are sensitive to land uses that are not the hazard in question, but whose presence may be correlated with the hazard. And third, that negative news about a hazard increases the assessment of risk and lowers nearby house values, but that this effect is temporary. We find that the quantitative effects of proximity to oil pipelines are relatively small: prices are lower by 5.7 percent ($39.3k) for properties with a pipeline easement, 2.1 percent ($14.4k) lower for those properties adjacent to a property with an easement, and 1.4 percent ($9.6k) for those adjacent to the former, one property further away from the pipeline. Though this last result is sensitive to specification choice. The prices of all residential properties further away from the pipeline in our data are unaffected. When expressed in cardinal distance, only the prices for residential properties within 100 meters of the pipeline easement are affected. The findings here suggest that care and flexibility with functional forms, the perception of hazards, and attention to land use contexts is necessary for an analysis of the negative externalities for residential property associated with proximity to environmental disamenities and that simple parametric treatments are highly likely to result in biased estimates.

JEL Codes: Housing Demand (R21), Valuation of Environmental Effects (Q51), Government Policy (Q58), Other Spatial and Pricing Analysis (R32)

# 1 Introduction

The increase in oil production in North America has to led to proposals such as Dakota Access and Keystone XL in the US, and Energy East, Northern Gateway and Trans Mountain expansion projects in Canada to move oil from North Dakota and Alberta to ports and refineries elsewhere on the continent. The greater part of the opposition has targeted the role of pipelines in abetting fossil fuel use and its effects on climate change, but along the proposed pipeline paths there has also been significant local opposition motivated by concern over the environmental risk from pipeline spills. A policy program for evaluating the routing and viability of a pipeline depends on an accurate assessment of the negative externalities associated with a pipeline. This paper uses a variety of static hedonic and dynamic event study methodologies to estimate the capitalization of this latter effect on residential property values.[1] Compared to existing work on the capitalization of environmental hazards, our use of a large data set of transactions from a dense suburban area along a 42 km stretch of pipeline in the Vancouver, BC Canada metropolitan area allows us to apply more precise and detailed treatments of location relative to the pipeline alignment and account more completely for the variety of externalities in the land use fabric than is the case in existing work. We find that the simple parametric treatments of proximity in the existing literature are likely to suffer from both specification and left-out variable bias. The former occurs because proximity effects may be highly localized making more naive continuous parametric treatments of distance inappropriate. The latter results from the correlation in geographic space between environmental hazards and other land uses that also impose externalities on nearby residential land uses. The other contribution of this paper is in parsing the effect of new information regarding a hazard, differentiating between a reminder of the risk imposed by the environmental hazard and a reminder of its presence.

A consistent, reliable framework for assessing the effects of environmental externalities is neces-

[1] The data for this paper were collected as part of a consulting project for Kinder Morgan examining the effects of oil pipelines on the values of nearby residential property values. This report is available from Canada's National Energy Board as filing 2015-08-20 Trans Mountain Pipeline ULC B417-28 - Reply_Evidence-Appendix _9A-Landowner_Compensation - A4S7H5

sary for appropriate cost-benefit analysis on facility siting and compensation for spills, leaks, and other hazardous discharges. The existing literature on the effects of proximity to environmental hazards on residential property values is highly varied and does not offer clear guidelines for assessing the magnitude of externalities. This is in part because the nature and awareness of hazards differ dramatically between hazardous waste sites, high-voltage powerlines, landfills, leaking oil storage tanks, and gas and oil pipelines. In general, work on pipelines tends to find no effect of proximity on residential property values. However, new information about the reminder of risks as well as pipeline construction does in some studies result in lower values than what would otherwise hold for nearby properties. We add to this literature and help explain possible reasons for the patchwork of results in existing work. We take advantage of a far richer data set, both in terms of the volume transactions, controls for externalities from a variety of other non-residential land uses, and the use of very fine-grained treatments for distance than in previous work.

We find that pipeline proximity results in lower property values, but only for the most immediately adjacent properties. Properties with a pipeline easement sell on average at a 5.7 percent ($39.3k at the mean) discount, while those properties adjacent to the easement property sell at a 2.1 percent ($14.4k) lower price. Houses on the next furthest lot have a discount of 1.4 percent ($9.6k).[2] Properties further away are unaffected. However, these results are sensitive to the type of land use through which a pipeline passes. The residential property adjacent to the the pipeline easement is 3.5 percent lower when the pipeline is located on a non-residential land use as compared with only 1.6 percent lower when the land use is residential or open space. In comparison, parametric distance specifications are quite sensitive to regression form and included variables. In our data a simple linear distance measure enters positively, but its estimated coefficient is not statistically different from zero if the specification controls for properties that have an easement on them. Better treatment of other highly local non-residential land uses reduces the coefficient point estimate by 25 percent. Finally, when we control for distance in a less parametric fashion, we find that distance

[2]Properties within 100 meters and not on the easement have a 1.2 percent lower value. 80 percent of these are the properties adjacent to or one further away from the easement.

only matters within 100 meters of the pipeline. In contrast continuous measures force the effect to fit all of the properties, potentially underestimating the pipeline effect for nearby properties and overestimating it for those more distant.

Using the same data and specification we also test for the effects of new information about risks on capitalization. The particular contribution we make is differentiating between news that reminds buyers of risks as compared with news that reminds them of the presence of a hazard. The pricing of risk should reflect the expected negative effects, the likelihood of an negative event occurring, but both are contingent on an awareness of the presence of the hazard. We conduct two difference in difference event studies, one for a well-publicized localized spill along the pipeline in the study area, and the second for the announcement by the pipeline's owner of a proposal to twin the pipeline and nearly triple the pipeline's capacity. We treat the former as a reminder of the risk associated with the pipeline and the of the presence of the pipeline. We understand the information embedded the second news event to be limited to a reminder of the presence of the pipeline. In the six months following the spill, transaction prices for properties within 250 meters of the pipeline away from the spill site were 5 percent lower than those further away.[3] However, this difference disappears by nine months. In contrast, just the reminder that there is a pipeline is not enough to affect prices: there is no change by location relative to the pipeline alignment in transaction prices following the expansion announcement.[4]

The contributions of this paper to the literature on the effect of environmental risks on house values in general and the effect of pipelines in particular lie in several areas. First, we present more detailed and precise measures of proximity at a very localized level than are found in other papers. Second, we address the land use context of the pipeline easement itself and identify its critical influence on the estimated effect of pipeline proximity on home value. The more general implication is that non-random distribution of land uses near hazards can bias the estimated proximity effects.

[3]The properties that experienced contamination did not sell so we did not estimate the direct effect of contamination.

[4]Pipeline are buried and there presence is not necessarily known to those nearby. It is possible that the announcement had no effect because buyers discounted the likelihood the proposed expansion would be allowed.

Finally, using the same data we take advantage of two different kinds of shocks to awareness of the pipeline's presence and the possible risks to see whether increase in both affects prices. These are in addition to the narrower value of better identifying the effect of oil pipelines on nearby residential property values.

The paper follows the standard framework. Immediately below is a brief review of the existing literature on the capitalization of environmental risks, primarily for oil pipelines, on house prices. This is followed by a description of the oil pipeline in question, the geography of proximity, and the transaction data we use in this paper. Finally we present the empirical tests of the effects of pipeline proximity and information shocks, the first a spill on the pipeline and the second expansion announcement, on house prices.

# 2 Literature Review

There is an extant literature that explores the effects of proximity to oil and gas pipelines on house prices. This research is part of the more general literature on the negative externalities of environmental hazards that measures the size of these effects through the relationship between exposure intensity in geographic space and the prices of residential real estate. This literature covers a very broad range of work on environmental externalities. Surveys of this literature include review papers by Farber (1998), Boyle and Kiel (2001), Jackson (2001), Braden et al. (2011) and Sigman and Stafford (2011). Their reviews cover papers on the effects on quality of life and risks to persons and property from a wide range of undesirable land uses (e.g. hazardous waste sites, power lines, landfills, incinerators, and pipelines) as measured through a hedonic house price equation with the inclusion of a measure of proximity to the hazard as a right hand side covariate. The methodologies range from simple static hedonic pricing equations to event studies or difference in differences approaches. With the the latter, the natural experiment is either some new information about the risk of the hazard or change in its status, such as approval, construction, start of operation, closure, finding of hazard, or remediation. Overall, it is hard to draw specific conclusions about the nature of proximity due to the varied nature of the externalities associated with each of the different types of environmental hazard studied in these works and the wide variation in the degree to which papers address surrounding land uses, the distances over which effects are estimated, and the problem of non-random location of hazardous sites. For example, the findings of the hazardous waste site literature suggest that house prices fall with proximity to the noxious location, but not always as the effects are sensitive to other nearby land uses and neighbourhood features.

Within this broad group of work, two streams of research more directly inform the research presented here. The first examines the explicit effect of oil pipelines (and relevant effects of gas pipelines), on nearby properties. These papers primarily use a static hedonic analysis methodology, regressing property value against distance to the pipeline and a set of structure and lot characteristics. The second studies the economic impact of proximity following some news regarding the risk of the pipeline, either a spill on the pipeline under study or news about spills in general, both of which might be expected to heighten awareness and increase the magnitude or the duration of the associated price effects. This type of information shock or new information about the presence of a pipeline is likely to be especially important for pipelines because the presence of pipelines is not necessarily known to buyers. While environmental disamenities such as high voltage transmission lines, industrial facilities, and landfills can be seen or have a sensory impact on nearby properties (e.g. air quality, noise, visual), pipelines do not, as they have little visual presence and, unless there is a leak or spill, entail no ongoing harm to nearby properties. The concern with pipelines is the risk of a catastrophic incident that results in loss of property value or complete loss of use due to contamination, quality of life or, in the case of gas pipelines, injury or death because of an explosion. Since the risks posed by pipelines are limited to the risk of an accident, measuring the effect of proximity to oil pipelines on residential prices helps to parse the mix of impacts associated with different types environmental hazards.

The risk to property from a pipeline rupture is non-trivial, with partial losses from nearby oil contamination on a property exceeding ten percent and for significant oil contamination a complete loss of use.[5] The most consistent work in this area comes from studies that examine the impact of contamination arising from leaking from underground oil storage facilities. For example, Simons et al. (1999) find loss of value from contamination of nearby soils to be between 14 and 16 percent. Zabel and Guignet (2012) relate house prices to publicized and unpublicized sites with leaking storage facilities. They find that only sites where the contamination is well known have proximity effects in the absence of known contamination, where these negative effects can exceed 10 percent. There is a need to perhaps differentiate between oil and gas pipelines. The spills of the former can lead to contamination and loss of use, while the latter do not, with effects dissipating rapidly. Spills and ruptures of the former do not represent an immediate risk of injury and death, while the risk of an explosion is acute with the latter.

In a survey on gas pipelines, Wilde et al. (2013) report no evidence of proximity price effects in the academic and professional appraisal literature, either for proximity in general or in the aftermath of ruptures.[6] Even a more extreme form of pipeline risk manifests little pricing risk. In Boxall et al.'s (2005) study of gas wells and pipelines in rural Alberta, the case of sour gas is examined. Sour gas is both more noxious and more dangerous if released than conventional natural gas, gasoline, or crude oil.[7] Pipelines appear to be associated with negative values, but this is likely a left-out variable problem. Contingent on the presence of sour gas wells, the presence of pipelines does not result in a further erosion in value. Three general problems with this type of static analysis are: awareness of the presence of the hazard, and then methodological hazards may be located in lower land value locations, and they may also be associated with negative externality land uses for reasons that are distinct from the specific hazard. For example, if for purposes of cost minimization

[5] While property owners typically receive compensation for the loss in value, the value of a property may be impacted well into the future as a result of ongoing stigma.

[6] For example, Kinnard Jr et al.'s (1994) hedonic study on gas pipelines and Diskin et al.'s (2011) matched-pair appraisal of properties adjacent to gas pipeline right-of-ways in three Arizona suburban subdivisions, both fail to find a negative relationship between pipeline proximity and residential sales prices.

[7] Health and safety risks associated with sour gas facilities represent a special hazard regulations requiring minimum setback distances between sour gas and oil facilities and residential land uses. In addition to setbacks, emergency plan response zones (EPZs) are established around sour natural gas facilities, the size of these zones can range up to several kilometers and the size is related to the maximum potential volumes or rates of release of gas. More more information see Boxall et al. (2005)

the original pipeline was laid through lower cost land, the factors that made that land low priced may also cause residences built in the area to be lower priced. Thus, proximity to the pipeline is correlated with lower house prices, but because of a third factor that attracted the pipeline to the location.

Using changes in information is common in other research on hazards, where hopefully the difference in differences methodology reduces problems with left-out variable bias from a hazard's non-random location and the effects of other unmeasured land uses. These studies examine either [1] changes in information regarding the presence of a hazard or [2] changes in the extent of the risk as environmental remediation occurs. For example, Dale et al. (1999) find that at a broad metro level, the price of houses near a shutdown lead smelter rose faster than elsewhere after both the closure and completion of environmental remediation. McCluskey and Rausser (2003) measure local house prices following the decommissioning of a hazardous waste incinerator. They find that the negative impact on housing prices arising from proximity to the incinerator dissipated after the closure, but only slowly. The inverse to these natural experiments is the siting and construction of a new facility. Kiel and McClain (1995) demonstrate that the expected negative proximity price effects from a rumoured, then proposed, then constructed, and finally operated garbage incinerator were only manifested during the construction phase. What is more, this discount partially diminished after ongoing operations commenced. Together, these findings suggests that house prices do respond as expected to new information. However, the revelation of new information seems to occur slowly, and is stronger during negative market conditions (Case et al., 2006). Studies of oil pipelines have used the effect of spills on un-contaminated properties in order to address the same problems with identification.

The absence of visual clues to their presence may mean that no proximity effects of pipelines reflects an information failure: buyers do not know they are present so they do not discount house values for nearby units. This can be overcome by news about the pipeline, particulary if there is a rupture. Spills convey two types of information. First is the presence of risk, by serving as a reminder of the pipeline's existence. Second, a spill conveys information on the magnitude of risk, depending on the severity of the spill event. Researchers have used a spill along a given pipeline as a natural experiment to test for the effect of pipeline proximity. For instance, studies such as Simons (1999) evaluate changes in the relative value of properties located away from a spill site along the pipeline easement after a spill. That paper finds that following a spill on the Colonial Pipeline in Fairfax County Virginia, the value of properties along the easement elsewhere in the same county experienced a 4.3-5.5 percent drop. [8] A second similar paper (Simons et al., 2001) where the spill affected local waterways found short run price declines as high as 11 percent in a small sample of houses on the polluted waterway. Other work on the impact of oil spills over time finds a rather quick dissipation of the negative effect on prices. The Deepwater Horizon oil spill off the Gulf Coast resulted in only temporary negative effects on coastal house prices: they returned to pre-spill levels within 101 days in Siegel et al. (2013) and no lasting statistically significant effects on sales volume or price levels in Winkler and Gordon (2013).

Work by Hansen et al. (2006) finds that in the absence of an information shock, there are no negative proximity effects from pipelines. Using a highly concave inverse distance specification, they find that prior to the rupture and subsequent explosion on the Olympic Pipeline, there was no relationship between distance to either pipeline and house prices in their data. However, following the explosion, which because of the tragic deaths of an adult and two children in a park adjacent to the rupture, was extremely well-known, properties 50 feet from the Olympic Pipeline were an estimated 5.5 percent lower than properties beyond 1,000 feet from the pipeline. Interestingly, there was no effect on the properties adjacent to a second oil pipeline that did not experience a rupture and thus lacked apparent "stigma" or remained unknown. The negative price effect reported was transient in its nature. The discount at which properties within 100 feet of the pipeline traded following the accident declined by 18 percent between 6 months and a year after the event, and by 27 percent after two years.[9]

[8] He does not report whether this effect dissipates with time, and furthermore the number of transactions in the easement after the spill is quite small, 76 over a four year period.

[9] It is worth noting that very few sales, about 110 occurred within 300 feet (approx. 90m) of the pipeline over the

The Hansen et al. (2006) study highlights the importance of new information but does not explicitly model the dynamics of information flow, relying on just a before and after. McCluskey and Rausser (2001) test for the effect of the volume of local media information on the perception of risk and find an explicit relationship, though they do not tie this to proximity. The same conjecture, that negative effects depend on information is explicitly tested by Freybote and Fruits (2015). They examine how proximity to a gas pipeline is affected by perception of risk. To measure risk they include a fixed effect that takes on the value of one if a pipeline explosion with fatalities was reported in the news in the same month as the transaction. They study a high pressure gas line over a 14-year period in ex-urban Oregon. Their findings suggest that property values increase by 0.8% per foot in distance when there is a media report of a pipeine explosion that resulted in death elsewhere in the transaction month during the construction period but none during operation. The magnitude is of concern given the specification as a property 100 feet further away would have an eighty percent higher price whther if it was adjacent to the pipeline or one mile away. An attractive feature of the data used in the paper is that it covers transactions observed prior to the construction, during the construction, and afterwards. The negative effect only appears during construction when the presence of the pipeline is more perceptible. Similarly, Kask and Maani (1992) find that negative price effects from pipelines only occur during the construction phase, when the presence is apparent, but once the pipeline is buried and operational there is no effect.

Three papers of note address issues in specification and left-out variable bias in ways that relate directly to our paper. In general the papers on proximity effects look at large areas and model distance with a very simple monotonic parametric measure. Even if there is a specification that allows for non-parametric relationships, for instance using fixed effects for distance bands, the minimum distance are typically at least a quarter mile. An exception is François (2002) who models the effect on house prices of proximity to high voltage power lines with a high degree of granularity and allows for a highly flexible specification. He finds that price effects are sensitive to distance, direction, and the extent of visual awareness in ways that are not explicitly linear.

multi-year analysis.

For many locations of environmental disamenities there can be other land uses that are considered undesirable. Failure to account for them will result in a left-out variable problem, that biases the coefficient on proximity away from zero. Taylor et al. (2016) correctly observe that sites with environmental hazards are also typically located near other land uses that may impose negative externalities on residential properties. They then account for this by including properties with a similar land use, but without a hazard in their empirical analysis. They find that the mix of commercial properties with negative effects on residential properties and sites with environmental risk have an additive effect on nearby residential land uses. Furthermore, they find that clean-up and remediation is not fully capitalized, and that a stigma effect remains. Work by Redfearn (2009) very clearly shows the problem with parametric treatments of distance. Using a semi-parametric specification, distance becomes a highly non-parametric factor that varies by direction as well as distance. Our treatment is not as general as Redfearn's in part because our effects are much more localized than his study of the value of access to rail transit stations.

The existing literature suggests that in general there are no effects of proximity to a pipeline on house values. When a spill has occurred, units closer to a pipeline, even if they are not contaminated, have lower values. There are a number of problems with these studies. First, pipeline work studies a small geographic area or uses relatively few transactions, which in turn may be quite heterogenous. Second, they do not adjust for the nature of the pipeline's easement, where distance from green space can be expected to have a different effect on nearby properties than distance from an industrial area. Third, the treatment of distance is typically just a parametric continuous measure and imposes assumptions about the relationship between proximity and value. Our contribution to this literature comes from having sufficiently rich data and events to address the problems identified in the research for a single hazard. First, like François (2002) we test for price effects that are not parametric in distance, allowing for highly granular effects at extremely close distances. Second, we account for a variety of other land uses that can affect property values whose locations may be correlated in space with the pipeline, as is the case in Taylor et al. (2016). In addition, we account for land uses through which the pipeline itself passes, trying to separate the pure pipeline effect from its land use context. Finally, we have two information events, one a spill and one an announcement. Comparing these two allows us to partially differentiate between the effects of presence and the type of risk.

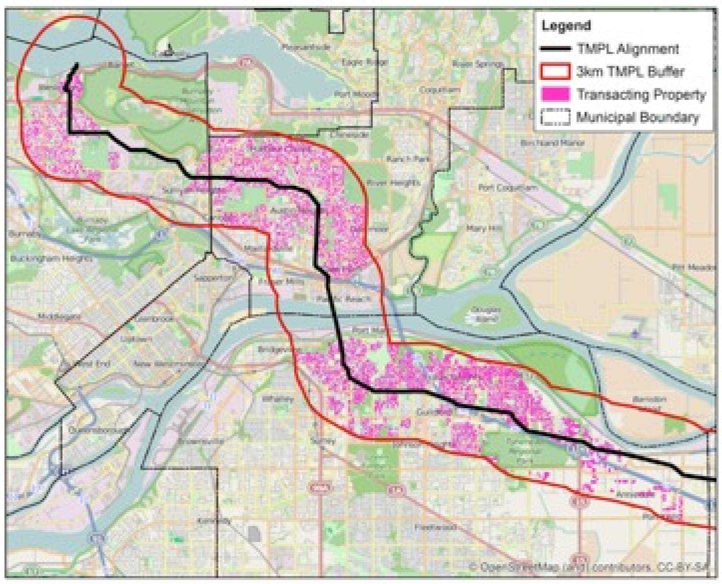
# 3 Data and Methodology

This study uses data along a segment of the Trans Mountain Pipeline (TMPL) that traverses the cities of Burnaby, Coquitlam, and Surrey in Lower Mainland area of Vancouver, BC. Burnaby is the pipeline terminus and the three cities reflect the western most and most urban section of the pipeline routing in British Columbia. The cities are all part of the Vancouver, BC Canada Census Metropolitan Area (CMA), their combined population as of the 2011 census is 842,200, making up 35 percent of the metro area's 2.37m population, and 18.6 percent of the area's land mass. The pipeline was built during 1952-53 and runs 1,155 km from Edmonton, AB to Burnaby, BC. In Burnaby there is a tank farm for storage and a marine terminal for shipments. The pipeline's initial capacity was 150,000 barrels per day (bpd). By 1973, the construction of additional pump stations expanded capacity to it's current maximum of 410,000 bpd. Peak delivery of 381,871 bpd occurred in 1972. Shipments have fallen since then as From throughput ranged from 200,000 to almost 300,000 bpd between 2002 and 2010 Kheraj (2015).

## 3.1 Description of sample and summary statistics

The primary data for this study are the singe family detached properties between 2000 and 2014 within a 1.0 km buffer along either side of the pipeline easement in the area of study. indicates the location of the easement of the Trans Mountain Pipeline. The location of the single-family detached property transactions in the sample along with the pipeline alignment and buffer are shown in Figure 1. These data were obtained from Landcor Data Corporation, a commercial provider of housing data for the province of British Columbia. The data includes every single family residential property transaction in Burnaby, Coquitlam and Surrey between 2000 and 2013 along with property characteristics such as lot size and floor area, the number of bedrooms, bathrooms, garages, and stories, and year built. For each property, we also obtain information on the distance to the pipeline alignment and also to other land uses including: commercial, industrial; civic (government, institutional, and recreational); major and minor arterial roads; and open or green space.

**Figure 1:** Study area with Transactions




Over the period 200 to 2014 house prices in metro Vancouver more than doubled, making price comparisons across time hard to interpret. To address this we report an adjusted house price measure, which is the observed price deflated to 2014 dollars using estimated city-specific quarterly house price indexes. The indexes are created using the Case-Shiller version of the more general Bailey-Muth-Nourse repeat sales methodology and paired transactions for single family properties in each city that lie outside the pipeline corridor. The final sample we use is this total transaction counts windsorize to cut the one percent tails in lot size, floor area and adjusted sales price. This leaves us with 12,419 transactions of 7,557 units within the 1.0 km band. Descriptive statistics for these data are presented in Table 1. The first group of variables are price and the standard hedonic lot and structure controls. The second group of variables correspond to the constructed geographic

**Table 1:** Descriptive statistics for all transactions

| | mean | median | sd | min | max |
|---|---|---|---|---|---|
| **Property Characteristics Variables:** | | | | | |
| Log price | 12.97 | 12.97 | 0.46 | 11.33 | 14.54 |
| Log of repeat sales index | 4.21 | 4.25 | 0.29 | 3.52 | 4.61 |
| Repeat Sales index adjusted price | 687,837 | 652,426 | 271,018 | 157,314 | 2,515,605 |
| Lot size (thousands of sq/ft) | 8,263 | 7,649 | 3,297 | 3,709 | 46,174 |
| Floor area (thousands of sq/ft) | 2,658 | 2,403 | 977 | 812 | 6,150 |
| Number of bedrooms | 4.20 | 4.00 | 1.25 | 1.00 | 8.00 |
| Effective age of property | 31.67 | 30.00 | 14.33 | 2.00 | 95.00 |
| Number of stories | 1.42 | 1.00 | 0.49 | 1.00 | 2.00 |
| Single garage dummy variable | 0.22 | 0.00 | 0.41 | 0.00 | 1.00 |
| Multi garage (Ordinal variable) | 0.59 | 1.00 | 0.51 | 0.00 | 3.00 |
| Number of full bathrooms | 2.03 | 2.00 | 1.17 | 1.00 | 6.00 |
| Number of partial bathrooms | 0.88 | 1.00 | 0.73 | 0.00 | 6.00 |
| Dummy, =1 if detached with suite | 0.25 | 0.00 | 0.44 | 0.00 | 1.00 |
| **Geographic Control Variables:** | | | | | |
| Dummy, =1 if property < 100m from civic land use 1 (park/golf course/open green space) | 0.14 | 0.00 | 0.34 | 0.00 | 1.00 |
| Dummy, =1 if property < 100m from civic land use 2 (govt bldg/works yard/cemetary) | 0.22 | 0.00 | 0.41 | 0.00 | 1.00 |
| Dummy, =1 if property < 100m from civic land use 3 (institutional land use) | 0.26 | 0.00 | 0.44 | 0.00 | 1.00 |
| Dummy, =1 if property < 250m from industrial land use | 0.06 | 0.00 | 0.24 | 0.00 | 1.00 |
| Dummy, =1 if property < 250m from commercial land use | 0.21 | 0.00 | 0.41 | 0.00 | 1.00 |
| Dummy, =1 if property < 40m from major arterial road | 0.07 | 0.00 | 0.25 | 0.00 | 1.00 |
| Dummy, =1 if property within 40m of minor arterial road | 0.01 | 0.00 | 0.12 | 0.00 | 1.00 |
| **Pipeline Proximity Variables:** | | | | | |
| Distance to pipeline in km | 0.47 | 0.46 | 0.30 | 0.00 | 1.00 |
| Observations | | | 12,419 | | |

control variables. These include dummy variables that take on the value of one if the property lies within a specified distance of civic, industrial, and commercial land uses and major and minor arterials. We group the civic land uses into three groups corresponding to their likely amenity impact: civic land use 1 includes land uses that are likely to be have a positive amenity value (e.g. parks, golf courses and open green space), civic land use 2 includes land uses that are likely to be disamenities (e.g. public works yards, cemeteries, misc government buildings), while use 3 covers institutions such as schools and hospitals. While few transactions are near a minor or major arterial road, seven and one percent within 40 meters of each respective type, approximately one quarter are with 100 meters of an institutional civic use. Most (94%) are more than 250 meters from an industrial land use, while a fifth are within the same distance of a commercial land use footnoteThe choice of distances from the dummies is the maximum that yields consistent statistically different than zero regression coefficients and uses the same distance within land use group types.

Properties within 100 meters of the pipeline have similar mean values for these variables. the exception is mean lot size, which is ten percent larger for properties close to the pipeline than in the overall sample. This is principally because the mean lot size for properties with a pipeline easement (so the pipeline transverses the property) is about 12,000 sq ft, which is about 50 percent larger than the mean lot size in the general sample. Larger lot size is endogenous, as the easement is 18m (59 ft) wide and no structures may be built on the easement. For a residential lot with an easement to be useful, it must be larger.

The large number of observations gives us flexibility to characterize the distance of a property from the pipeline using measures that more closely measure the properties which are in close proximity to the pipeline. We measure proximity to the pipeline three separate ways: as a continuous function of distance (0 to 1.0 km), in discrete bands of distance away from the pipeline, and finally as an ordinal measure of adjacency. For the latter we rank each property by distance from the pipeline in the number of properties removed. A property with an easement would have an adjacency of zero, a property adjacent to the property with an easement would have an adjacency of one, the next property, the value would be two. Adjacency is calculated along a vector perpendicular to the pipeline easement. .[10] In Table 2 we provide frequency counts on these different ways to characterize proximity. The upper panel, Panel (a), shows the frequency counts for transactions as an ordinal ranking of distance. We think that this measure may capture an element of awareness of a hazard, since even if it is hidden you might be expected to be more aware of it if you abut the hazard's location. Among our 12,419 transactions, one percent are of parcels with an easement and almost five percent are of a property that abuts the land use with the easement. This would be the immediate neighbour of a property with an easement or along a road where the easement runs down the middle or along side the road. Another four percent are one property further away. Nearly all of the properties identified in Panel (a), are within 100 meters. Panel (b), the lower panel groups transactions by distance. Using rings will allow us to estimate effects with a less parametric

[10]The latter orders properties 0 to 3, then beyond, based on the number of properties that separate them from the easement. This latter we think of as distance in information space, as information about the pipeline is highest for those closest or with neighbours who have an easement. Distance in this case is in the flow of information across property owners, and measured by the number of properties between a landowner and the easement.

specification. The transactions are distributed fairly smoothly by distance. Nearly twelve percent of the sample is within the nearest 100m ring, and approximately half of the transactions are within half a kilometre of the pipeline.

**Table 2:** Frequency counts on distance to pipeline easement and adjacency

| Panel (a) : Pipeline Proximity - Adjacency Measures | Count | Proportion (%) | Cumulative (%) |
|---|---|---|---|
| Indicator : Pipeline easement on property | 134 | 1.08 | 1.08 |
| Indicator : Property is 1 parcel from pipeline | 587 | 4.73 | 5.81 |
| Indicator : Property is 2 parcels from pipeline | 490 | 3.95 | 9.75 |
| Indicator : Property is 3 parcels from pipeline | 421 | 3.39 | 13.14 |
| Total | 1,498 | 13.14% | |

| Panel (b) : Pipeline Proximity - Distance Bands | Count | Proportion (%) | Cumulative (%) |
|---|---|---|---|
| Indicator : Property is 0 - 100m from pipeline | 1,474 | 11.87 | 11.87 |
| Indicator : Property is 100 - 250m from pipeline | 2,098 | 16.89 | 28.76 |
| Indicator : Property is 250 - 500m from pipeline | 2,927 | 23.57 | 52.33 |
| Total | 6,499 | 52.33% | |

There is substantial overlap between the adjacency and distance band measures reported in Table 2. In table 3 we cross-tabulate the distance bands and adjacency measures. There is substantial overlap between properties no more than one property removed from the easement property (adjacency values of 0, 1, or 2) and being within 100m of the pipeline: eighty percent are within 100 meters and 99% are within 250 meters. Because the variables are so closely related, in the regressions we test for the fixed effect of each of these variables separately.

**Table 3:** Cross Tabulation of Adjacency and Distance Bands Measures

| | Property is 1 Parcel from Pipeline | Property is 2 Parcels from Pipeline | Property is 3 Parcel from Pipeline | (%) Total by Row |
|---|---|---|---|---|
| Property is 0 - 100m from pipeline | 38.18 | 28.91 | 13.02 | 80.11 |
| Property is 100 - 250m from pipeline | 1.00 | 3.00 | 14.95 | 18.96 |
| Property is 250 - 500m from pipeline | 0.00 | 0.80 | 0.13 | 0.93 |
| (%) of Total by Column | 39.19 | 32.71 | 28.1 | 100% |
| Total Observations | | | | 1,498 |

## 3.2 Identification challenges and proposed tests

A clean test to measure the impact of pipeline, or any other hazard, proximity on house prices is challenging because the identification is affected by both left out variable bias and endogeneity in the relationship between pipeline and residential location choices. Ideally a randomly located pipeline in a stable unchanging residential area would allow for a straight-forward difference in differences test. In reality pipelines are not randomly located. The cost of constructing a pipeline is a function of its length, the cost of acquiring the pipeline easement, and the degree of local opposition. Pipeline firms will tradeoff among these factors in determining a pipeline?s alignment. As well, they may invest in local amenities to obtain local approval. This leads to several types of estimation bias. While we address these factors for a pipeline, these difficulties would pertain to the estimation of any other hazard.

The simple hedonic estimation of house price on proximity to a hazard will be subject to both left out variable and endogeneity bias in the estimated coefficient on proximity. Left out variable bias may occur because pipelines may be located on inexpensive land. The unobserved factor that causes the low land prices that attracts pipeline development to lower land acquisition costs also results in lower land prices for residential development, so that nearby homes have lower prices too. The second type of left out variable bias is the more general hedonic regression problem of structure quality when cheaper houses built on less expensive land have lower unobserved quality, so that the effect of proximity is biased away from zero as location is correlated with unobserved unit quality. The third form of bias might result from the endogenous location of amenities and pipelines. This is either because pipeline builders provide amenities as part of the approval process or because following pipeline construction, local governments turn pipeline easements into linear green spaces or create amenities on the space that does not involve permanent buildings. This would bias a negative proximity effect towards zero .

We are not able to evaluate properties before and after the construction of the pipeline because of the pipeline's age. Also, 92% of the properties in the sample were built after the pipeline was constructed, and only one detached unit in the data with an easement existed prior to the pipeline construction. Thus, the pipeline presence would be an in-situ reality for all residential development. Instead we have two approaches. First, we control for the type of land use through which the pipeline easement passes, so we differentiate between a pipeline on industrial land and on open space, as well as whether properties are proximate to a variety of non-residential land uses including open space and parks. This addresses hopefully helps to address the first and third element of endogenous amenities. The length of the pipeline segment we study and density of residential development in the data along with census tract dummies should also help with excluded geographic factors. The first type of static hedonic regression tests of log price on proximity, lot and structure characteristics, and geographic controls (both dummies for nearby land use types and census tract fixed effects) will help with the first and third type of bias, but not the second.

We supplement the standard proximity tests with difference in differences tests associated with two shocks, comparing the difference in response to these shocks by proximity to the pipeline. The advantage of these tests is that they should be immune to the identification issues proposed above, but they cannot capture the effect of the pipeline's presence, only differences in the disamenity value. The first is a spill along the pipeline easement and the second is the announced plans to build a second pipeline along the existing easement to triple capacity. While not as complete a test as one with a random placement, it does offer some insight on the effects of proximity from two different types of random events that highlight risk (oil spill) and remind residents of the presence of the pipeline (expansion announcement). In the case of the first we test for the effect in areas away from the spill site. Both tests essentially ask whether houses closer to the pipeline experienced a change in price post event relative to those further away. Other land uses and house characteristics should stay constant over the relatively short analysis window, thus obviating the identification problems described above.

In controlling for the influence of other types of nearby land uses that may also be influencing house prices in order address the concerns raised by Taylor et al. (2016). In addition, we take advantage of the variation in the pipeline easement land use itself is not constant over the alignment. Over our area of study, the pipeline easement occurs on residential, commercial, and industrial properties; along or under major and minor arterial roads; through open or green space; and across civic (government, institutional, and recreational) land uses. A property adjacent to the pipeline easement that is green space might be affected differently than one that is adjacent to a pipeline easement on an arterial road or a non-residential land use because of the amenity value of the green space. In our data, we are able to identify the pipeline land use context. We define the pipeline easement land use context for a given property as the closest along a vector orthogonal to the pipeline. This allows us to test for the effect different pipeline land use contexts by interacting these pipeline land use contexts with proximity measures.

These estimation approaches along with the rich data allow us to do a more effective and complete test of the effect of proximity than in many existing studies. First, the density of the urban area yields a large volume of transactions, all within 1.0 km of the pipeline. Second, in comparison to rural or ex-urban areas, the characteristics of the single-family houses we study are relatively homogeneous and the suburban landscape is rich in transactions.[11] Finally, the quality of available geographical data is high, which allows us to address identification issues as noted above.

In the hedonic regressions we use log house price as the dependent variable. All regressions include census-tract fixed effects and jurisdiction-specific quarter-year dummies to address local neighbourhood effects and city specific temporal variation in house prices. Dependent variables in all regressions include the linear element of lot and structure characteristics along with quadratic terms for floor area and lot size. Through different specifications we test the various measures of adjacency along with identifying the effects of better controls for nearby land uses and the pipeline land use context.

[11]The pipeline transverses one other municipality in the metropolitan area, Langley. We exclude this stretch because much of the area is agricultural with a quite heterogeneous mix of residential and agricultural land uses.

# 4 Results

Table 4 presents the baseline regressions for the relationship between distance to the pipeline and house prices. Specification (1) is the the regression of log house price on characteristics without any pipeline controls. In specification (2) we add distance to the pipeline. In specifications (3) - (5) we include the dummy variables for nearby land uses. In specifications (4) - (5) we add a dummy for whether the property has a pipeline easement and interact the easement dummy with property size in specification (5).

In the simplest treatment in regression (1), lot and structure coefficients have all of the expected signs. The inclusion of census tract fixed effects and city specific quarterly time series dummies yields a fairly high R-squared of 0.867. In regression (2) we add distance to the pipeline in a simple linear form to the baseline regression (1). Unlike other work, here the results would suggest that proximity matters: properties one km from the pipeline are 1.6 percent more valuable (about $10,800 at the mean). On a per 100m basis the effect of distance of $1,080 this would appear to be of marginal importance.

In regression (3) we add dummies for proximity to major roads and a variety of civic, commercial, and industrial land uses.[12] These dummy variables are all statically different from zero, off the expected sign and have a greater effect on price than does the pipeline proximity measure. The largest effect of 10 percent is for properties within 40 meters of a major arterial, which include the TransCanada, Barnett, or Lougheed Highways, and the second largest negative effect of 6 percent is for properties within 250 meters of an industrial land use. Including these controls lowers the pipeline proximity effect by nearly 30 percent, though the point estimate of 0.011 remains statistically different from zero. As per Taylor et al. (2016), this effect highlights the problems for any hedonic study on proximity to a negative amenity that does not carefully address other land uses.

[12] Within 100 meters of a civic land use, 250 meters of a commercial or industrial land use, and 40 meters from an arterial, with major and minor arterials treated separately. Civic land uses are type 1 - parks and schools, type 2 - dumps and corporation yards, type 3 - municipal buildings and facilities.

**Table 4:** Baseline regression specifications with simple distance measures

| Dependent variable = ln(price) | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| **Property Characteristics** | | | | | |
| Lot size (thousands of sq/ft) | 0.0164*** | 0.0167*** | 0.0171*** | 0.0175*** | 0.0175*** |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0015) |
| Lot size squared | –0.0001*** | –0.0001*** | –0.0001*** | –0.0001*** | –0.0001*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| Floor area (thousands of sq/ft) | 0.1566*** | 0.1555*** | 0.1507*** | 0.1503*** | 0.1503*** |
| | (0.0100) | (0.0101) | (0.0099) | (0.0099) | (0.0099) |
| Floor area squared | –0.0073*** | –0.0072*** | –0.0069*** | –0.0069*** | –0.0069*** |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0015) |
| Number of bedrooms | –0.0053*** | –0.0055*** | –0.0057*** | –0.0057*** | –0.0057*** |
| | (0.0018) | (0.0018) | (0.0018) | (0.0018) | (0.0018) |
| Effective age of property | –0.0024*** | –0.0024*** | –0.0024*** | –0.0025*** | –0.0025*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Number of stories | 0.0352*** | 0.0350*** | 0.0343*** | 0.0346*** | 0.0346*** |
| | (0.0049) | (0.0049) | (0.0049) | (0.0049) | (0.0049) |
| Single garage dummy variable | 0.0071 | 0.0071 | 0.0061 | 0.0060 | 0.0060 |
| | (0.0044) | (0.0044) | (0.0043) | (0.0043) | (0.0043) |
| Multi garage (Ordinal variable) | 0.0523*** | 0.0526*** | 0.0516*** | 0.0509*** | 0.0509*** |
| | (0.0045) | (0.0045) | (0.0044) | (0.0044) | (0.0044) |
| Number of full bathrooms | 0.0028 | 0.0029 | 0.0042 | 0.0041 | 0.0041 |
| | (0.0028) | (0.0028) | (0.0028) | (0.0028) | (0.0028) |
| Number of partial bathrooms | 0.0130*** | 0.0133*** | 0.0107*** | 0.0105*** | 0.0105*** |
| | (0.0029) | (0.0029) | (0.0028) | (0.0028) | (0.0028) |
| Dummy, =1 if detached with suite | –0.0002 | 0.0001 | 0.0035 | 0.0035 | 0.0036 |
| | (0.0041) | (0.0041) | (0.0040) | (0.0040) | (0.0040) |
| **Geographic Control Variables** | | | | | |
| Dummy, =1 if property < 100m from civic land use 1 (park/golf course/open green space) | | | 0.0110** | 0.0110** | 0.0110** |
| | | | (0.0054) | (0.0054) | (0.0054) |
| Dummy, =1 if property < 100m from civic land use 2 (govt bldg/works yard/cemetary) | | | –0.0261*** | –0.0258*** | –0.0258*** |
| | | | (0.0051) | (0.0051) | (0.0051) |
| Dummy, =1 if property < 100m from civic land use 3 (institutional land use) | | | –0.0079** | –0.0078** | –0.0078** |
| | | | (0.0038) | (0.0038) | (0.0038) |
| Dummy, =1 if property < 250m from industrial land use | | | –0.0596*** | –0.0600*** | –0.0601*** |
| | | | (0.0075) | (0.0075) | (0.0075) |
| Dummy, =1 if property < 250m from commercial land use | | | –0.0094** | –0.0095** | –0.0095** |
| | | | (0.0040) | (0.0040) | (0.0040) |
| Dummy, =1 if property < 40m from major arterial road | | | –0.1056*** | –0.1062*** | –0.1063*** |
| | | | (0.0064) | (0.0064) | (0.0064) |
| Dummy, =1 if property within 40m of minor arterial road | | | –0.0400*** | –0.0401*** | –0.0401*** |
| | | | (0.0125) | (0.0125) | (0.0125) |
| **Pipeline Proximity Variables** | | | | | |
| Distance to pipeline in km | | 0.0158** | 0.0111* | 0.0077 | 0.0077 |
| | | (0.0064) | (0.0066) | (0.0067) | (0.0067) |
| Pipeline Easement on Property | | | | –0.0515*** | –0.0424 |
| | | | | (0.0151) | (0.0259) |
| Interaction : Easement Dummy = 1 x Lot Size | | | | | –0.0007 |
| | | | | | (0.0016) |
| Census Tract Dummies | Y | Y | Y | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y | Y | Y | Y |
| Adj. R-square | 0.867 | 0.867 | 0.871 | 0.871 | 0.871 |
| Number of Cases | 12,419 | 12,419 | 12,419 | 12,419 | 12,419 |

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses.

For regression (4) we include a dummy if a property has a pipeline easement, so the pipeline transverses the property. Controlling for these properties eliminates the more general proximity effect. Properties with an easement transact at a five percent discount ($35,400 at the mean). While perhaps unique to this case, this result does suggest that distance effects observed in the literature may be highly localized and including a parametric continuous distance measure to a hazard for properties that are a considerable distance away is a source of specification bias. We pursue this further below with more granular treatments of distance. Finally, in regression (5) we introduce an interaction between this easement dummy test and lot size. Although neither the coefficients for the easement or the interaction are statistically different from zero, the magnitude and sign of the coefficients suggest a two part effect in which the per square foot discount for properties that have an easement is declining in lot size. The sensitivity of the distance coefficient in the regressions in Table 4 to the specification suggests that simple parametric relationships for proximity may be problematic. The effect of accounting for the closest properties, those with an easement, raises the possibility that proximity effects are driven entirely by lots extremely close to the hazard in question.

In Table 5 we apply a very general treatment of distance to the pipeline and transaction price with dummy variables for distance bands of 1-100m, 100-250m, 250-500m, and the excluded 500m-1km, where the effect is fixed within a band to shed light on these issues. Regression (1) highlights the sensitivity of measurement to extreme proximity, as the proximity effect is only for those properties within 100m of the pipeline alignment and the properties with an easement, for which the point estimate is unchanged from table 4. The effect for the close non-easement properties remains small, a 1.25% discount. What cannot be determined, though, is whether these results reflects differences in risk assessment, spills may be perceived to be very localized, or awareness, as a buried pipeline may not register for a homebuyer 250m away.[13]

[13] Wikipedia reports a standard Manhattan block as 274m in length.

**Table 5:** Distance in Discrete Bands

| Dependent variable = ln(price) | (1) | (2) |
|---|---|---|
| Pipeline Easement on Property | –0.0547*** | –0.0576*** |
| | (0.0151) | (0.0151) |
| Dummy, =1 if property 0 - 100m from pipeline | –0.0125** | |
| | (0.0055) | |
| Dummy, =1 if property 100 - 250m from pipeline | 0.0048 | |
| | (0.0049) | |
| Dummy, =1 if property 250 - 500m from pipeline | 0.0037 | |
| | (0.0043) | |
| 0 - 100m from pipeline x pipeline context = Civic/Comm/Ind/Utility | | –0.0416*** |
| | | (0.0115) |
| 0 - 100m from pipeline x pipeline context = Open/Residential/Res.Road | | –0.0104 |
| | | (0.0063) |
| 100 - 250m from pipeline x pipeline context = Civic/Comm/Ind/Utility | | –0.0054 |
| | | (0.0091) |
| 100 - 250m from pipeline x pipeline context = Open/Residential/Res.Road | | 0.0021 |
| | | (0.0057) |
| 250 - 500m from pipeline x pipeline context =Civic/Comm/Ind/Utility | | –0.0014 |
| | | (0.0073) |
| 250 - 500m from pipeline x pipeline context = Open/Residential/Res.Road | | 0.0018 |
| | | (0.0050) |
| Property Control Variables | Y | Y |
| Geographic Control Variables | Y | Y |
| Census Dummies | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y |
| Adj. R-square | 0.871 | 0.871 |
| Number of Cases | 12,419 | 12,419 |

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses.

In regression (2) of Table 5 we further address left out variable bias from nearby land uses, in this case those through which the pipeline passes. We interact each of the distance bands with the pipeline's land use context, the land use. on which the easement rests. For simplicity we pool these into negative and positive land uses based on the coefficients for geographic features in Table 4. The regressions include the general geographic control dummies so this interaction in regression (2) reflects the specific pipeline effect on that land use. The results suggest that the effect of pipeline proximity is a function of a pipeline's land use and not the pipeline itself: a pipeline under a benign land use such as residential, residential road, or open space and park does not have a statistically different than zero effect on properties within 100m, but when the pipeline easement is on land used for industrial, commercial, or civic purposes properties within 100m have a 4.2%. These results further reinforce the importance of controlling for all highly-local land uses when evaluating the effects of hazards on residential prices.

As an alternative to cardinal distance we also measure distance ordinally in terms of the number of properties a particular house is distant from the pipeline alignment. We use this distance measure in Table 6, where 0 is a property with an easement, 1 is a property adjacent to the property with the easement, 2 is one further away, 3 one again, and 4 plus the excluded default. As shown in Table 3, these measures are highly correlated with linear distance: 97 percent of properties adjacent to the easement property (one property distant) are within 100m of the pipeline alignment, 88 percent of those two properties distant, and 46 percent of those three distant. In regression (1) the importance of extreme proximity manifests as the discount for adjacent properties is 2.1% and for those properties one property distant 1.4%, and after that no effect, even though nearly half of transacting houses three properties distant are within 100m of the alignment. In the second specification, regression (2), we interact these adjacency measures with the pipeline's land use context. Unlike in Table 5, here we find that immediate proximity, even when the pipeline's land use is the more positive residential or open space uses, lowers property values slightly (1.6%). The negative effect for the unfavourable land use types remains higher at -3.5%. The single atypical result is that the negative effect when the pipeline runs under negative land uses increases for properties two distant from the alignment, though it is not statically significant when the land use is residential or open space. These results do reinforce the highly localized nature of negative effects: transacting residences one property from the easement property are a mean distance of 22m from the alignment, for those two properties distant the mean distance is 67m, and even those three distant the mean distance from the pipeline is only 98m. Proximity matters, but only at that extreme margin of closeness, where one would expect the buyers and sellers to be most likely to be aware of the pipeline's presence and to see a spill as most likely to effect their property.

**Table 6:** Distance in Adjacency Measures

| Dependent variable = ln(price) | (1) | (2) |
|---|---|---|
| Pipeline Easement on Property | –0.0568*** | –0.0567*** |
| | (0.0149) | (0.0149) |
| Dummy, =1 if property 1 parcel from pipeline | –0.0211*** | |
| | (0.0074) | |
| Dummy, =1 if property 2 parcels from pipeline | –0.0143* | |
| | (0.0079) | |
| Dummy, =1 if property 3 parcels from pipeline | 0.0072 | |
| | (0.0085) | |
| 1 parcel from pipeline x Pipeline context = Civic/Comm/Ind/Utility | | –0.0352** |
| | | (0.0172) |
| 1 parcel from pipeline x Pipeline context = Open/Residential/Res.Road | | –0.0164* |
| | | (0.0089) |
| 2 parcels from pipeline x Pipeline context = Civic/Comm/Ind/Utility | | –0.0673*** |
| | | (0.0159) |
| 2 parcels from pipeline x Pipeline context = Open/Residential/Res.Road | | 0.0000 |
| | | (0.0099) |
| 3 parcels from pipeline x Pipeline context = Civic/Comm/Ind/Utility | | –0.0127 |
| | | (0.0250) |
| 3 parcels from pipeline x Pipeline context = Open/Residential/Res.Road | | 0.0112 |
| | | (0.0101) |
| Property Control Variables | Y | Y |
| Geographic Control Variables | Y | Y |
| Census Dummies | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y |
| Adj. R-square | 0.871 | 0.871 |
| Number of Cases | 12,419 | 12,419 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

# 5 Event Studies : Difference in Difference Regressions

The static hedonic analysis in the previous section uses detailed measures of local land uses and the land use context of the pipeline alignment to address the bias issues in estimating the effect of proximity to the pipeline hazard and house prices. While we believe this treatment to be among the most thorough in the environmental hazard literature, the concern regarding bias ion coefficient estimates cannot be said to have been eliminated. In this section we use a difference in differences approach to avoid the bias issue by observing the variation in price response by distance from the pipeline following two events: the first a spill on the pipeline and the second the announcement of plans to triple the pipeline capacity. These two events should have different price effects because they convey different information. The spill both reminds sellers and prospective buyers of the hazard posed by pipelines and serves as a reminder of the pipeline's existence. The expansion announcement suggests an increase in the possible size of a spill and also a reminder of the pipeline's presence. We are interested both in the magnitude of any effect and its persistence.

The first event, the "Westridge Oil Spill occurred on July 24, 2007 when a backhoe penetrated the Trans Mountain Pipeline spur in Burnaby, BC. This stretch of pipeline runs less than two kilometers from the Trans Mountain terminus on Burnaby Mountain to Port Metro Vancouver's Westridge Marine Terminal. The spill was small, it released 1,500 barrels of heavy crude oil and only one home was severly contaminated but there was considerable media attention.[14] The second event we use is the May 2012 announcement in by Kinder Morgan of their plans to nearly triple the pipeline's capacity by twinning the pipeline along its existing alignment. We find no evidence of a public discussion of this plan prior to the announcement.

For these tests we conduct simple difference in difference tests around each of the event dates. The after event dummy is intersected with a distance band dummy, where the coefficient on the interaction term identifes the change in the effect of proximity as a result of the event. The narrow time window of analysis limits the number of transactions in the data so we are not able to use measures for houses one property away from the alignment or even within 100 meters. instead we compare the change in the effect of being within 250 meters of the pipeline as a result of the shock.

## 5.1 Effect of Spill

Table 7 below shows the difference in price appreciation after the spill for properties within 250 meters of the alignment compared to those that are 250 to 1,000 meters. We use windows for the before and after element of the diff in diff methodology of 0-3 months, 0-6 months, and 0-9,

[14] According to the operator eight homes were "heavily oiled" and 36 less so. They report that "one residence received extensive renovations to both its interior and exterior." https://www.transmountain.com/westridge-2007-spill.

and then 0-12 months for the difference comparisons. In the three months following the spill - regression (1) - units within 250 meters of the alignment sold at a 5.4% discount compared with those further away relative to values for both in the period previous to the spill.[15] This is a large effect when compared with other findings here. It is similar in size to the discount for a property with an easement and almost four ties as large as the discount for a property adjacent to an easement property that is residential or open space. The magnitude is similar to what Simons (1999) finds, but in our case limited to properties much closer to the pipeline. Regressions (3)- 4) show that the negative proximity effect associated with the information shock dissipates quickly with time. After six months there is no statically different than zero effect on the relative change in prices for nearby properties, and the point estimate is even coser to zero after one year. This dissipation is consistent with Hansen et al. (2006),though we find that it evaporates completely. Our finding of an effect differs from Freybote and Fruits (2015) who report no effect of news from other pipeline events on property prices and proximity to a buried pipeline, just to a pipeline under construction. There is a substantial literature on how people perceive risks ( see Tversky and Khaneman (1974) and Pachur et al. (2012) ) and these findings may be understood within the assessment of risk. This test cannot distinguish between the event highlighting the presence of a risk, which is then priced accurately, but quickly forgotten, or an overreaction to new news on risks that then returns to an appropriate assessment.

[15] With a 500m band the point estimates are lower and not statistically different from zero.

**Table 7:** Difference in Difference Regressions: Effect of Oil Spill (250m Bands)

| Dependent variable = ln(price) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dummy, =1 if property < 250m from pipeline | 0.0250 | 0.0264 | 0.0183 | 0.0102 |
| | (0.0227) | (0.0178) | (0.0149) | (0.0125) |
| Dummy, =1 if Sale 3 months post spill | 0.0658** | | | |
| | (0.0270) | | | |
| Sale < 3 months post spill x property < 250m from pipeline | –0.0543* | | | |
| | (0.0308) | | | |
| Dummy, =1 if Sale 6 months post spill | | 0.0671** | | |
| | | (0.0269) | | |
| Sale < 6 months post spill x property < 250m from pipeline | | –0.0517** | | |
| | | (0.0234) | | |
| Dummy, =1 if Sale 9 months post spill | | | 0.0586** | |
| | | | (0.0271) | |
| Sale < 9 months post spill x property < 250m from pipeline | | | –0.0300 | |
| | | | (0.0201) | |
| Dummy, =1 if Sale 12 months post spill | | | | 0.0545** |
| | | | | (0.0268) |
| Sale < 12 months post spill x property < 250m from pipeline | | | | –0.0197 |
| | | | | (0.0167) |
| Property Control Variables | Y | Y | Y | Y |
| Geographic Control Variables | Y | Y | Y | Y |
| Census Tract Dummies | Y | Y | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y | Y | Y |
| Adj. R-square | 0.767 | 0.743 | 0.736 | 0.745 |
| Number of Cases | 570 | 922 | 1,286 | 1,735 |

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses.

As a simple robustness check to the results in Table 7 we re-test the spill effects assuming that the spill occurs two years earlier, with a placebo spill in July 2005. What we hope to capture is any trend effect in the data associated with properties close to the pipeline. The results in Table 8 below show no evidence of some trend in the data that pre-dates the spill. All difference in difference interaction coefficients show no statistically different from zero relative difference before and after the placebo spill between units close to the pipeline and those further away. A similar test for a placebo spill July 2009, two years after the actual spill also yields no results.

**Table 8:** Robustness Check : Westridge Oil Spill Falsifications Regressions

| Dependent variable = ln(price) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dummy, =1 if property < 250m from pipeline | 0.0002 | –0.0058 | 0.0044 | 0.0058 |
| | (0.0207) | (0.0180) | (0.0168) | (0.0147) |
| Dummy, =1 if Sale 3 months post spill | –0.0069 | | | |
| | (0.0229) | | | |
| Sale < 3 months post spill x property < 250m from pipeline | 0.0237 | | | |
| | (0.0277) | | | |
| Dummy, =1 if Sale 6 months post spill | | –0.0050 | | |
| | | (0.0222) | | |
| Sale < 6 months post spill x property < 250m from pipeline | | 0.0202 | | |
| | | (0.0258) | | |
| Dummy, =1 if Sale 9 months post spill | | | 0.0162 | |
| | | | (0.0226) | |
| Sale < 9 months post spill x property < 250m from pipeline | | | –0.0090 | |
| | | | (0.0227) | |
| Dummy, =1 if Sale 12 months post spill | | | | 0.0107 |
| | | | | (0.0216) |
| Sale < 12 months post spill x property< 250m from pipeline | | | | 0.0040 |
| | | | | (0.0191) |
| Property Control Variables | Y | Y | Y | Y |
| Geographic Control Variables | Y | Y | Y | Y |
| Census Tract Dummies | Y | Y | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y | Y | Y |
| Adj. R-square | 0.756 | 0.730 | 0.725 | 0.738 |
| Number of Cases | 544 | 804 | 1,066 | 1,359 |

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses.

## 5.2 Effect of Expansion Announcement

Our second natural experiment uses the pipeline expansion announcement from May 2012. There is no coverage in the local media prior to the announcement of a possible expansion, so we treat it as a surprise event. We understand the information content of the annlouncement event to be a reminder of the presence of the pipeline, and while there is nothing to suggest the scope of the risk, it is possible that people perceived any risk to be elevated because a larger capacity would mean worse spills. We apply the standard difference in difference methodology around the announcement date. The results in Table 9 show no differential price response following the expansion announcement between properties within 250 meters of the pipeline easement and properties 250-

1,000m from the easement. This is consistent with Freybote and Fruits (2015), where they only observe pipeline proximity effects during construction. Our interpretation of the results in Table 9 combined with our earlier findings, is that except in the case of an event like a spill that heightens subjective assessments of risk, only those properties closest to a pipeline experience a proximity discount. This is not due to a lack of market awareness, but for the reason that properties not within one to two properties of the alignment, the presence is not treated as a risk.

**Table 9:** Pipeline Expansion Announcement Event Study Regressions

| Dependent variable = ln(price) | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dummy, =1 if property < 250m from pipeline | –0.0283 | –0.0274 | –0.0333** | –0.0228** |
| | (0.0241) | (0.0186) | (0.0147) | (0.0111) |
| Dummy, =1 if Sale < 3 months post announcement | 0.0095 | | | |
| | (0.0197) | | | |
| Sale < 3 months post announcement x property < 250m from pipeline | –0.0104 | | | |
| | (0.0368) | | | |
| Dummy, =1 if Sale < 6 months post announcement | | 0.0132 | | |
| | | (0.0181) | | |
| Sale < 6 months post announcement x property < 250m from pipeline | | –0.0158 | | |
| | | (0.0257) | | |
| Dummy, =1 if Sale < 9 months post announcement | | | 0.0117 | |
| | | | (0.0176) | |
| Sale < 9 months post announcement x property < 250m from pipeline | | | –0.0094 | |
| | | | (0.0211) | |
| Dummy, =1 if Sale < 12 months post announcement | | | | 0.0096 |
| | | | | (0.0171) |
| Sale < 12 months post announcement x property < 250m from pipeline | | | | –0.0068 |
| | | | | (0.0166) |
| Property Control Variables | Y | Y | Y | Y |
| Geographic Control Variables | Y | Y | Y | Y |
| Census Tract Dummies | Y | Y | Y | Y |
| Jurisdiction Quarter Dummies | Y | Y | Y | Y |
| Adj. R-square | 0.815 | 0.826 | 0.844 | 0.869 |
| Number of Cases | 401 | 603 | 808 | 1,174 |

* p < 0.1, ** p < 0.05, *** p < 0.01. Standard errors in parentheses.

# 6 Summary and Conclusions

This paper uses the example of oil pipelines to explore the sensitivity of estimates of the cost of proximity to hazards to both the specification of distance and the types of highly localized existence land uses. There are important implications for both the siting of hazards and the structure of compensation to existing landowners from a more accurate proximity cost methodology. We find, unlike previous papers, that houses near to pipelines do trade at a discount. In our data it is only the property with an easement and then the closest one or two properties that experience negative effects on value from nearby pipelines. Even at this level the effects are sensitive to the correct treatment of other land uses and, in the case of a pipeline, to the land use under which the pipeline passes, a result based on a more precise and granular treatment of land uses and but entirely consistent with the more general finding in Taylor et al. (2016). For example, when the pipeline transverses industrial and commercial land uses, the negative proximity effect is at least twice as large as when the pipeline is passing through a residential area.

The magnitude of the effects we find are relatively small. A residential property with an easement has up to a 5.7% lower value on average, though we cannot separate the risk effect from the loss of use effect because of restrictions associated with the easement. A property adjacent to such an easement property has a price that is 1.6-3.5% lower than a more distant unit depending on the land use on which the easement lies. Beyond the second property distant there is no effect in our data. Given that these narrow effects are only for the closest properties, it is not surprising that the literature using parametric specifications has not previously found a relationship between negative values and closeness to an oil pipeline except following a spill. Interacting these proximity by the type of land use further strengthens our contention of the importance in modelling proximity and land use effects with fine granularity.

Our difference in difference analysis supports the findings elsewhere that risk assessments are affected by recent pertinent information. However, the results also show that this effect is quite transient and not true for all types of information shocks. We only see changes in risk pricing following a local spill and not following news of a planned increase in the pipeline. In the cvase of the spill the effect on the pricing discount is large, over five percent, but these effects disappear after six months following a spill elsewhere on the pipeline. As with our static price effects, these only apply to closer units, but they extend on average throughout a 250-meter band. The tests on pipeline expansion announcement yield no difference in difference results. In combination these findings suggest that it is heightened perception or a reminder of pipeline risk and not a renewed reminder of the presence of the pipeline that causes lower transaction prices.

This paper sheds light on some of the factors that contribute to large variations in results of studies that examine the effect of proximity to environmental hazards on residential prices. The richness of our data permits us to model distance from the hazard more finely and account for a broad range of other land uses, proximity to which can be expected to affect residential property values. We find that both have notable effects on the relationship between proximity and house prices. The more precise tests here show that proximity may only matter at very short distances, and that the failure to account for other land uses, and even the land use type of the hazard, will bias estimates away from zero.

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