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Use of Contingent Valuation Analysis in a Developing Country: Market Perceptions of Contamination on Johannesburg's Mine Dumps

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This study reports the results of a contingent valuation (CV) survey that was carried out in Johannesburg, South Africa. Students at Wits University conducted more than 300 face-to-face interviews with Africans living and/or working in Soweto, an African township located on the outskirts of Johannesburg, and nearby areas. The questions they asked were designed to determine the perceptions of risk regarding airborne mine dust and radon, a naturally occurring gas, and the effect that these perceptions had on the valuation of residential properties impacted by these substances. A probit model was used to evaluate the determinants of bidder behavior, using respondent demographics and other characteristics as independent variables. Residential property discounts for potentially contaminated housing sites by marginal bidders at the top of the market varied from -24% to -50%. Research issues in developing countries were addressed. Contingent valuation results in South Africa were compared to published results in the United States.

1. Introduction

Numerous studies have evaluated the effect that different types of existing contamination have on property values. Traditional use of actual sales has been, and will continue to be, an important research methodology. However, except in situations where the properties have been cleaned up, full information on environmental contamination is not usually available. The typical market participant is not an environmental scientist, and not all of the relevant facts are usually known. It is this lack of knowledge and uncertainty that creates risk-related price discount effects[1].

Recent real estate research has also focused on alternative methods of measurement, particularly in cases where market data are not available. Contingent valuation (CV) analysis is one such technique. Soliciting responses from people using a structured questionnaire that gives a detailed description of a hypothetical property in an improved or degraded condition, CV compares this property with a baseline, or unaffected, property. This approach has been used rigorously to test market perceptions and draw conclusions.

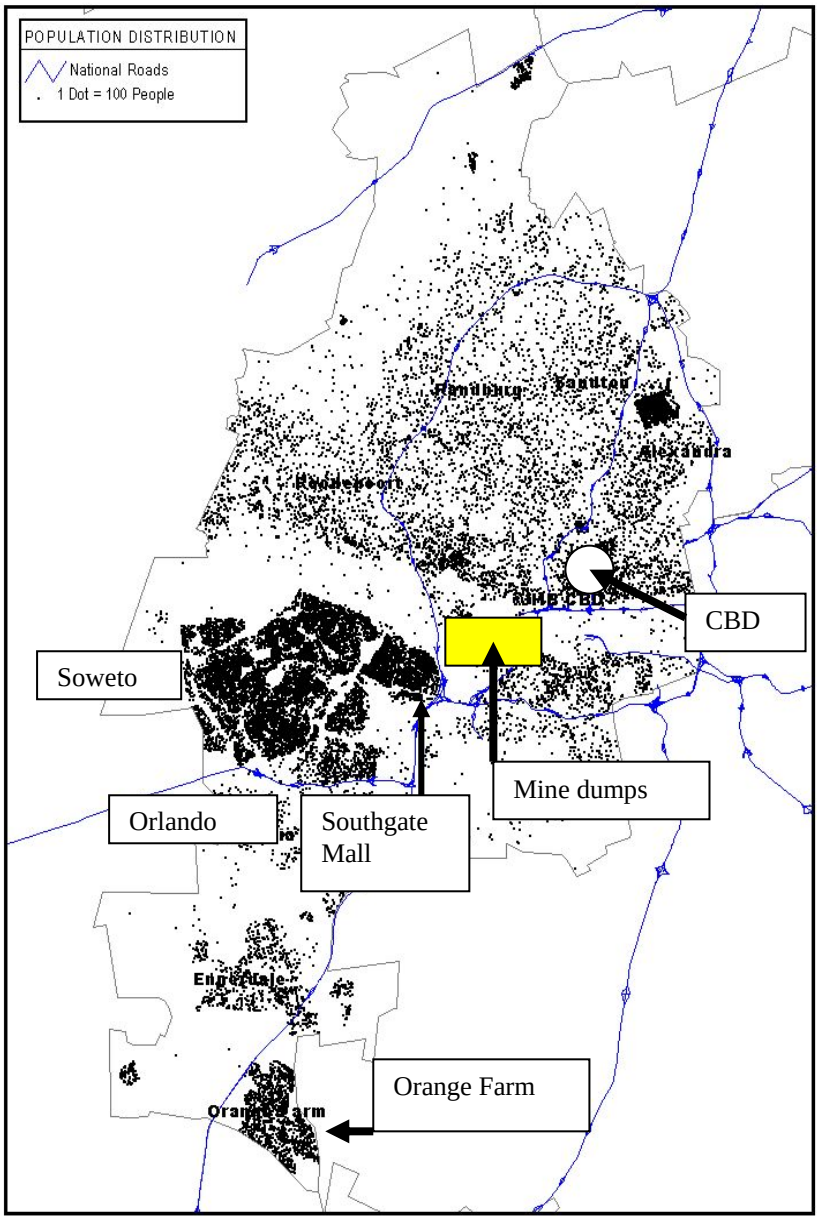
Despite some well-known shortcomings, it has emerged as a useful technique for determining the impact of environmental damage on real properties in situations where sales data are not available, where full information on previous sales is not available, or for areas with no sales data because they have yet to be developed. This study explores the effectiveness of CV as a way of determining the potential impact of radon contamination on the property values of yet-to-be-developed properties within the context of the former gold mine dumps in Johannesburg, South Africa.

Johannesburg is a former gold mining boomtown that has evolved since 1886 into a bustling and regional trade center with a population of about 3.5 million and an annual growth rate of about 4.1% (Boraine et al, 2006). Residue from gold-mining activities has generally been stacked into high piles, most of which are more than 100 feet high and spread over hundreds of acres. The remaining dumps are located near the central business district. With the price of gold at record highs, many existing dumps are being recycled for their gold value. Figure 1 shows the location of some of these properties relative to the developed areas of Johannesburg.

This study begins with a brief introduction to Johannesburg's housing markets. Some of the recent literature on radioactive material and on CV studies is then covered. This is followed by a discussion of the particular challenges of conducting surveys and on this type of research in developing countries such as South Africa. We then set forth the research hypotheses. The research methodology is described, and the results are presented and analyzed. The concluding paragraphs relate the results of this study to benchmarks established in previously published research.

[1] Thanks to one of the reviewers for clarifying this point.

Figure 1 Population Distribution



The main purpose of this study is to determine if and how CV can be successfully applied in the context of a developing country. This is accomplished by analyzing

the bids and percentage discount responses of respondents to a survey. In addition, demographic factors that are associated with successful bidding on contaminated properties are analyzed. The results are then related back to the existing literature on CV.

2. Johannesburg's Housing Markets and Mining Lands

Established in 1886, Johannesburg is the hub of economic activity in South Africa. It is also the most important financial center on the African continent. The city is divided into northern and southern districts, with the railway lines that bisect it serving as a sort of boundary. A gold reef extending 50 miles in an east-west direction is located to the south of the city.

With the establishment of Parktown and the construction of mansions by mining barons in the early 1890's, the city's northern district evolved into the expensive part of town (Beavon, 2004). Housing was needed for the blacks that worked in the mines. As a result, Klipspruit – which was located to the south of the railway line, south of the reef, and close to the mines – was developed in 1904 (Beavon, 2004). This settlement later evolved into what is now known as Soweto, or South West Township.

The growth of Johannesburg continued with the northern suburbs developing into whites-only neighborhoods and the south into mostly non-white neighborhoods, with the majority being of African descent. Today, the south of Johannesburg houses just over 50% of the city's population, with a majority of the black population in Johannesburg living in the southern part of the city (Beavon, 2004). This is despite the fact that since 1989, there have been no prohibitions against people living wherever they want. Housing prices have remained the main obstacle to blacks moving into more expensive neighborhoods.

The residential property market in Johannesburg was shaped by the Group Areas Act, which was enacted in 1950 and remained in effect until it was repealed in 1991. Under this act, people had to live in areas designated by their race: white, black, Indian, or colored. Cities were considered to be for whites only. Blacks were allowed to work and live in them only if their services were needed. As a result, whites were allowed to own land and property in urban areas, but this was impossible for blacks, who were only allowed to rent houses built and owned by the state. This, moreover, was on the condition that they had an employment-related permit to live in an urban area (Beaven, 2004).

As a result of this policy, a real estate market developed in the white areas. A somewhat limited market also evolved in the Indian and colored neighborhoods. Since blacks were not allowed to own land in urban districts, no such market developed in the areas reserved for them. Even today, a large part of the housing market in black neighborhoods comprises government-built housing. Many

residential units are very similar in size and layout, and they have the same basic amenities.

Jaffe and Sirmans (1995) define the real estate market a mechanism by which real estate goods and services are exchanged. This mechanism is influenced by the wants of the participants in the market as well as by political and governmental intervention in the market. In the context of South Africa, we find that up until 1989, there was always a conflict between the wants of the "could-be" participants and the political interventions that were mostly forced upon them. Such interventions led to a non-balanced property market that was clearly not adhering to the expected normal influences of supply and demand.

Because not all South Africans were allowed to participate in an open property market, an unbalanced and an unequal market evolved – when and where it existed. It also prohibited some "could-be" participants from entering the market altogether. The main victims of these laws were the black population. They were not allowed to own land; they could only either rent it or have a permit to occupy it. That led them to not benefit from the accumulation of wealth, which is one of the key benefits of owning property.

Tensions started to ease after 1989. They eased even more with the celebrated land reform statutes of 1991, which granted property ownership rights to residents of black townships (Abt Associates, 1998). By 1994, when the first non-racial democratic election was held, policies and government acts were set in order to ensure that all South Africans were included in the shaping of every aspect of life in the country, both freely and responsibly. Some of these changes were geared toward having an open real estate property market where participation was based on ability rather than politically driven considerations.
It is important to understand that the mines acted as a sort of buffer separating the rich neighborhoods in the north from the poor neighborhoods in the south. This land is still owned by the mining companies, and its value is inversely related to the price of gold. Sihlongonyane and Karam (2003) concluded in their research on the integration of Johannesburg that the mining land north of Soweto and south of the Central Business District (CBD) could act as a main integrator. By utilizing it for housing, it would help to reverse the effects of segregation by allowing blacks to move to "convenient locations that are closer to transport, jobs, and urban facilities" (Sihlongonyane and Karam 2003). The main problem getting in the way of the development of this land was the potential existence of contamination, especially radon gas.

3. Radon Issues

Gold and uranium are both alluvial heavy minerals, and they are found together in Johannesburg and some of the other nearby gold-mining areas. Some of these areas, particularly those that have undergone heavy metal mining, have naturally occurring

high levels of radon. The piles of residue left behind after an area has been mined contain radium, and this turns into radon, a gas, as it decays. Radon is dangerous to human health if it is inhaled over a long period of time, especially in a confined space. This makes it inadvisable to construct houses on sites where mining has taken place.

One solution would be to prevent residential properties that are built on such sites from having basements or any type of enclosed area at the ground level. These could be stacked flats with ground level parking, residential spaces above commercial spaces, or townhouses with open-air garages (or car ports) at the ground level. These or similar configurations would lower the risk of cancer and other long term problems. Any intrusion into the ground in the form of gardening and/or utility servicing would have to be discouraged. This would require careful management.

In South Africa, the National Nuclear Regulator (NNR) is charged with determining if a property is safe for residential or commercial occupation when radon is apparent. The local municipality, the province (environmental and procedural), and the Department of Minerals and Energy all have a say in the redevelopment of former mining lands.

Information on health risks from radon is not readily available in South Africa. However, data from North America and Europe indicate that over a lifetime, the risks of dying from radon exposure for non-smokers is close to the generally accepted safety threshold of between two and seven deaths per 1,000 persons [2] If exposure is less than a life time, or 20 years, for example, death rates would be even lower.
In this study, mine dust contamination and radon are modeled in two ways. One is as described above, when it is a residual factor with radon gas coming from underground. The other is through airborne mine dust emanating from existing mine piles. We asked survey respondents about their prospective interest in bidding on properties in which both of these characteristics were present.

4. Literature Review

There is no known empirical literature on the development of housing (and its value) on mine dumpsites or for houses with radon contamination. However, two studies have been done in the United States on the effect of radioactive materials on nearby property values. Smolen et al (1992) studied the effect of an announced radioactive landfill on residential housing prices in the state of Ohio. They used hedonic regression analysis to evaluate residential sales from 1986 to 1990. A landfill site for radioactive waste was proposed in 1989, and this announcement resulted in a clear, initial negative impact of 17 to 205. Owing to extensive public resistance to the

[2] World Health Organization Website 2005, Krewski, et al, 2005

landfill, the proposal was canceled, and the negative effect on housing prices disappeared soon thereafter.

Kinnard, Jr., et al (1991) evaluated the effect on housing prices of a release of radioactive materials from a major industrial facility in the Midwest. They found that sales prices after the event fell by about 2%, but there was no relationship between the release and the distance from the plant within the six-mile area that was studied.

More generally, CV has been widely used to estimate the value of non-market goods such as public lands. This would include the benefits of improved air and water quality, increased health risks from drinking water and groundwater contamination, outdoor recreation, and protecting wetlands, wilderness areas, and endangered species (Carson 2000). The importance of CV was set forth by Portney (1994), who envisioned the large role that CV could play in forming public policy.

Recent applications for CV include real estate research, particularly for calculating environmental damage (Clinch and Murphy, 2001). Chalmers and Roehr (1993) recognize using CV for analyzing contaminated real estate in an “as is” condition, especially when traditional approaches to valuation are not available. They support using formal procedures to interview market participants, including buyers, for real estate cases that involve contamination.

McLean and Mundy (1998) advocate using CV in real estate. They imply that some buyers are unaware of the impact of contamination on their property and that this absence of information impacts the reliability of sales data. They also advocate using CV when the availability of sales data is inadequate, thus making traditional valuation techniques unreliable and difficult to use. In another article, Mundy and McLean (1998) evaluate the CV approach in the context of federal guidelines for non-market goods and services. They discuss advantages and disadvantages of CV and then demonstrate its use in conjunction with a case study in the state of Washington.

Simons (2002) used CV as one of several techniques to estimate property damage resulting from polychlorinated biphenyl (PCB) contamination in Anniston, Alabama, in the United States. One hundred and fifty people were asked via telephone if they would purchase property that was contaminated with PCBs. Only 5% of the respondents would be willing to bid on the property, and they would expect a 20% to 83% discount on the full value of an uncontaminated property.

CV has also been used in other contexts. McClelland et al (1990) evaluated risk beliefs and their effect on residential property values in a case study of a hazardous waste landfill. They mailed a survey to nearby residents, asking them about their perceptions of health risks associated with living near a landfill. Results showed that younger and female respondents were more concerned about odors and were more likely to perceive living near landfills as too risky. Males were less concerned about these issues.

Jenkins-Smith et al (2002) used CV to examine the effect of a refinery and smelter on residential property markets. Sellers were required to disclose the existence of contaminated soil to potential buyers. CV was administered via telephone. Fifty-three percent of respondents refused to bid on the stated scenario. Among those that did, the average bid after disclosure was 31% below the average price for houses.

Simons and Throupe (2005) conducted a CV study among 200 potential homebuyers in the state of South Carolina, concerning the effects that toxic mold had on residential property values. Buyers were provided with full disclosure of the past mold problem. Survey results indicated that a 20% to 37% discount was expected for residential properties that had previously had toxic mold but that had since been remediated.

Simons and Saginor (2006) examined the effects of environmental contamination and positive amenities on residential property values in the United States using a regression-based, meta-analysis technique. The study summarized a literature review of 75 mostly peer-reviewed journal articles. This allowed the preparation of a data set of about 290 observations that contained information about each study's loss, with various explanatory variables including distance from the source, the type of contamination, if it was an urban or a rural environment, the geographic region, market conditions, the type of methodology (case study, regression, survey), and several other variables. Broad contamination types, amenities, selected economic regions, distance from the source, information, research method, and several other variables were statistically significant. In particular, regression studies were found to have a 7% smaller loss, assuming all else was constant.

Simons and Winson-Geideman (2005) reported the results of CV studies conducted in eight US states. More than 1,100 telephone interviews examined valuation effects on residential properties impacted by leaking underground storage tanks. When faced with fact paragraphs describing a home with contaminated groundwater, potential bidders expected price discounts of 25% to 33%. The results showed that the bidding patterns in most of the states were statistically similar and that male bidders more than 49 years of age and with no high school diploma were more likely to bid; those with higher incomes, and those bidding on properties with certain rather than suspected contamination were less likely to bid. Survey results benchmarked reasonably close to, but higher than expected, preference outcomes for residential leaking tank sites in Ohio.

The Simons and Winson-Geideman (2005) peer-reviewed article served as a blueprint for the current work. The survey instrument for this research was largely based on its overall form (the order of questions and sections) and content (the style of the fact paragraph and its duration). The use of a probit model to determine the characteristics of bidder behavior was patterned after the article. Several bidder characteristic findings from it are also compared with the current research.

The probit model is a form of dichotomous choice (similar to a logit model) that allows the researcher to determine which demographic bidder characteristics are associated with certain outcomes. The outcome in this case is submitting a relatively high bid on various types of property, especially those with potential environmental contamination issues.

As a research methodology, CV has well documented limitations. For example, if survey participants have a financial stake in the outcome of a legal case, they could give biased results to survey questions in order to get money. Other respondents might have issues with the polluting company and therefore give responses based on factors that are not relevant to the matter under consideration. To avoid these validity threats, the researchers for this study did not name the polluters, and no litigation was contemplated.

Other respondents have been known to give certain answers to try to "please" the surveyors. This issue has been addressed by training the surveyors to stay on a prearranged script. Also, some respondents may give answers that might not reflect their actions in real life because there are no consequences to providing responses to hypothetical questions (Rowe, d'Arge and Brookshire,1980; and Mathews and Desvousges, 2002). This is known as a discrepancy between stated and revealed preferences (Jackson, in Kinnard, 2003).

Hypothetical bias validity threats can include potential overbidding (leading to smaller losses than might be expected) and potential underbidding, which can lead to larger losses than would normally be expected. Some bidders faced with this type of survey could overbid owing to their lack of familiarity with the environmental situation, trivializing perceived risks, and the artificial nature of the survey (compared to an actual transaction). This could underestimate the discount because a high side bidder could in actuality pull out, whereas in a hypothetical situation, they might state that they would bid the full value. The underbidding component is largely addressed by removing unreasonably low bids from the pricing calculations, focusing instead on bids at the top of the market and closer to full value, which would be more likely to be accepted by a seller. This is referred to as the marginal bid approach (as opposed to the average bid approach, which averages all bids).

Two peer-reviewed studies have compared, revealed, and stated preferences for contaminated real estate, which is one empirical way of assessing the extent of hypothetical bias. They found that stated, or survey, techniques generate higher losses than actual sales outcomes, in the range of mid single digits (Simons and Saginor, 2006; Simons and Winson-Geideman, 2005). This range gives an indication as to the potential order and magnitude of hypothetical bias. Therefore, while hypothetical bias is still a potential validity threat to this research, we believe its effects are manageable.

5. Data Gathering and Procedures

The data used in this study were collected in September and October of 2005 (there were 216 surveys) and May of 2006 (with an additional 100 surveys, for a total of 316 completed interviews). The survey team comprised 18 graduate students in Town Planning and Housing at the University of the Witwatersrand in Johannesburg, South Africa. The senior author was in residence on a Fulbright Scholarship studying contaminated land redevelopment and housing policy. The class project featured the policy study of putting housing on the mine dump sites, and a large part of the work involved primary data gathering to collect facts and attitudes concerning the housing preferences of potential market participants.

With respect to methodology, most of the CV studies in the United States that the authors were aware of used the telephone as a medium. However, this was not feasible in South Africa. Phone access is not as universal in the country. What is more, many of the people that have phones only turn these on when they are traveling about the country. Cell phone charges are also quite high.

The surveys were therefore administered in person, and they took about 30 minutes to complete. There were about 140 questions on housing preferences and satisfaction, commuting patterns, perceptions of relative risk, and demographics. There were also four standard CV fact paragraphs, two of which focused on mine dump issues. These are discussed in more detail below.

There were other methodological issues that had to be sorted out. These concerned internal validity, which related to collecting accurate and useful data, and external validity, or the generalization of the results. The first issue involved comprehension of the material. South Africa has eleven official languages, and English is one of them. Although all of the interviews were conducted at least partly in English, Zulu, SeSotho, or one of the other indigenous languages was used in about one-third of them. Because of the complexity of the issues, this was sometimes necessary in order to clarify certain points. Interviewers were therefore matched with respondents on a "backup" language basis in order to facilitate this process.

Other than the language issue, the survey methodology followed the usual research protocols. The initial instrument was pre-tested for time length, clarity, and other potential problems. Subsequent instruments utilized the same or very similar questions. The survey went through 11 drafts before the final version was decided upon. Between drafts eight and nine, a two-hour focus group was conducted in Soweto with a range of potential respondents in order to field test our interviewing approach and refine the instrument.

The authors provided specific instructions for survey administration and procedures. For example, the pretest identified several definitions that appeared vague to some respondents, but clear to others. Because of this, surveyors were given expanded definitions (i.e., radon, risk, etc.) to provide to respondents if asked.

Once the surveys were collected, students were provided with a coding template in which to enter data. The data were sent to the senior author, who assembled the data set and supervised the data cleaning process. A random sample of collected surveys was then checked against the hard copy for data entry error. The data coding error rate was about 2%.

The survey form itself included some preliminary questions to get the respondent comfortable with the Likert-style one-to-five relative rank bidding scale for housing and risk preferences. We collected data on housing satisfaction, which we do not cover in this paper, and also on attitudes toward risk, which is covered briefly because it addressed radon and mine dust. We then asked about the baseline value of the respondents' own home. After that, we read the respondents four fact paragraphs to determine if they would bid on any of the following scenarios: a home far from the city center, a stacked flat at an uncontaminated site lose to the city center, a home with radon, and a home with airborne mine dust. We also asked them the amount of money they would bid on each unit. Finally, data on the respondents' demographic features were collected.

Several tripwires and internal validity checks were built into the survey in order to confirm that the respondents understood it. Some of the questions assessed basic math skills (e.g., negative and positive numbers) and selected definitions were available to be re-read to respondents in their mother tongue if needed. We also compared the risk part of the survey with stated results (this is discussed more in the probit section). Virtually 100% of the respondents were black, and 17 of the 18 student interviewers were black. This racial compatibility reduced any potential cultural friction, which might invalidate the results.

6. Sampling Approach

The issue of developing contaminated land for housing is sensitive. South African political leaders have widely promised that access to housing is a right, and there has been a push to develop millions of small, heavily subsidized individual units. However, the demand for these units far exceeds the supply. Because of the actual or perceived health risks that are associated with radon, we considered it unconscionable to consider putting low-income housing on these former mining lands because the potential occupants really have no choice about whether to live there or not. We therefore directed the housing market analysis toward market players with choices or those in the affordable housing range of R130,000[3] to R400,000 (about US$20,000 to US$60,000). This was our target population, and it was not intended to be representative of the Johannesburg population as a whole, which is generally less affluent.

[3] R stands for rand, the official currency of South Africa.

Given that a target population was identified, the second main issue concerned external validity: finding a desired range of financially qualifying potential buyers. We initially opted for a cluster sample approach, interviewing at four predetermined locations on five different days. These venues included one remotely located low-income project (Orange Farm), the lower middle class Orlando East area in Soweto, and two shopping malls (Eastgate and Southgate), of which the latter is in Soweto. All of the last 100 surveys were administered at Southgate Mall in Soweto.

Access to respondents was achieved in one of two ways. For lower income respondents, such as those in Orlando East and Orange Farm, we liaised with the ward councilors, who notified us about the dates that residents' meetings would take place. These typically had several hundred people in attendance. We took advantage of these gatherings, at which different issues affecting residents were discussed, to interview residents. Once we arrived, the ward leadership would introduce us to residents and explain our purpose for being there. It was during and at the end of such meetings that we were able to conduct our interviews with residents. We only interviewed those residents that willingly agreed to take part. In Orlando East and Orange Farm, respondents were aware of others at the interview. The response rates were about 10% of possible respondents. Because participation was voluntary, this would be classified as a non-random sample.

At the shopping malls, where the bulk of the surveys were administered, we employed a more traditional random sample approach. Southgate was a good venue because it was close to the impacted area and shoppers there were familiar with the mine dumps and airborne mine dust issues. Respondents were not necessarily aware of others because in these sites, interviewers targeted people at random – on lawns, at restaurants, on resting benches inside and outside the malls, etc. The safety and security of student interviewers was a concern, and they were asked to operate in teams, interviewing separate respondents in close proximity to one another.
Despite the fact that permission to conduct such interviews was first sought from the management of the shopping malls, respondents were only informed of the interviews and the details of the survey when they agreed to take part. The interviewers were allowed to take a short break between interviews. After that, they were expected to approach the first available person and ask him or her to participate. Hence, once an interview was completed, the surveyor selected another respondent at random within a minute or two. About 10% of the interviews were aborted during the interview process, mostly because the respondent had to leave. We did not select potential respondents based on target incomes. We allowed the data to present themselves.

7. External Validity and Sample-Population Comparisons

Because this is essentially a non-random sample, we cannot provide an overall response rate. Owing to the unique data gathering approach, it is likely that this

research could not easily be replicated although we have no reason to believe that results would differ substantially from those presented here. While we do have a sufficient sample to run a statistical analysis, we cannot easily assert a relationship to the intended population of middle-income homebuyers. However, we do compare our sample demographics to the overall Johannesburg demographic profile for comparison purposes, where data are available.

8. Comparison of Sample and Johannesburg Homeowner Demographics

Despite the opportunistic way the data were collected, the totality of this cluster sample is logically consistent with Johannesburg residents as a whole. The surveys focused largely on potential middle income homeowners, who are generally older, better educated, and less likely to be members of a minority group than the overall population, which includes renters. Data on middle-income homeowners is not available so we compared the sample, which was taken in 2005, to the entire Johannesburg population in 2001 (as per Stats SA). For example, our sample included about 75% men, compared with 50% in the overall Johannesburg population.

The median age of respondents was about 36 years, about two years older than the population as a whole. A total of 31% of the sample had less than a high school education, compared with 67% of the entire population. At the same time, 29% of the respondents were college graduates or had a postgraduate education, compared with 7% of the general public. Monthly income among respondents was reported to be R4,500 (about US$660 at the November 2007 exchange rate), substantially more than the average income for the population as a whole, which was likely less than R2,500 per month in 2001. The sample was also more mobile, with 30% owning a personal car, compared with a 3% for the overall population. Therefore, the sample's demographic characteristics line up as more affluent in comparison to the general population, but no statistical relationship could be derived.

This illustrates why research in third world countries can prove challenging. One reason we got more men than women was that when pairs (e.g., a woman with a man) were approached, the man would tend to answer. Hence, there was a cultural reason why our sample was overrepresented with males. However, on the other economic characteristics, it was very difficult to get usable statistics (for example, on just homeowners, for a comparable geographic area) to compare the sample to. Available data were out of date because great changes had taken place both in in-migration to the Johannesburg area since the last census had been taken and also because of upward mobility and economic prosperity. Also, the number of people with extremely low incomes and educational levels was quite high, skewing down the figures and making valid comparisons using averages very challenging.

9. Mecha

We initially asked respondents some questions on housing satisfaction, transportation, and preference, which, for the sake of brevity, are not discussed here. We did ask the respondents 10 items related to housing or behavioral risks, using a Likert scale format. We sought to determine where radon and mine dust ranked in this hierarchy. The results are presented in Table 1. HIV/AIDS, tuberculosis, and airborne mine dust were ranked as having a relatively higher, or average, risk, while radon ranked low.

Table 1 Results Concerning Average Perceived Risk

Type of risk	**Risk**
Getting HIV/AIDS, dying in 10 years	**1.26**
Breathing problems from blowing mine dust	**1.31**
Getting very sick from contaminated water	**1.33**
Getting Tuberculosis	**1.37**
Radon and small cancer risk in 20 years	**1.45**
Dolomite soils/house collapsing in hole	**1.45**
Driving on bald tires and crashing	**1.49**
Riding in a taxi, maybe having an accident	**1.55**
Smoking cigarettes and cancer risk in 20 years	**1.64**
N=316. these figures represent average relative perceived risk 1 = High concern regarding risk 5 = Low concern regarding risk	

The CV fact paragraphs were then read to respondents. In order to determine the baseline value of the respondents' current home, they were asked the following open-ended question, where the answer was to be provided in currency:

Let's suppose you are looking for a new home in a different location. You need to find a home quickly and have been looking for some time. You are looking for a four room house with registered ownership, with water, sewer and electricity, a place to park a car, and you find one that meets your space and location needs[4]*. If the neighborhood is also what you are looking for, what is the most you would be willing to offer (total price) to buy the home (in rand)?*

[4] A typical home of this type would include a kitchen, bathroom, stove, and would be about 500 square feet in size.

The average response to the above question was about R190,000 (US$28,300). This provided the baseline home value against which the later responses were compared, and a discount was calculated.

After obtaining the baseline home value, four different scenarios were then presented to the respondents. These scenarios included two uncontaminated scenarios and two with some form of mining-related environmental issue. The respondents were asked to value the changes to each property based on the information in the scenarios. The fact paragraphs were read, and the respondents were asked to provide open ended responses. These were restricted to the maximum they would pay, in rand. Zero was an allowable response.

The first scenario (A) focused on a standard housing unit in a remote location, and for the sake of brevity, it is not dealt with here. The second scenario (B) addressed a stacked flat unit configuration, with minimal use restrictions, in a very good location close to the Johannesburg CBD. Its text was as follows:

The home is located within a kilometer of Main Reef Road, between Soweto and the Johannesburg Central Business District. The travel time to the CBD by taxi is 10 minutes. The house is new and has other new homes around it. Schools and shopping are nearby. A vegetable garden on the ground is not possible, and the four room unit is on the second floor of a three storey building. Except for this, the home and neighborhood are just like the one you are looking for.

The third scenario (C) focused on radon contamination. It was in the same location as the above scenario. It reads as follows:

The home is located on former mining lands, close to the Johannesburg Central Business District. Schools and shopping are nearby. The travel time to the CBD by taxi is 10 minutes. The mine tailings have been taken away, but the land has a small amount of leftover chemicals under it, including radon. The site has been cleaned to where the levels are the same as other property elsewhere. The government is satisfied that the property is suitable for housing. There is a small risk[5] of having health problems in 20 years. Vegetable gardening on the ground is not possible, and the four room unit is on the second floor of a three -storey building. Except for this, the home and neighborhood are just like the one you are looking for.

The asterisks for radon and risk indicate where interviewers were permitted to read pre-specified elaboration text to further refine these important issues. The fourth scenario (D) focused on airborne mine dust. It was in the same location as the two above scenarios. It reads as follows:

[5] If asked, the interviewer was instructed to tell the respondent that this meant one cancer death per 1,000 people in 20 years.

The home is located on former mining lands close to the Johannesburg Central Business District. The travel time to the CBD by taxi is 10 minutes. Schools and shopping are nearby. The house is located next to an existing mine dump that is 30 meters high. Sometimes the wind blows the dust onto the neighborhood where the house is located. There is a risk of having health problems. Vegetable gardening on the ground is not possible, and the four -room unit is on the second floor of a three storey building. Except for this, the home and neighborhood are just like the one you are looking for.

The final part of the survey instrument asked the respondents a series of demographic questions. These were designed to determine their educational level, gender, age cohort, income level, and the number of people in each household.

10. Research Hypotheses and Methodology

Bid percentages (the percentage of those respondents that bid at all on a given fact paragraph scenario) and discounts (the amount of the discounts, given that there was bidding) among the respondents were examined using descriptive statistics. Although these could logically follow the probit analysis in that respondents made bids before the results were analyzed, we present the discounted bids first to focus on the top half and quarter of the markets, which are more likely to be accepted by potential sellers. A probit analysis is then used to determine the impact of demographic features and terminology changes on the bidding behavior of higher bidding-participants.

The research hypotheses are that the likelihood of bidding on the second (uncontaminated) scenario is higher than on the third and fourth scenarios because of the contamination issue. We also expect the discounts to be higher for the fourth (airborne mine dust) scenario than the third (radon) scenario because 1) it reflects an immediate health issue, as opposed to one far off in the future; and 2) because respondents ranked it as a higher concern in the risk section noted above. This latter point is sometimes referred to as the scope effect in CV literature.
With respect to the probit analysis, we assume that, as in the United States, male respondents and those with less education and lower income levels would be more likely to bid closer to the full value for contaminated properties than other groups, holding all else constant. We are curious about the value of the location premium to potential buyers, but we have no formal hypotheses about it. Finally, we are curious if respondents in the lowest income group (those earning less than R2,500, or US$370, per month) can competently complete a complex survey of this type.

In order to assess the impact of the radon and mine dust contamination scenario on respondents, two factors are of key importance. First, the portion of residents not willing to bid on a scenario reflects a loss in market demand. Second, the ratio of a maximum stated bid to the baseline case is interpreted as the potential percentage loss on the property. One minus this ratio reflects the discount. For example, if the

person's baseline price is R150,000 and the maximum bid is R120,000, this would be considered a 20% discount.

Because we employ the marginal bidder technique, where only those bids closest to the full price are market-making, half or fewer of all bidders are considered in the final results. Certain very low "bottom-fisher" bids, such as those with discounts of up to 99%, would be assumed to be a type of "game-playing," rather than a serious attempt to bid. A rational seller would not accept such a bid. So, in order to better reflect the market and recognize that top marginal bidders are more likely to successfully bid on a property, we only consider the top half bidders based on the discount percentage.[6] Further, the data are partitioned again (top quarter bidders) and then analyzed using both pools of bidders.

With respect to the probit analysis, both *top half bids* and *top quarter bids* are used as dependent variables in separate model estimates. The probit model is used in quantitative studies that include a dichotomous choice dependent variable. The model is specified as:

$$Y = \beta_0 X_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_N X_N + u \quad (1)$$

where Y is the dependent dichotomous variable (top half bid or top quarter bid) and the β weights represent the coefficient values of various independent demographic variables (X) and u represents the error term. The independent variables used in this analysis include age, education, household size, gender, car ownership, employment status, house value, interview location, and tenure. Descriptions of the variables are included in Table 2.

Demographic variables such as age, education, and income were input into the model, and those with statistical significance were retained for future analysis. The rest of the variables (income, gender, number of people in the household) were retained because theory would indicate a relationship. Local market conditions were retained for analysis for top half bidders, with the entirely residential category acting as the reference.

6 Consider a property offered for sale for R500,000 by the seller. Four bids are made: R420,000, R320,000, R375,000, and R475,000. The average of these bids is R397,500. If asked what the likely sales price would be, the logical answer would be the top bid of R475,000, rather than the average sales price of R397,500. The average sale price of the bidding pool (sometimes called willingness to pay) has little bearing on the final price because the lower bids only make the market price if the other bids drop out. Similarly, if there is only one unit for sale, then the top bidder would be most likely to have the seller accept his or her bid. However, when multiple properties are for sale, pooling top bids into top quarter and top half of the market better estimates stated preferences for the sale price.

Table 2 Probit Demographics

Gender		
Male	214	67.7%
Female	100	31.6%
Age of Respondent		
20-29	90	28.5%
30-39	101	32.0%
40-49	83	26.3%
50-59	21	6.6%
60-69	15	4.7%
Over 70	3	0.9%
Place of Residence		
Southgate	161	50.9%
Orlando	59	18.7%
Eastgate	31	9.8%
Other	65	20.6%
Educational Attainment		
Less than grade 8	38	12.0%
Standard 8	62	19.6%
High school graduate	95	30.1%
Some college	34	10.8%
College graduate	57	18.0%
Post-graduate	30	9.5%
Monthly Household Income (in Rand)		
Under 2,500	55	17.4%
2,500-3,500	80	25.3%
3,500-4,500	28	8.9%
4,500-5,500	36	11.4%
5,500-6,500	19	6.0%
6,500-7,500	16	5.1%
Over 7,500	80	25.3%
Mode of Work Transportation		
Walk	46	14.6%
Taxi	125	39.6%
Bus	14	4.4%
Train	23	7.3%
Own Car	94	29.7%
Carpool	6	1.9%

11. Results

The descriptive results of this analysis show the percentage of respondents that bid on each scenario as well as the average bid, top half bid, and top quarter bid. These data are shown in Table 3. The baseline property value was R189,194. For Scenario A, the uncontaminated property located one hour from the CBD, 97% of the respondents provided a bid. The average bid was discounted by 8%, the top half bid averaged a premium of 28%, while the top quarter bid had a premium of 50%. Thus, although the remote location was undesirable to most bidders, some actually preferred an outlying location, usually because they worked nearby.

Table 3 Bidding Results

Scenario A: Far Away		
Invalid bids	8	
Premium bids	3	
Total bids	298	**96.75%**
Average bid	-7.61%	
Top 1/2 bid	**28.04%**	
Top 1/4 bid	**50.09%**	
No bid	10	
Total valid bids	308	
Grand total	316	

Scenario B: Close in Flats		
Invalid bids	9	
Premium bids	3	
Total bids	281	**91.53%**
Average bid	0.91%	
Top 1/2 bid	**-1.48%**	
Top 1/4 bid	**13.60%**	
No bid	26	
Total valid bids	307	
Grand total	316	

Scenario C: Radon		
Invalid bids	6	
Premium bids	1	
Total bids	193	**62.06%**
Average bid	-52.89%	
Top 1/2 bid	**-38.03%**	
Top 1/4 bid	**-22.48%**	
No bid	118	
Total valid bids	311	
Grand total	316	

Scenario D: Mine Dust		
Invalid bids	8	
Premium bids	2	
Total bids	139	**45.13%**
Average bid	-68.12%	
Top 1/2 bid	**-56.57%**	
Top 1/4 bid	**-39.95%**	
No bid	161	
Total valid bids	308	
Grand total	316	

For Scenario B, the uncontaminated stacked flat located 10 minutes from the CBD, 92% of the respondents offered a bid. The average bid had a negligible premium of 1%; the top half bid averaged a 1.5% discount, while the top quarter bid had a premium of 14% (see Table 3). Therefore, even though about one-sixth of all

respondents would not bid on the property, some apparently favored the location and did not mind the stacked flat product to the point that their bids were at a premium.

For Scenario C, the stacked flat property with radon, near the CBD, 62% of the respondents offered a bid. Therefore, more than one-third of respondents declined to bid on the property at all. The average bid was discounted by 53%; the top half bid averaged a 38% discount, while the top quarter bid had a discount of 22% (see Table 3). Thus, it would seem plausible that there was a market for this type of property, and the range of discounts would be in the 20% to 35% range, at least initially.

For Scenario D, the stacked flat property with airborne mine dust near the CBD, 45% of the respondents offered a bid. Therefore, more than half of all respondents declined to bid on the property at all. The average bid was discounted by 68%; the top half bid averaged a 56% discount, while the top quarter bid had a discount of 40% (see Table 3). Thus, it would seem plausible that there was a market for this type of property, and the range of discount would be in the 40% to 56% range, at least while the mine dump remained next to the property.

12. Probit Analysis

The results of the probit model show the impact of the independent variables (e.g., demographics) on the respondent's probability of being in the top half bid and top quarter bid groups. Using forward variable selection, 30 models were run using different combinations of variables. These models used five different sets of variables and were run using the top half and top quarter bids for apartments, apartments near sites with radon, and apartments near sites with mine dust based on the survey scenarios. Minor multi-collinearity issues were discovered among several variables.

This issue was observed if people used their own car to get to work and if they were in the more than R5,000 income bracket. In South Africa, most car owners have higher incomes. Owning a car was significant in only two of the 12 models, while having an income of more than R5,000 was significant in four of the 24 models. While the ratio was the same, the income variable had higher *t*-values in the models. Another multi-collinearity issue arose with the number of people – including children and/or employees – per household. The number of people per household consistently showed significance in the dust mine scenarios for the top quarter models.

If the variables were significant in the first two sets of models, they were included in subsequent models. Table 4 is a summary of the variables and their significance across all the models. The significance level was lowered to 0.15, owing to the exploratory nature of this part of the research. Despite the changing significance of several variables, the model was internally consistent regarding the sign of the

relationship between variables within models. A few trends across each of the models will be discussed before the final model is presented

Table 4 Model Significance Summary Rseults

Exhibit 5: Model Significance Summary Results								
	Apartments		Radon		Mine Dust		Total Significant *	Number of Models
Over 49 years old	5	17%	9	30%	10	33%	24	30
College degree	0	0%	0	0%	2	17%	2	12
Education rural	5	17%	9	30%	0	0%	14	30
People per household	10	33%	0	0%	2	7%	12	30
Kids per household	2	17%	0	0%	1	8%	3	12
Employees per household	0	0%	0	0%	0	0%	0	12
Income over $5,000 Rand	0	0%	1	4%	1	4%	2	24
Gender	10	33%	10	33%	5	17%	25	30
Own car	0	0%	2	17%	0	0%	2	12
English	4	17%	8	33%	4	17%	16	24
Year at current residence	0	0%	0	0%	6	25%	6	24
Did not matriculate	0	0%	1	8%	0	0%	1	12
Needs housing subsidy	8	33%	4	17%	0	0%	12	24
Radon			10	100%			10	10
Mine dust					6	60%	6	10
Education less than standard 8	0	0%	0	0%	0	0%	0	6
Orlando East	0	0%	3	17%	0	0%	3	18
Southgate	0	0%	3	17%	0	0%	3	18
Total	44		60		37		141	

*Total significant is defined as the number of times the variable was significant in any model at the .15 level or greater

In the models involving apartments (Table 5), the gender variable was significant and negative. This result indicated that women did not want to live in apartments. English language was a significant and positive factor in all four top quarter bid models for apartments. Needing a housing subsidy to live in the described apartment was significant and positive in all apartment models for the top half and top quarter of all bidders. This variable was also significant at the 0.05 level. Age was also significant in all but one of the apartment models. It was significant and negative for the top quarter models. This indicates that the people more than 49 years of age were the most likely to bid on an apartment and would also expect a higher discount. Theory would indicate that older people found apartment living undesirable and would not pay a premium to live in one.

The presence of radon presented interesting results (shown in Table 6). When Scenario C was described to respondents, the definition of radon for those who asked was “a radioactive gas formed by the decay of uranium.” The results in the radon models are likely attributable to the amount of time required for exposure to the substance to have serious health effects. Radon was positive and significant at the 0.15 level in all of the models. This positive relationship supported the internal validity of the survey because a higher score meant the respondent perceived radon as having a relatively lower level of risk. Rural education was significant and positive in all of the top quarter radon models, indicating that growing up in a rural

area had a positive impact on deciding whether to bid on an apartment in the presence of radon. Requiring a housing subsidy to rent the apartment was significant and positive in all but one of the bidding models.

Table 5 Apartment Model *t*-Values

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter
Over 49 years old	.552	2.040***	.670	2.540***	.801	1.829**	.615	2.055***	.581	1.942**
College education			-.205	-.207			-.544	-.802		
Rural education	1.962***	1.097	2.630***	1.353	1.843**	1.120	1.900**	1.118	1.852**	1.081
People per household	-2.061***	-1.760**	-2.330***	-2.271***	-1.535*	-1.825**	-1.799**	-1.853**	-1.634*	-1.669**
Kids per household	1.531*	.773	1.569*	1.178						
Employees per household	.420	.854	.863	1.257						
Income over $5,000 Rand			.298	-.466	.220	-.917	-.010	-.754	-.056	-.840
Gender	-2.613***	-3.879***	-2.549***	-4.127***	-2.529***	-3.640***	-2.412***	-3.776***	-2.451***	-3.812***
Own car	-.992	-1.169	-1.231	-.575						
English	1.332	3.899***			.881	4.092***	1.046	4.015***	1.050	3.982***
Years in current home	-.614	.454			-.760	.018	-.699	-.034	-.745	-.058
Did not matriculate	.173	.651							.301	.504
intercept	-.869	-3.422***	.942	-1.459	-1.248	-3.607***	-1.241	-3.282***	-1.365	-3.486***
Needs housing subsidy	2.273***	1.454*			2.582***	1.581*	2.528***	1.478*	2.556***	1.523*
Radon										
Dust										
Education below standard 8					-.482	1.262				
Orlando					.247	.635	.256	.777	.210	.709
Southgate					.687	.922	.831	.856	.770	.802
fit chi sq	306.337	292.095	312.019	302.173	305.782	288.878	306.767	289.683	306.000	288.139
sig	.284	.504	.348	.503	.306	.573	.307	.576	.303	.585
*Significant at the .15 level										
**Significant at the .1 level										
***Significant at the .05 level										

Table 6 Radon Model *t*-values

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter
Over 49 years old	2.643***	1.486	2.443***	1.377	2.422**	1.983***	2.371***	1.746**	2.645***	2.009***
College education			-.258	-.863			-.673	-1.126		
Rural education	1.320	2.153***	1.672**	2.344***	1.561*	2.204***	1.629*	2.276***	1.542*	2.219***
People per household	1.331	1.076	.609	.549	.377	.927	.206	.741	.423	.920
Kids per household	-.907	.230	-.577	.380						
Employees per household	-.762	-.973	-.304	-.544						
Income over $5,000 Rand			1.581*	.161	.612	-.644	.839	-.186	.252	-.735
Gender	-2.810***	-2.065***	-2.822***	-2.159***	-2.525***	-1.931**	-2.501***	-1.835**	-2.585***	-1.942**
Own car	-1.703**	-1.133	-1.675**	-.488						
English	2.776***	2.015***			2.279***	1.563*	2.361***	1.814**	2.215***	1.607*
Years in current home	-.724	-.180			-.330	-.449	-.289	-.397	-.342	-.438
Did not matriculate	-1.428	-.345							-.898	-.459
intercept	-4.353***	-4.829***	-4.004***	-5.394***	-5.035***	-5.300***	-5.008***	-5.145***	-4.848***	-5.233***
Needs housing subsidy	2.422***	1.082			2.437***	.992	2.375***	.819	2.489***	1.027
Radon	2.652***	3.113***	3.164***	3.733***	2.887***	3.600***	2.977***	3.687***	2.891***	3.614***
Dust										
Education below standard 8					.052	-.283				
Orlando					.649	1.874**	.689	1.811**	.685	1.874**
Southgate					1.196	2.140***	1.286	2.208***	1.139	2.156***
fit chi sq	307.634	270.821	305.526	284.974	305.696	271.697	304.967	273.447	312.959	273.067
sig	.254	.808	.432	.751	.293	.809	.318	.800	.202	.793
*Significant at the .15 level										
**Significant at the .1 level										
***Significant at the .05 level										

Gender (females were less likely to bid) and age (those more than 49 of age were more likely to bid) were also significant at the 0.10 level or higher in all of the radon models. None of the variables that proxied for income or educational level were significant, even at a 0.15 level of significance.

The Southgate geographic variable was also significant at the 0.1 level and positive in two of the top quarter models. The Orlando and Southgate geographic variables were expected to be significant and negative owing to the incidence of radon in the area, and both location variables were positive and significant at the 0.15 level or better for the three top quarter models. For Orlando, radon was an area issue, but the lack of negative significance might mean that the residents in the neighborhood were used to the presence of radon.

The models for mine dust revealed several expected results indicating a reduced willingness to bid for apartments. Unlike radon, mines and mine dust were visible and respondents understood the possible health hazard of living near mines (see Table 7). As with radon, there was internal validity with the mine dust risk variable, indicating a positive relationship between lower perceived risk and bidding. Age (those more than 49 years of age) was significant in the top quarter models for mine dust, and gender (females were less likely to bid) was negative and significant.

Table 7 Mine Dust Model *t*-value

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter	Half	Quarter
Over 49 years old	1.959***	2.157***	1.494*	1.862**	1.509*	2.368***	1.664**	2.190***	1.881**	2.195***
College education			-.839	-1.885**			-1.353	-2.076***		
Rural education	.713	.145	.745	.222	.823	.085	.906	.228	.772	.055
People per household	1.196	-.157	.577	-.530	.879	1.461*	.828	1.341	1.103	1.516*
Kids per household	-.633	1.602*	-.686	1.390						
Employees per household	-.403	.160	-.010	.404						
Income over $5,000 Rand			1.024	1.395	-.325	.151	.119	.991	-.533	.315
Gender	-1.820**	-1.110	-2.018***	-1.194	-1.593*	-.938	-1.768**	-.951	-1.821**	-.939
Own car	-.710	-.664	.222	.046						
English	3.347***	1.187			3.641***	1.236	3.588***	1.437	3.409***	1.286
Years in current home	-1.405	-1.470*			-1.464*	-1.626*	-1.403	-1.550*	-1.442*	-1.632*
Did not matriculate	-.156	.273							-.195	.537
intercept	-3.643***	-3.945***	-4.031***	-5.272***	-3.811***	-4.767***	-3.349***	-4.339***	-3.552***	-4.790***
Needs housing subsidy	-.150	-.302			-.196	.070	-.397	-.263	-.224	.048
Radon										
Dust	1.300	2.247***	1.958***	2.623***	1.215	2.535***	1.258	2.560***	1.222	2.500***
Education below standard 8					1.324	.217				
Orlando					.405	1.062	.391	.911	.421	1.059
Southgate					-.111	.683	-.249	.610	-.313	.681
fit chi sq	294.396	295.171	309.294	308.693	290.284	291.191	293.086	282.979	291.904	296.478
sig	.450	.437	.374	.383	.534	.519	.504	.667	.507	.432
*Significant at the .15 level										
**Significant at the .1 level										
***Significant at the .05 level										

The number of years people had lived at their current residence was also negative and significant at the 0.05 level in all of the top quarter models, indicating that people would prefer to stay where they were than move to an apartment located near a site containing mine dust. An odd finding was that households with only one person were more likely to bid in the top quarter models. As with radon, no income or wealth proxies were significantly more likely to bid on the apartments located near sites with mine dust. This result did not refute other findings that showed that people with choices tended to avoid pollution when they could (Simons and Winson-Geideman, 2005). However, that study also indicated that age (older), and gender (males) were more likely to bid, which was consistent with the findings of this research.

After analyzing all of the models for internal consistency, Model 5 appeared to be the best model with the highest statistically significant *p* values for the apartment and mine dust models.

The models shown to date have only provided *t* statistics. The following models in Tables 8 and 9 also show the β coefficients and signs for the best model. Table 8 shows the complete probit results for the 141 top half bidding pool of respondents out of the original total of 316 respondents. The 141 respondents were based on the 281 respondents that offered a bid amount for apartment Scenario B. The following two tables contain the beta weights as well as the *t*-statistics.

Table 8 Top Half Bidding Results

	Top Half Bidding Pool All Apartment Bidders				Top Half Bidding Pool All Radon Bidders				Top Half Bidding Pool All Mine Dust Bidders			
	β Value	Std. Error	t Value	Sig.	β	Std. Error	t	Sig.	β	Std. Error	t	Sig.
Rural education	0.271	0.146	1.852	0.064**	0.225	0.146	1.542	0.123	0.121	0.157	0.772	0.440
Gender	-0.402	0.164	-2.451	0.014***	-0.480	0.186	-2.585	0.01***	-0.357	0.196	-1.821	0.069**
Intercept	-0.466	0.341	-1.365	0.172	-2.041	0.421	-4.848	0.000***	-1.406	0.396	-3.552	0.000***
English	0.175	0.167	1.050	0.294	0.417	0.188	2.215	0.027***	0.712	0.209	3.409	0.001***
Needs housing subsidy	0.618	0.242	2.556	0.011***	0.667	0.268	2.489	0.013***	-0.055	0.244	-0.224	0.823
Did not matriculate	0.057	0.189	0.301	0.763	-0.185	0.206	-0.898	0.369	-0.042	0.216	-0.195	0.845
Orlando	0.048	0.227	0.210	0.833	0.175	0.256	0.685	0.494	0.110	0.262	0.421	0.674
Over 49 years old	0.100	0.172	0.581	0.561	0.486	0.184	2.645	0.008***	0.356	0.189	1.881	0.06**
Income over 5,000 Rand	-0.010	0.174	-0.056	0.955	0.048	0.192	0.252	0.801	-0.105	0.198	-0.533	0.594
People per household	-0.058	0.035	-1.634	0.102**	0.016	0.038	0.423	0.673	0.044	0.040	1.103	0.270
Southgate	0.133	0.173	0.770	0.441	0.221	0.194	1.139	0.255	-0.061	0.194	-0.313	0.754
Years in current home	-0.005	0.006	-0.745	0.457	-0.002	0.007	-0.342	0.732	-0.010	0.007	-1.442	0.149
Radon					0.222	0.077	2.891	0.004***				
Mine dust									0.109	0.089	1.222	0.222
	Chi-Square		Df	Sig.	Chi-Square		Df	Sig.	Chi-Square		Df	Sig.
Pearson Goodness-of-Fit Test	306.000		294	0.303	312.959		293	0.202	291.904		293	0.507
*** = Significant at .05 level												
** = Significant at .1 level												

Because the probit model only addresses a willingness to bid on a particular scenario, no discounted price data (e.g., percent discounts in the top quarter or top

half of the market) appear in this part of the study. Rather, the emphasis is on the characteristics of the bidders, rather than the amount they bid.

Based on the Pearson goodness-of-fit test, the models fit the data reasonably well. If the chi-square statistic is small and/or significant, it indicates that there may be one of several issues with the model, ranging from the lack of a linear relationship between the data and model or an unequal distribution of points around the regression line, signifying data heterogeneity (Norusis, 2005). According to the SPSS for probit analysis, "if the significance value of a given test is small (less than 0.05), then the model does not adequately fit the data." Our significance values not being less than 0.05 demonstrate that overall the models fit the data well.

One of the most important demographic indicators in bidding was whether the respondent required a housing subsidy to rent the apartment. Referring to Table 8, those respondents needing a housing subsidy were more likely to bid. This relationship was statistically significant at a level of confidence of 0.05. A positive sign on the coefficient indicated a positive relationship with the probability of bidding. However, the β coefficients did not have a percentage interpretation in their current form. In the top half apartment bid group, the variables generally performed as expected. Female respondents were less likely to bid on the scenario than males (significant at the 0.05 level). Those needing a housing subsidy were more likely to bid, and this β at 0.618 was the highest value in the model. Those with more people per household were less likely to bid.

Probit analysis for the top half of the bidding pool for respondents bidding on the apartment in the presence of radon provided the expected results. The need for a housing subsidy (again the highest β at 0.667), the ability to speak English, being male, and being over the age of 49 (second highest β at 0.486) were significant at the 0.05 level. In addition to their significance levels, these variables were also positively related to their willingness to bid. This result indicated that people would be willing to move into the apartments despite the presence of radon as long as they received a housing subsidy. The positive and significant sign of the radon risk variable was a reassuring internal validity check.

For the top half of respondents bidding on the mine dust scenario, being male, being over the age of 49, and having an ability to speak English (with the highest β at 0.712) were significant at the 0.1 level and positive. This result reflected people who were older would be willing to move to an area with mine dust. The ability to speak English was positively correlated with a willingness to bid on an apartment in the mine dust area. We believe that English language respondents might be further removed from traditional housing and might therefore have better access to downtown Johannesburg.

The same probit analysis was undertaken for the top quarter of the bidding pool. The results of the analysis on the top quarter bid group are shown in Table 9, which is based on 70 bidders. When the dependent variable was reduced to the top quarter of

all bidders, several variables increased in significance. Respondents had more choices (i.e., an uncontaminated site) at a similar or the same price and therefore were less likely to bid, regardless of demographics.

Table 9 Top Quarter Bidding Results

	Top Quarter Bidding Pool				Top Quarter Bidding Pool				Top Quarter Bidding Pool			
	β Value	Std. Error	t Value	Sig.	β	Std. Error	t	Sig.	β	Std. Error	t	Sig.
Rural education	0.165	0.152	1.081	0.280	0.366	0.165	2.219	0.026***	0.011	0.206	0.055	0.956
Gender	-0.828	0.217	-3.812	0.000***	-0.454	0.234	-1.942	0.052***	-0.226	0.241	-0.939	0.348
Intercept	-1.398	0.401	-3.486	0.000***	-2.736	0.523	-5.233	0.000***	-2.319	0.484	-4.790	0.000***
English	0.837	0.210	3.982	0.000***	0.370	0.230	1.607	0.108	0.321	0.250	1.286	0.198
Needs housing subsidy	0.408	0.268	1.523	0.128	0.339	0.330	1.027	0.304	0.015	0.303	0.048	0.961
Did not matriculate	0.112	0.221	0.504	0.614	-0.113	0.247	-0.459	0.646	0.137	0.255	0.537	0.592
Orlando	0.197	0.278	0.709	0.478	0.588	0.314	1.874	0.061**	0.329	0.310	1.059	0.290
Over 49 years old	0.375	0.193	1.942	0.052***	0.438	0.218	2.009	0.044***	0.490	0.223	2.195	0.028***
Income over 5,000 Rand	-0.173	0.206	-0.840	0.401	-0.172	0.234	-0.735	0.462	0.077	0.243	0.315	0.752
People per household	-0.069	0.041	-1.669	0.095**	0.041	0.045	0.920	0.358	0.072	0.047	1.516	0.130
Southgate	0.161	0.201	0.802	0.423	0.537	0.249	2.156	0.031***	0.164	0.241	0.681	0.496
Years in current home	0.000	0.007	-0.058	0.954	-0.003	0.008	-0.438	0.661	-0.015	0.009	-1.632	0.103**
Radon					0.302	0.084	3.614	0.000***				
Mine dust									0.242	0.097	2.500	0.012***
	Chi-Square		Df	Sig.	Chi-Square		Df	Sig.	Chi-Square		Df	Sig.
Pearson Goodness-of-Fit Test	288.139		294	0.585	273.067		293	0.793	296.478		293	0.432

*** = Significant at .05 level
** = Significant at .1 level

13. Probit Results for Top Quarter Bidding Pool Bidders

The top quarter bidding results for the apartment scenario contained several significant variables. As in the previous top half apartment model, females were less likely to bid on the apartments (and had the second highest β at 0.828). This result was also negative and significant at the 0.05 level. The variable for needing a housing subsidy was not significant at the 0.1 level. An English-speaking ability (which had the highest β in this model at 0.837) was also significant and positive at the 0.05 level. Being more than 49 years of age was significant at the 0.05 level, perhaps because of a desire not to live in high-density housing. The number of people per household variable was also significant at the 0.1 level.

For the radon scenario, several variables that were expected to be negative were consistently positive. Orlando and Southgate were the two neighborhoods in greater Johannesburg where radon and mine dust were most prevalent. Despite this fact, they were significant at the 0.1 level and .05 level, respectively. They also had the highest positive βs at 0.58 and 0.54, respectively. In addition to the geographic variables, respondents attending secondary school in a rural area were more likely to bid on the radon scenario based on the variable being positive and significant at the 0.05 level. These results reinforced one of two possibilities: either people did not understand the effects of radon or saw it as a low risk, or they were so used to it that it did not play a

role in their bidding behavior. Rounding out the bidding, gender (males were more likely to bid), age (those more than 49 years of age were more likely to bid), and positive attitudes toward radon risk were all significant and positively associated with bidding.

The mine dust scenario had several unexpected results. The number of people per household was positive and significant at the 0.15 level, suggesting that people would be willing to move into apartments where mine dust was present owing to current crowded living conditions. Being more than 49 years of age was significant at the 0.05 level and positive, indicating a willingness of older people to move into apartments near sites containing mine dust. The mine dust risk variable was significant at the 0.05 level and positive, demonstrating that mine dust might not be viewed as a negative consideration regarding the willingness to bid on the apartment. The number of years living in the current home was significant (at close to the 0.1 level) and negative. As in the previous model for radon, this result was probably due to an unwillingness to move from their current home rather than because of the contamination.

14. Conclusions

This study has analyzed the results of a survey of householders in Johannesburg, South Africa, using contingent valuation analysis (CV). The focus of the study was the effect that radon and airborne mine dust would have on residential property values. The data set included 316 personal interviews and examined the consistency of the results for housing developments on former mine dumps, controlled for income, age, education, level of contamination, local market type, and other factors.

The results of this study generally demonstrate that surveys using the CV technique can be performed in developing countries. For example, one part of the surveys included questions about a respondent's risk perceptions of radon or mine dust. Indifferent responses were associated with a larger likelihood of bidding on that type of property. Although the demographic composition of the non-random, middle-income sample, as expected, was higher than that of Johannesburg as a whole with respect to income, education, and car ownership, the findings from this study cannot readily be generalized to the overall population.

The research hypothesis that discounts would be greater for visible problems (airborne mine dust) than for unfamiliar and longer-term hidden issues (radon) was supported by the descriptive statistics. The average discount for the top quarter of the bidding pool (assuming the marginal top bidders got the property) indicated an average discount of 22% for radon vs. 40% for mine dust. The apartment discount

(close-in location, no contamination) had a 14% premium among this most likely group of bidders[7].

Aside from local market issues, the probit results indicate that several factors are associated with the likelihood of bidding on a contaminated residential property. The most important variables in this research that are positively associated with bidding on potentially contaminated property are as follow: needing a housing subsidy, the ability to speak English, the age of the respondent (more than 49 years of age), and dummy variables for places near existing mine dump piles (such as Orlando and Southgate). Variables that were statistically significant for radon were not always significant for mine dust, indicating they are valued somewhat differently in the marketplace.

Contrasting these results with environmental contamination studies done in the United States reveals that different variables are in play. In the US, the main indicators associated with bidding on contaminated property were confirmed contamination (negative) and no high school education (positively associated with bidding). Other US results were that those more than 49 years of age and males were significantly more likely to bid (in some models), and income was negatively associated with bidding. In this research, the gender result was consistent with the findings of McClelland et al (1990) and Simons and Winson-Geidman (2005), who found that females were more reluctant to live near a risky facility than men. Gender was consistent in many of the models in this research. This research also found similar results with respect to age (those more than 49 years of age being more likely to bid). However, it did not support the findings associated with education levels, and speaking English as a first language was positively associated with bidding, so perhaps this is a proxy for education in some capacity.

While certainly not perfect, the survey results support the notion that economic behavior concerning residential property affected by contamination in developing countries is workable, and market behavior and values are generally consistent among other markets across the world. Demographic factors such as education and gender, the age of potential buyers, housing subsidy needs, and factors related to knowledge of contamination are all likely to be important factors. Since the need for housing is acute in developing countries (including South Africa), contingent valuation analysis can be a useful tool in determining market acceptance of certain housing options associated with risk and uncertainty.

[7] It is acknowledged that there are no pre-determined hard and fast rules concerning the application of top quarter, top half, or average discount figures pertaining to this situation. Future researchers would be well advised to address this important issue.

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